15 -ാം കേരള നിയമസഭ

9 -ാം സമ്മേളനം

നക്ഷത്ര ചിഹ്നം ഇല്ലാത്ത ചോദ്യം നം. 1278 **11-09-2023 - ൽ മറുപടിയ്ക്ക്**

തീരദേശ ഹൈവേ

ചോദ്യം		ഉത്തരം	
ശ്രീ. ടി. സിദ്ദിഖ്		**ശ്രീ. പി.എ.മുഹമ്മദ് റിയാസ്** **(പൊതുമരാമത്ത്-വിനോദസഞ്ചാര വകുപ്പ് മന്ത്രി)**	
(എ)	സംസ്ഥാനത്ത് തീരദേശ ഹൈവേ നിർമ്മാണത്തിനായി ഡി.പി.ആർ. തയ്യാറാക്കുന്നതിന് ഏതൊക്കെ ഏജൻസികളെയാണ് ചുമതലപ്പെടുത്തിയിട്ടുള്ളത്; ഏതൊക്കെ സോണുകളിലെ ഡി.പി.ആർ. പ്രസിദ്ധീകരിച്ചിട്ടുണ്ട്; പ്രസിദ്ധീകരിച്ച ഡി.പി.ആർ.കളുടെ പകർപ്പുകൾ ലഭ്യമാക്കുമോ?	(എ)	സംസ്ഥാനത്ത് തീരദേശ ഹൈവേ നിർമ്മാണത്തിനായി വിശദപദ്ധതിരേഖ തയ്യാറാക്കുന്നതിന് NATPAC, LNTIEL, IDECK എന്നീ ഏജൻസികളെയാണ് ചുമതലപ്പെടുത്തിയിട്ടുള്ളത്. തിരുവനന്തപുരം, കൊല്ലം, ആലപ്പുഴ ജില്ലകൾ NATPAC നും, എറണാകുളം, തൃശ്ശൂർ ജില്ലകൾ LNTIEL നും, മലപ്പുറം, കോഴിക്കോട്, കണ്ണൂർ, കാസർഗോഡ് ജില്ലകൾ IDECK നുമാണ് ചുമതല. ഇതിനുപുറമേ മലപ്പുറം, കോഴിക്കോട് കണ്ണൂർ, തൃശ്ശൂർ ജില്ലകളിലെ 8 റീച്ചുകളുടെ ഡി.പി.ആർ തയ്യാറാക്കിയിട്ടുള്ളത് പൊതുമരാമത്ത് വകുപ്പ് നേരിട്ടാണ്. ഒരു റീച്ചിന്റെ പ്രവൃത്തി ചുമതല ആർ.ബി.ഡി.സി.കെ യ്ക്കും നൽകിയിട്ടുണ്ട്. കിഫ്ബി അംഗീകരിച്ച DPR കളുടെ പകർപ്പ് അനുബന്ധമായി ചേർത്തിരിക്കുന്നു.

സെക്ഷൻ ഓഫീസർ

GOVERNMENTOFKERALA

PUBLIC WORKS DEPARTMENT
ROADS AND BRIDGES

NAME OF WORK : - KIIFB 2017-18 - CONSTRUCTION OF AZHIKOD-MUNAMBAM BRIDGE IN THRISSUR DISTRICT

NAME OF CIRCLE	:	ROADS AND BRIDGES CENTRAL CIRCLE ALUVA
NAME OF DIVISION	:	ROADS DIVISION THRISSUR
NAME OF SUB DIVISION	:	BRIDGES SUBDIVISION THRISSUR
NAME OF SECTION	:	BRIDGES SECTION CHALAKUDY
CONSTITUENCY	:	KAIPAMANGALAM
AMOUNT	:	16000 LAKHS

CHIEF ENGINEER (ROADS & BRIDGES)
PUBLIC WORKS DEPARTMENT
THIRUVANANTHAPURAM

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SALIENT FEATURES

1.	Title of the project	KIIFB 2017-18 - CONSTRUCTION OF AZHIKOD-MUNAMBAM BRIDGE IN THRISSUR DISTRICT
2.	Department	Public Works Department
3.	Details of Project Location	
	District	Thrissur & Ernakulam
	Taluk	Kodungallur & Kochi
	Corporation/Municipality/Panchayath	Pallipuram Panchayath & Eriyad Panchayath
	Assembly Constituency	Kaipamangalam Constituency & Vypeen Constituency
4.	Implementing agency/SPV	Kerala Road Fund Board, Kavadiyar, Thiruvananthapuram
5.	DPR prepared by	Assistant Engineer, PWD Bridges Section, Chalakudy
6.	Project outlay	160.00 Crores
7.	Budget provision	160.00 Crores
8.	Budget speech reference	Budget speech 2017-18 Vol I part II para - 157 page No.69 serial No. 22 for KIIFB
9.	Administrative sanction	Principle Administrative Sanction vide GO(Rt) No. 942/2017/PWD Tvm dt.10/07/2017. Individual A.S to be sanctioned as per this DPR
10.	Nature of the project	New Bridge proposal is to across Munambam Kayal to connect Azhikodu in Kaipamangalam LAC in Thrissur District and Munambam in Vypin LAC in Ernakulam District.
11.	Present condition	This is the link from Vypin to Kodungallur & NH-17. At present Jankar service is used to cross the Munambam Kayal.
12.	Need for the Project	By the construction of Proposed Bridge there will be no traffic Congestion in NH- 17 & NH-47. Hence there will be considerable savings in time and distance for the transportation of goods from Vallarpadam. At present Jankar service is used to cross the Munambam Kayal. The Azhikode-Muziris Jankar service was disrupted many times as it developed problem. A huge amount

		was required for the Jankar repairing. At those times, locals will face many difficulties to cross the Kayal.
13	Type of Bridge	Pre Stressed Concrete Box Girder & Deck slab
	Total span length of bridge	12 spans of 52.60 m & Centre Lookout area , total length is 631.920 m
	Overall and carriage way widths	12.00M, 7.5m two lane carriage way
	Provision of footpath	1.5m width footpath on either side
	IRC loading class	a) Wearing Coat – 2KN/m2 b) Carriage way – Two lane of IRC class A c) Foot path – 5KN/m2
	Other details of proposed bridge	Bored in cast in situ piles 1.20m dia Foundation resting into Dense sand strata, POT- PTEF bearing , RCC Hand rails etc
14	Details of Approach roads	
	• Length of Approach road	100m Approach road and 150m service roads for both sides.
	• Carriage way width	7.50m two lane carriage way & 1.50m Footpath at each sides
	• Thickness of layers	GSB : 25 cm for approach road & 20 cm for service roads WMM : 25 cm for approach road & 15 cm for service roads
	• Other details	Traffic safety items as thermoplastic centre line painting, road studs, crash barrier, sign boards etc
15	Details of investigations/surveys conducted	
	• Traffic	• Anticipatory Traffic Study conducted
	• Geotechnical	Yes

16	Whether Land Acquisition involved ?	Yes
	If yes, furnish details	20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. Government order obtained for acquiring 0.2405 hectare land at Azhikode side vide Order no. GO(RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018. Provision for an amount of Rs. 1500 Lakhs is included for the Land Acquisiton & Peg marking Alignment boundary.
17	Total estimated cost and item wise cost break up and details of Schedule of Rates	160.00 Crores; MORTH with Delhi SOR 2016 with cost index 37.25%.
	Whether detailed estimate attached?	Yes
18	Details of revenue streams	KIIFB
19	Details of Cost Benefit Analysis (CBR value)	Attached
20	Details of project risks	For shifting existing Jenkar service, electrical and water supply utilities, Construction of Toll Booth etc are included in the estimate. 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. Clearance from Inland Waterways Authority of India, Port, CRZ and National Highway Departments is required. Existing Jenkar service, Electrical posts and water pipes are to be shifted for the approach road construction. This can be tackled as soon as the Administrative sanction is issued by KIIFB, in co-ordination with the respective Departments, viz the KSEB, KWA and the Revenue Department. The relevant intimation has to be sending to the local bodies regarding the commencement of works.

21	Details of project management organisation strategy	Chief Engineer (R & B), Tvpm. ↓ Superintending Engineer (R & B), CC Aluva ↓ Executive Engineer (R & B), Thrissur ↓ Assistant Executive Engineer (Bridges), Thrissur ↓ Assistant Engineer (Bridges), Chalakudy & PWD QC wing
22	Details of Contract Management Strategy	Work should be arranged through open e-tender, Analyse the bids received from competitive tenderers, awarding of contract to the lowest successful bidder, Execution of agreement by the competent authority
23	Details of Project Implementation Schedule (PIS) & Work Breakdown Schedule (WBS) - Proposed duration to complete the project	Expecting the work to commence on the financial year 2018-19 and to complete by 2010-21. The duration of project to 24 months.
24	Details of statutory clearances	Land Acquisition at both sides is required. Utilities shifting of KSEB, BSNL, KWA to be done and NOC from Inland Waterways Authority of India, Port, CRZ and National Highway Departments to be obtained before the commencement of work.
25	Quality control infrastructure and mechanism	3 tier Quality check-up is implemented. Contractor has to set up QC lab at site and responsible for 1st tier QC. 2nd by QC to be done by PWD QC wing and 3rd tier quality assurance by a committee constituted by PWD
26	Operations & Maintenance (O&M) arrangements of the project after completion	In the estimate no provision is given for the maintenance of the approach roads. After completion of bridge construction, it will be handing over to PWD Roads section of that area. No maintenance is expected and hence no provision is included for the same. Now a day the maintenance is to be carried out by the contractor up to his liability period and thereafter the department itself. In future O&M Strategy of the project will be under the new maintenance wing of the

		Public works department.
27	Details of attached drawings	Approved Alignment Drawing, Tentative General Design Drawing, Program Chart, Road Map
28	Other attachments	Estimate Report, Detailed estimate, Data analysis

2. EXECUTIVE SUMMARY

General- Azhikode – Munambam Bridge is proposed to be constructed across Munambam Kayal to connect Azhikodu in Kaipamangalam LAC in Thrissur District and Munambam in Vypin LAC in Ernakulam District. If this proposed bridge is to be completed there will be considerable savings in time and distance for the transportation of goods from Vallarpadam. This will ease traffic congestion in NH 17 & NH 47 which is now having high traffic volume. Administrative Sanction has been accorded as per Order No. GO (RT) No. 216/2011/PWD Dated. 04.02.2011 for Rs. 92 Crores. Investigation works for the above proposed bridge has been completed and the alignment plan and investigation report had submitted to the Design wing. Tentative Design Drawing had obtained as per No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012. This Bridge estimate is prepared based on Tentative Design Drawing No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012.

20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikodu Village in Azhikodu side are required for the construction of the approach road. As per old LA Act, 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikodu Village in Azhikodu side are required for the construction of the approach road. Government sanction obtained for for acquiring 20.99 Are land at Munambam side as per vide order no. GO(RT) No. 5423/2013/RD Dtd. 07.10.2013. 4(1) Notification had published for this purpose as per old LA Act. Government sanction obtained for acquiring 24.05 Are land at Azhikode side as per vide order no. GO(RT) No. 449/15/RD Dtd. 23.01.2015. But LA act renewed. This bridge is now proposed in KIIFB 2017-18 (Annexure II Sl no. 22) as per the Principal Sanction No. GO(RT) No. 942/2017/PWD TVM Dtd. 10/07/2017.

Hence new requests for the land acquisition as per new LA Act submitted to the Thrissur and Ernakulam district Collectors. Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed. Ernakulam Special Tahasildar (LA) & Thrissur Special Tahasildar (LA) are requested an urgent action for re fixing the boundary stone for starting the Land Acquisition procedures at Munambam & Azhikode side. For acquiring 0.2405 hectare land at Azhikode side,Govt. Order is obtained vide Government order no. GO(RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018

As per Tentative General Design Drawing, this proposed bridge has 12 spans of 52.60 m & Centre Lookout area, total length is 631.920 m and width is 7.5m two lane carriage way and 1.5m width footpath on either side.

Design of Bridge -This estimate is prepared based on the Tentative General Design Drawing No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012 of PWD design wing DRIQ. Design wing is reported that, this drawing is meant for preparing DPR for Administrative Sanction and on getting AS the same shall be intimated to that office for preparing Detailed Design Drawing and Technical Sanction shall be issued only after the receipt of the Detailed Design Drawing, because slight changes in dimensions of the bridge elements may happen during the preparation of Detailed Design Drawing. Drawing is uploaded in this PRICE site for verification.

Appendix-A Bridge proper : Confirmatory Boring and Bridge Proper To obtaining the correct foundation depth details and soil strata provision for confirmatory boring in each foundation point is proposed. The foundation of the bridge is designed by the Bored cast–in situ M40 grade RCC piles 1200mm dia for an average depth of 75m with casing pipe and HYSD steel bars. Provision for temporary Island, floating pontoon, bailing out water etc are given. M35 grade concrete for pile cap, abutments, abutments cap, dirt wall, piers & pier cap. M50 grade concrete for pedestal. Supplying & fixing POT – PTEF bearings, Strip seal expansion joints, Pre stressed RCC M50 PSC box girders for beam & M 50 concrete for slab, reinforcement for RCC works, RCC railing, Mastic asphalt wearing coat, painting etc. are proposed in this appendix. The total cost of this appendix comes to Rs. 13760.0009234 Lakhs

Appendix-B : Approach Road ,Sideprotection & River Protective works

For forming the approach road gravelly earth filling is proposed for a length of 100m on both sides and 150m service roads on Azhikode and Munambam sides. The land acquisition cost is also included in this estimate. The Granular Sub Base for base and sub base is WMM surface ,Prime coat and Tack coat, Closed premixed 20 mm for tarring work, Thermoplastic Centre line , Metal beam crash barrier ,Reflective Road Studs, Sign & Direction Boards, painting etc are also proposed. Coconut piles are proposed for the foundation trench, dry rouble packing in foundation trench, CC foundation and RCC bed. The foundation & super structure is proposed using filled Gabion wall. Two box culverts and 150m drain are proposed on Azhikode and Munambam sides. The total cost of this appendix comes to Rs. 542.8213411 L

Appendix-C: Embankment Stabilization Technic Works

Providing and installing flexible vertical drains for soil stabilization is proposed in the approach area for the speedy settlement of the soil. The total cost of this appendix comes to Rs. 26.1479790 L

Appendix – D : Jankar Shifting works

The proposed alignment of the bridge is laying the existing path of boat jetty at Munambam area. Hence provisions are given for the temporary construction of shifting the jetty during the time of the bridge work. Total cost of this appendix comes to Rs. 24.6046830L

Appendix – E : Land Acquisition cost

20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. New Requisition for the land acquisition as per new LA Act was submitted to the Thrissur and Ernakulam district Collectors. Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed. Thrissur Special Tahasildar (LA) is requested for the amount of Rs. 6,48,00,000/- for the Land Acquisition at Azhikode side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B-352/17 Dtd.

26.12.2017 and Ernakulam Special Tahasildar (LA) is requested for the amount of Rs. 8,13,60,000/- for the Land Acquisition at Munambam side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B2-625/17 Dtd. 06.12.2017.(details are uploaded in Project details 3). Administrative sanction obtained for acquiring 0.2405 hectare land at Azhikode side as per vide Government order no. GO(RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018. Provision for an amount of Rs. 14.6160 Crores is included for the Land Acquisition only. Estimate for RS. 1.12 Lakhs for peg marking of alignment boundary has been submitted for approval through PRICE ID 2018/1364 separately.

Appendix F- Construction of Toll Booth

LS provision for an amount of Rs. 15.00 Lakhs is included for the construction of Toll Booth

Appendix G – Utility Shifting works

LS provision for an amount of Rs. 80.00 Lakhs is included for the utility shifting charges

Appendix H – Unforseen items

LS provision for an amount of Rs. 88.40 Lakhs is included for the Unforseen items

The estimate is prepared based on MORTH with Delhi SOR 2016 with cost index 37.25%.The total estimate amount comes to Rs.160 Crores (Rupees One hundred and sixty Crores only)

3. CHAPTERS:

3.1. INTRODUCTION

Azhikode-Munambam Bridge is proposed to be constructed across Munambam kayal to connect Azhikode in Kaipamangalam LAC in Thrissur District and Munambam in Vypin LAC in Ernakulam District. Munambam is an important place in Vypinkara Island which is connected to Ernakulam through Gosree bridge. The missing link from Vypin to Kodungallur and NH-17 is now felt an absolute

necessity since Gosree Bridge is opened to traffic and the Vallarpadom Container Terminal was functioning in its commercial operation. This will be ease traffic congestion in NH-17 & NH-47 which is now having high traffic volume. By the construction of proposed bridge, there will be no traffic Congestion in NH- 17 & NH-47. Hence there will be considerable savings in time and distance for the transportation of goods from Vallarpadam.

At present Jankar service is used to cross the Munambam Kayal. The Azhikode-Muziris Jankar service was disrupted many times as it developed problem. A huge amount was required for the Jankar repairing. At those times, locals will face many difficulties to cross the Kayal.

The Proposed Bridge serves as a major connectivity of Munambam in Ernakulam District and Azhikode in Thrissur District. The new link will be blessing for the people of Northern kerala and they can have a easily access to reach Kochin city using this proposed Azhikode-Munambam Bridge through Vypin pallipuram state highway and new coastal road. This proposed new Bridge will give a major boom to the tourist industry and this will be the shortest route connecting the famous beaches such as Cherai and Azhikode and will connect pilgrim centers such as marthoma

Shrine, Chettikkad Church, Cheraman masjid, Kodungallur Devi temple and Pallipuram Fort.

Munambam is a place near Kochi, India at the north end of Vypeen Island, surrounded by the Arabian Sea on the west, Periyar river on the east, and a mouth of the sea on the north . The main occupation of its inhabitants is fishing. Munambam is famous in Ernakulam and Thrissur districts for the presence of major fishing harbour in this region. It is also the mouth of the district major river Periyar which can be seen from the Munambam Muziris beach.

Chettikkad Church

St. Anthony of Padua is one of the Catholic Church's most popular saints. Saint Anthony of Padua, patron saint of lost and stolen articles, was a powerful Franciscan preacher and teacher. He's typically portrayed holding the child Jesus—or a lily—or a book—or all three—in his arms. Many people give alms to St. Anthony Bread in thanksgiving to God for blessings received through the prayers of St. Anthony.

Marthoma Shrine

The Marthoma Pontifical shrine is a major pilgrim centre that comes under the Muziris Heritage Project. The church, also known as Marthoma Pontifical shrine, on the banks of the River Periyar is located about 6 km from Kodungallur, in the village of Azhikode in Kerala. It is believed

that St. Thomas , the apostle landed in Kodungallur on November 21st, 52 A.D. He is believed to have formed seven churches in Kerala, the first one being in Kodungallur itself. The bone of the right arm of St. Thomas was brought from Ortona in Italy and enthroned in the present Pontifical shrine. From then on, the shrine at Azhikode has been a great pilgrimage centre attracting thousands from all around the world, irrespective of caste and creed.

Kodungalloor Bhagavathy Temple

The Bhagavathy Temple at Kodungallur is of great renown throughout Kerala. The Bharani festival at the KodungallurBhagavathy Temple is one of the grandest in Kerala. It is a month of festivities from the Bharani asterism in the month of Aquarius to seven days after the Bharani asterism in the month of Pisces. During this occasion, one can also witness the largest congregation of oracles, not seen anywhere in Kerala.

CheramanJuma Masjid

This mosque in Kodungalloor resembles a Hindu temple in appearance. It was earlier made of wood. Built in 629 A.D., this is the first mosque in India where Juma prayers were started. Recent changes have been made and it now has concrete minarets. The interiors remain wooden with a Kerala oil lamp right in the centre. This lamp is of great

significance to people of all religions. Some of them bring oil for the lamp on the auspicious occasion of major family events.

Pallipuram Fort

Pallippuram Fort known as Ayakkotta or Alikkotta (kotta in Malayalam means fort) was constructed by the Portuguese in 1503. The fort is is hexagonal in shape. The relics of this fort now stand as a bastion of three storeys in height. Inside the fort, the floor is raised to 5 feet from the ground. Underneath this platform, a small cellar opens on to a passage, which runs obliquely from north to south. The cellar is 4 feet high and 7 feet square. The fort is located about 8 km on the North Paravur- Munambam route.

3.1.1. Project Definition and Concept

People have always been interested in transporting themselves and their goods from one place to another. So the rivers, mountains and valley are considered as a basic problem facing the people in their transportation and movement from one place to another. The history of development of bridge construction is closely linked with the history of human civilization.

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it. Bridges and other related major structures play an important role in defining

the manner in which a highway affects the aesthetic, scenic, historic, and cultural resources of the corridor within which it is located. We have different types of bridges in Kerala.

In Kerala the road network is very much strengthened using a number of bridges which can be classified on the basis of shape, construction materials, span etc. Generally a bridge is a cross passage which is having a span more than 6.00m.

3.1.1 Scope of this project

This estimate is prepared based on the Tentative General Design Drawing No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012 of PWD design wing DRIQ. As per Tentative General Design Drawing, this proposed bridge has 12 spans of 52.60 m & Centre Lookout area, total length is 631.920 m and width is 7.5m two lane carriage way and 1.5m width footpath on either side.

Confirmatory Boring and Bridge Proper To obtaining the correct foundation depth details and soil strata provision for confirmatory boring in each foundation point is proposed. The foundation of the bridge is designed by the Bored cast–in situ M40 grade RCC piles 1200mm dia for an average depth of 75m with casing pipe and HYSD steel bars. Provision for temporary Island, floating pontoon, bailing out water etc are given. M35 grade concrete for pile cap, abutments, abutments cap, dirt wall, piers & pier cap. M50 grade concrete for pedestal. Supplying & fixing POT – PTEF bearings, Strip seal expansion joints, Pre stressed RCC M50 PSC box girders for beam & M 50 concrete for slab, reinforcement for RCC works, RCC railing, Mastic asphalt wearing coat, painting etc. are proposed.

For forming the approach road gravelly earth filling is proposed for a length of 100m on both sides and 150m service roads on Azhikode and Munambam sides. The land acquisition cost is also included in this estimate. The Granular Sub Base for base and sub base is WMM surface ,Prime coat and Tack coat, Closed premixed 20 mm for tarring work, Thermoplastic Centre line , Metal beam crash barrier ,Reflective Road Studs, Sign & Direction Boards, painting etc are also proposed. Coconut piles are proposed for the foundation trench, dry rouble packing in foundation trench, CC foundation and RCC bed. The foundation & super structure is proposed using filled Gabion wall. Two box culverts and 150m drain are proposed on Azhikode and Munambam sides.

Embankment Stabilization Technic Works: Providing and installing flexible vertical drains for soil stabilization is proposed in the approach area for the speedy settlement of the soil.

Jankar Shifting works: The proposed alignment of the bridge is laying the existing path of boat jetty at Munambam area. Hence provisions are given for the temporary construction of shifting the jetty during the time of the bridge work.

Land Acquisition: 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. New Requisition for the land acquisition as per new LA Act was submitted to the Thrissur and Ernakulam district Collectors. Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed. Thrissur Special Tahasildar (LA) is requested for the amount of Rs. 6,48,00,000/- for the Land Acquisition at Azhikode side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B-352/17 Dtd. 26.12.2017 and Ernakulam Special Tahasildar (LA) is requested for the amount of Rs. 8,13,60,000/- for the Land Acquisition at Munambam side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B2-625/17 Dtd. 06.12.2017. (details are uploaded in Project details 3). Administrative sanction obtained for acquiring 0.2405 hectare land at Azhikode side as per vide Government order no. GO (RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018. Provision for an amount of Rs. 14.6160 Crores is included for the Land Acquisition only. As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors. District Collectors of both sides are arranged team for Social Impact Study for each side and SIA team visited the site & started the work. Estimate for RS. 1.12 Lakhs for peg marking of alignment boundary has been submitted for approval through PRICE ID 2018/1364 separately.

LS provision for construction of Toll Booth, utility shifting charges are also provided.

3.1.2. Project background

Munambam is an important place in Vypinkara Island which is connected to Ernakulam through Gosree bridge. The missing link from Vypin to Kodungallur and NH-17 is now felt an absolute necessity since Gosree Bridge is opened to traffic and the Vallarpadom Container Terminal was functioning in its commercial operation. This will be ease traffic congestion in NH-17 & NH-47 which is now having high traffic volume. By the construction of proposed bridge, there will be no traffic Congestion in NH- 17 & NH-47. Hence there will be considerable savings in time and distance for the transportation of goods from Vallarpadam.

At present Jankar service is used to cross the Munambam Kayal. The Azhikode-Muziris Jankar service was disrupted many times as it developed problem. A huge amount was required for the Jankar repairing. At those times, locals will face many difficulties to cross the Kayal. Hence Azhikode-Munambam Bridge is proposed to be constructed across Munambam kayal to connect Azhikode in Kaipamangalam LAC in Thrissur District and Munambam in Vypin LAC in Ernakulam District.

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3.1.3. Project Details

This estimate is prepared based on the Tentative General Design Drawing No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012 of PWD design wing DRIQ. As per Tentative General Design Drawing, this proposed bridge has 12 spans of 52.60 m & Centre Lookout area, total length is 631.920 m and width is 7.5m two lane carriage way and 1.5m width footpath on either side.For reducing the embankment height ,land span of 3 nos. in Munambam side and 2 nos. in Azhikode side is included in this estimate.

Confirmatory Boring and Bridge Proper: To obtaining the correct foundation depth details and soil strata provision for confirmatory boring in each foundation point is proposed. The foundation of the bridge is designed by the Bored cast–in situ M40 grade RCC piles 1200mm dia for an average depth of 75m with casing pipe and HYSD steel bars. Provision for temporary Island, floating pontoon, bailing out water etc are given. M35 grade concrete for pile cap, abutments, abutments cap, dirt wall, piers & pier cap. M50 grade concrete for pedestal. Supplying & fixing POT – PTEF bearings, Strip seal expansion joints, Pre stressed

RCC M50 PSC box girders for beam & M 50 concrete for slab, reinforcement for RCC works, RCC railing, Mastic asphalt wearing coat, painting etc. are proposed.

Approach Road, Side protection & River Protective works: For forming the approach road gravelly earth filling is proposed for a length of 100m on both sides and 150m service roads on Azhikode and Munambam sides. The land acquisition cost is also included in this estimate. The Granular Sub Base for base and sub base is WMM surface ,Prime coat and Tack coat, Closed premixed 20 mm for tarring work, Thermoplastic Centre line , Metal beam crash barrier ,Reflective Road Studs, Sign & Direction Boards, painting etc are also proposed. Coconut piles are proposed for the foundation trench, dry rouble packing in foundation trench, CC foundation and RCC bed. The foundation & super structure is proposed using filled Gabion wall. Two box culverts and 150m drain are proposed on Azhikode and Munambam sides.

Providing and installing flexible vertical drains for soil stabilization is proposed in the approach area for the speedy settlement of the soil.

The proposed alignment of the bridge is laying the existing path of boat jetty at Munambam area. Hence provisions are given for the temporary construction of shifting the jetty during the time of the bridge work.

Land acquisition: 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. New Requisition for the land acquisition as per new LA Act was submitted to the Thrissur and Ernakulam district Collectors. As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors. They arranged a team for Social Impact Study for each side. Thrissur Special Tahasildar (LA) is requested for the amount of Rs. 6,48,00,000/- for the Land Acquisition at Azhikode side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B-352/17 Dtd. 26.12.2017 and Ernakulam Special Tahasildar (LA) is requested for the amount of Rs. 8,13,60,000/- for the Land Acquisition at Munambam side including the cost of Land, Charges for rehabilitation,

establishment, social impact study, contingency etc. as per Lr. No. B2-625/17 Dtd. 06.12.2017. (details are uploaded in Project details 3). Administrative sanction obtained for acquiring 0.2405 hectare land at Azhikode side as per vide Government order no. GO (RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018. Provision for an amount of Rs. 14.6160 Crores is included for the Land Acquisition only. As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors. District Collectors of both sides are arranged team for Social Impact Study for each side and SIA team visited the site & started the work. Estimate for RS. 1.12 L for peg marking of alignment boundary has been submitted for approval through PRICE ID 2018/1364 separately.

LS provision for construction of Toll Booth, utility shifting charges are also provided.

3.1.4. Objective and scope of the work

Munambam is an important place in Vypinkara Island which is connected to Ernakulam through Gosree bridge. The missing link from Vypin to Kodungallur and NH-17 is now felt an absolute necessity since Gosree Bridge is opened to traffic and the Vallarpadom Container Terminal was functioning in its commercial operation. This will be ease traffic congestion in NH-17 & NH-47 which is now having high traffic volume. By the construction of proposed bridge, there will be no traffic Congestion in NH- 17 & NH-47. Hence there will be considerable savings in time and distance for the transportation of goods from Vallarpadam.

At present Jankar service is used to cross the Munambam Kayal. The Azhikode-Muziris Jankar service was disrupted many times as it developed problem. A huge amount was required for the Jankar repairing. At those times, locals will face many difficulties to cross the Kayal. Hence Azhikode-Munambam Bridge is proposed to be constructed across Munambam kayal to connect Azhikode in Kaipamangalam LAC in Thrissur District and Munambam in Vypin LAC in Ernakulam District.

3.2. STATUS FEASIBILITY STUDIES

As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors.

They arranged a team for Social Impact Study for each side. At present Jankar service is used to cross the Munambam Kayal. The Azhikode-Muziris Jankar service was disrupted many times as it developed problem. A huge amount was required for the Jankar repairing. At those times, locals will face many difficulties to cross the Kayal. Hence Azhikode-Munambam Bridge is proposed to be constructed across Munambam kayal to connect Azhikode in Kaipamangalam LAC in Thrissur District and Munambam in Vypin LAC in Ernakulam District.

3.3. REQUIREMENT/ DEMAND ANALYSIS

Munambam is an important place in Vypinkara Island which is connected to Ernakulam through Gosree bridge. The missing link from Vypin to Kodungallur and NH-17 is now felt an absolute necessity since Gosree Bridge is opened to traffic and the Vallarpadom Container Terminal was functioning in its commercial operation. This will be ease traffic congestion in NH-17 & NH-47 which is now having high traffic volume. By the construction of proposed bridge, there will be no traffic Congestion in NH- 17 & NH-47. Hence there will be considerable savings in time and distance for the transportation of goods from Vallarpadam.

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3.4. ENGINEERING SURVEYS AND INVESTIGATIONS

1. **Topographic Survey/levelling survey & Soil and Materials Survey**

The investigation work has been done by a Government approved consultant 'M/S Esteem Developers Ltd, Cochin – 18'. The work was awarded to them by tender. The soil investigation and laboratory study were carried out on 07.02.2000. This report summarizes the investigation and furnishes recommendations for the foundation. Report attached separately.

2. **Traffic Survey**

At present Jankar service is used to cross the Munambam Kayal. The Azhikode-Muziris Jankar service was disrupted many times as it developed problem. A huge amount was required for the Jankar repairing. At those times, locals will face many difficulties to cross the Kayal. The two side approaches are ends at the banks of the river. If proposed bridge is to be constructed, Anticipatory Traffic Study Report is attached below.

Anticipatory Traffic Study Report

Location Azhikode

TIME	Car,Jeep, Van	Buses, Lorry	TRUCKS	MINI TRUCKS	AUTO	Bike, Scooters	CYCLES
7am-8am	31	20	10	9	198	311	10
8am-9am	48	18	6	8	185	318	9
9am-10am	125	18	10	10	181	349	6
10am-11am	94	18	8	10	189	329	8
11am-12pm	98	21	15	18	274	411	5
12pm-1pm	188	11	6	15	258	370	8
1pm-2pm	111	10	8	5	168	318	4
2pm-3pm	119	16	14	9	223	336	5
3pm-4pm	155	18	15	11	203	269	4
4pm-5pm	163	14	13	10	191	271	3
5pm-6pm	125	15	11	9	186	293	4
6pm-7pm	150	21	14	11	171	285	5
7pm-8pm	156	16	8	9	140	273	3
8pm-9pm	106	14	6	8	111	183	4
9pm-10pm	95	10	5	5	81	195	3
10pm-11pm	60	8	9	8	56	156	0
11pm 12am	48	11	5	6	40	111	0
12 am-1 am	31	6	4	5	31	95	0

1am-2 am	24	4	3	4	36	103	0
2am-3am	26	1	1	3	53	44	0
3am-4am	40	1	3	6	44	58	8
4am-5am	99	4	5	8	73	99	3
5am-6am	31	5	6	9	98	165	4
6am-7am	63	16	9	15	183	236	3
TOTAL	**2184**	**295**	**191**	**208**	**3370**	**5575**	**94**

3.5. FUNCTIONAL DESIGN

The project involves construction of a new bridge across Munambam Kayal. Investigation and scientific study for the project has been done by a Government approved consultant 'M/S Esteem Developers Ltd, Cochin – 18'. The soil investigation and laboratory study were carried out on 07.02.2000. Investigation report & alignment has been submitted for getting approval and Design by them. This DPR is prepared based on the investigation reports & Tentative General Design Drawing No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012 of PWD design wing DRIQ. As per Tentative General Design Drawing, this proposed bridge has 12 spans of 52.60 m & Centre Lookout area, total length is 631.920 m and width is 7.5m two lane carriage way and 1.5m width footpath on either side. For reducing the embankment height ,land span of 3 nos. in Munambam side and 2 nos. in Azhikode side is included in this estimate.The structural designs and provisions given in the detailed estimate are in accordance with the field data compiled from that investigation study. The detailed investigation report, Tentative Design Drawing, alignment plan were included in the DPR and attached separately.

3.6. ENGINEERING DESIGN

This estimate is prepared based on the Tentative General Design Drawing No. CEDO/ BD/ 36/ 12 Dtd. 12.9.2012 of PWD design wing DRIQ. As per Tentative General Design Drawing, this proposed bridge has 12 spans of 52.60 m & Centre Lookout area, total length is 631.920 m and width is 7.5m two lane carriage way and

1.5m width footpath on either side. For reducing the embankment height ,land span of 3 nos. in Munambam side and 2 nos. in Azhikode side is included in this estimate.

Confirmatory Boring and Bridge Proper: To obtaining the correct foundation depth details and soil strata provision for confirmatory boring in each foundation point is proposed. The foundation of the bridge is designed by the Bored cast–in situ M40 grade RCC piles 1200mm dia for an average depth of 75m with casing pipe and HYSD steel bars. Provision for temporary Island, floating pontoon, bailing out water etc are given. M35 grade concrete for pile cap, abutments, abutments cap, dirt wall, piers & pier cap. M50 grade concrete for pedestal. Supplying & fixing POT – PTEF bearings, Strip seal expansion joints, Pre stressed RCC M50 PSC box girders for beam & M 50 concrete for slab, reinforcement for RCC works, RCC railing, Mastic asphalt wearing coat, painting etc. are proposed.

Approach Road, Side protection & River Protective works: For forming the approach road gravelly earth filling is proposed for a length of 100m on both sides and 150m service roads on Azhikode and Munambam sides. The land acquisition cost is also included in this estimate. The Granular Sub Base for base and sub base is WMM surface ,Prime coat and Tack coat, Closed premixed 20 mm for tarring work, Thermoplastic Centre line , Metal beam crash barrier ,Reflective Road Studs, Sign & Direction Boards, painting etc are also proposed. Coconut piles are proposed for the foundation trench, dry rouble packing in foundation trench, CC foundation and RCC bed. The foundation & super structure is proposed using filled Gabion wall. Two box culverts and 150m drain are proposed on Azhikode and Munambam sides.

Providing and installing flexible vertical drains for soil stabilization is proposed in the approach area for the speedy settlement of the soil.

The proposed alignment of the bridge is laying the existing path of boat jetty at Munambam area. Hence provisions are given for the temporary construction of shifting the jetty during the time of the bridge work.

Land acquisition: 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are

required for the construction of the approach road. New Requisition for the land acquisition as per new LA Act was submitted to the Thrissur and Ernakulam district Collectors. As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors. They arranged a team for Social Impact Study for each side. Thrissur Special Tahasildar (LA) is requested for the amount of Rs. 6,48,00,000/- for the Land Acquisition at Azhikode side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B-352/17 Dtd. 26.12.2017 and Ernakulam Special Tahasildar (LA) is requested for the amount of Rs. 8,13,60,000/- for the Land Acquisition at Munambam side including the cost of Land, Charges for rehabilitation, establishment, social impact study, contingency etc. as per Lr. No. B2-625/17 Dtd. 06.12.2017. (details are uploaded in Project details 3). Administrative sanction obtained for acquiring 0.2405 hectare land at Azhikode side as per vide Government order no. GO (RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018. Provision for an amount of Rs. 14.62,72,000 Lakhs is included for the Land Acquisition only. As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors. District Collectors of both sides are arranged team for Social Impact Study for each side and SIA team visited the site & started the work.Estimate for RS. 1.12 L for peg marking of alignment boundary has been submitted for approval through PRICE ID 2018/1364. Hence this estimate provision for an amount of Rs. 14.6160 Crores is included for the Land Acquisition only.

LS provision for construction of Toll Booth, utility shifting charges are also provided.

Total estimate amount comes to Rs. 160 Crores. The estimate is prepared based on the MORTH with DSR 2016 with cost index 37.25%. The provisions provided are least and adequate for the satisfactory completion of the work. Sufficient traffic safety measures have proposed to make the road accidents free and to ensure safer vehicular traffic. The detailed estimate is included with the following appendices for the easiness and reliability in implementation of work:

SL. NO.	HEADING DESCRIPTION
Appendix A	CONFIRMATORY BORING & BRIDGE PROPER
Appendix B	APPROACH ROAD,SIDE PROTECTION & RIVER PROTECTION
Appendix C	EMBANKMENT STABILIZATION
Appendix D	JENKAR SHIFTING
Appendix E	LAND ACQUISITION
Appendix F	CONSTRUCTION OF TOLL BOOTH
Appendix G	UTILITY SHIFTING charges of KSEB,KWA and BSNL authorities

The detailed investigation report, cross sectional drawings, alignment plan were included in the DPR and attached separately.

3.7 FINANCIAL ESTIMATES & COST PROJECTIONS

The estimate is prepared based on the MORTH with DSR 2016 with cost index 37.25%. The provisions provided are least and adequate for the satisfactory completion of the work. The total amount comes to Rs. 160.00 Cr. The provisions provided in the estimate are least and minimum for the satisfactory completion of the work.

The work split up is as tabulated below:

SL. NO.	HEADING DESCRIPTION	AMOUNT (Rs)
Appendix A	Confirmatory boring & bridge proper	1376000092.34
Appendix B	Approach road, side protection & river protection	54282134.11
Appendix C	Embankment stabilization	2614797.90
Appendix D	Jenkar shifting	2460468.30
Appendix E	Land acquisition	146160000.00
Appendix F	Construction of toll booth	1500000.00

Appendix G	Utility shifting charges of KSEB,KWA and BSNL Authorities	8000000.00
	Unforseen items	8840000.00
	Lumpsum for round off	142507.00
Total		**1,60,00,00,000.00**

3.8. REVENUE STREAMS

Budget speech 2017-18 Vol I part II para - 157 page No.69 serial No. 22 for KIIFB. Principle Administrative Sanction has obtained from KIIFB vide GO (Rt) No. 942/2017/PWD Tvm dt.10/07/2017. Individual A.S to be sanctioned as per this DPR. As soon as the Administrative Sanction is received from KIIFB land acquisition process can be initiated. Administrative sanction obtained for acquiring 0.2405 hectare land at Azhikode side as per vide Government order no. GO(RT) No. 358/2018/PWD,TVM Dtd. 28.02.2018. Administrative sanction for acquiring 0.2099 hectare land at Munambam side is required. Land acquisition of Azhikode & Munambam sides is required by the Revenue Department. LA cost including Land value (market value is provided as per local enquiry), Rehabilitation, SIA study, periodical increment in land value, Establishment charge, Contingency charge, multiplication factor and valuation survey. Shifting of existing Jenkar Service, Utility shifting charges of KSEB, KWA and BSNL authorities are also required.

3.9. COST BENEFIT ANALYSIS& INVESTMENT CRITERIA

Cost Benefit Analysis to this project is attached separately as Annexure - 6

3.10. ENVIRONMENTAL & SUSTAINABILITY ASPECTS

Environmental impact study is needed as per MoEF. Environmental impact study will do by the Revenue Department with the Land Acquisition. As per new LA Act, Special Tahasildars (LA) are deputed and joined site inspections in both sides are completed by the instructions of Thrissur and Ernakulam district Collectors. District Collectors of both sides are arranged team for Social Impact Study for each side and SIA team visited the site & started the work. Necessary environmental aspects were considered by the Design wing of public works department during the

design of the bridge. An optimum design with minimum environmental impact was made for the bridge by the DRIQ Board.

3.11. RISK ASSESSMENT AND MITIGATION MEASURES

For shifting existing Jenkar service, electrical and water supply utilities, Construction of Toll Booth etc are included in the estimate. 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. Clearance from Inland Waterways Authority of India, Port, CRZ and National Highway Departments is required. Existing Jenkar service, Electrical posts and water pipes are to be shifted for the approach road construction. This can be tackled as soon as the Administrative sanction is issued by KIIFB, in co-ordination with the respective Departments, viz the KSEB, KWA and the Revenue Department. The relevant intimation has to be sending to the local bodies regarding the commencement of works. The procedures can be initiated on getting the Administrative sanction from the KIIFB. As soon as the Administrative Sanction is received from KIIFB land acquisition process can be initiated.

3.12. PROJECT MANAGEMENT ORGANISATION

The project will be tendered and supervised by the PWD and work will be carried out as per the prevailing conditions and norms and as per the Kerala PWD Manual. The various offices involved during the execution of the project were: Office of the Chief Engineer (R&B) Thiruvananthapuram, Superintending Engineer (R & B)- CC Aluva, Executive Engineer (R & B)- Thrissur, Assistant Executive Engineer (Bridges)- Thrissur, Assistant Engineer (Bridges)- Chalakudy & the QC wing - Thrissur.

3.13. CONTRACT MANAGEMENT STRATEGY

The work will be e-tendered and schedule will be quoted in item rate. The lowest successful bidder will be invited and agreement will be executed. The contract will be prepared based on the Kerala PWD manual, general conditions of contract and other relevant documents incorporated in the standard bid documents while tendering.

3.14. IMPLEMENTATION SCHEDULE & WBS

Bar Chart showing schedule of works spanning for a duration of 18 months attached along separately as Annexure – 7.

3.15. STATUTORY CLEARANCES

For shifting existing Jenkar service, electrical and water supply utilities, Construction of Toll Booth etc are included in the estimate. 20.99 Are land in the Kuzhuppilly Village in Munambam Side and 24.05 Are land in Azhikode Village in Azhikode side are required for the construction of the approach road. Clearance from Inland Waterways Authority of India, Port, CRZ and National Highway Departments is required. Existing Jenkar service, Electrical posts and water pipes are to be shifted for the approach road construction. This can be tackled as soon as the Administrative sanction is issued by KIIFB, in co-ordination with the respective Departments, viz the KSEB, KWA and the Revenue Department. The relevant intimation has to be sending to the local bodies regarding the commencement of works.

3.16. QUALITY MANAGEMENT PLAN

During execution of work 3 tier quality checking is mandatory. The 1st tier by the Contractor. The contractor has to set up a quality lab at site. The 2nd tier quality monitoring will be done by the PWD QC wing and 3rd tier quality assurance by a committee constituted by PWD.

3.17. OPERATIONS & MAINTENANCE PLAN

After obtaining Administrative sanction and Technical sanction from the competent authorities, the project will be e-tendered. The work will be awarded to the lowest successful tenderer and agreement will be executed by the competent authority. The prevailing general conditions of contract will follow. Also the contractor is responsible for rectification of defect during the defect liability period of the work.

CONCLUSION

The bridge when completed will give a substantial boosting up in the Tourism, agriculture and small scale industrial sector in the area and will contribute a lot in the economic growth of the surrounding villages and generate employment opportunities to the local people.

ANNEXURES

1. Estimate Report
2. General Abstract
3. Detailed Estimate
4. Observed Data
5. Approved Alignment Drawing
6. Tentative General Design
7. Soil Investigation Report
8. Road Cross section
9. Cost Benefit Analysis
10. Bar Chart
11. Key Map
12. LA letters & Govt. Orders
13. Other Attachments

DETAILED APPRAISAL REPORT

RE-CONSTRUCTION OF ELATHUR KORAPUZHA BRIDGE ON NH 66 (OLD NH 17) IN KOZHIKODE DISTRICT

Rep No. AR-2017-TRANx-PWD008-05

1. SALIENT FEATURES

1.1 Project details in brief

- Name of Project: Elathur Korapuzha Bridge on NH 66
- District: Kozhikode
- Project outlay: Rs. 28 crores
- Report Prepared by: KRFB for PWD Kerala (NH Division)
- Data reviewed: Detailed Project Report for Re-Construction of Elathur Korapuzha Bridge on NH 66 in Kozhikode District

1.2 The proposed river bridge is on NH66 (Old NH 17) at Korrapuzha in Kozhikode district. The GoK has accorded administrative sanction vide GO (Rt) No.1660/2016/PWD dt.30.12.2016. KRFB has been appointed as the SPV for the implementation of the project. Kerala PWD NH division has submitted a detailed project report for the proposed bridge which contains a project description, General Arrangement Drawing (GAD), project cost estimation and a cost benefit analysis

1.3 The proposal is to re-construct an existing bridge along the alignment of NH66.

1.4 The new proposal has a width of 12m with 7.5m carriage way and 1.5m footpath on both sides.

1.5 The total length of the bridge is 224m with 7 spans of 32m each.

1.6 The total cost of construction as given in the DPR is 28 crores based on DSR 2016 and a cost index of 37.25%.

1.7 It is reported that the horizontal alignment of the bridge remains unchanged and land acquisition is eliminated.

2. REQUIREMENT / DEMAND ANALYSIS

2.1 Report notes that the existing Korappuzha bridge was constructed during 1940 for Class B loading with 5.5m carriage way without footpath. The width is just sufficient for 2 LMVs to just cross each other leading to frequent accidents and congestions over the bridge.

2.2 The present PCU at the location is reported to be 39491.

2.3 As per the report, existing bridge is in a dilapidated condition structurally with cracks, exposed reinforcement in bottom portion covered with shotcreting, failed bearings supported by concrete fill.

2.4 It is reported that LA is not feasible owing to thickly populated right side and presence of railway line in left side.

3. FUNCTIONAL DESIGN

3.1 The DPR confirms that changing the horizontal alignment is not considered as the bridge falls on NH alignment with approach on both sides.

3.2 It is reported that the geo-technical investigation and sub-surface exploration were conducted in 2015 with 9 boreholes drilled and hard strata located at maximum depth of 26.15m below GL.

3.3 As per the report, the total traffic volume observed at Korappuzha bridge is 39491 PCU.

3.4 The report notes that existing bridge is at the centre of the ROW and hence scope for maintaining the existing structure or constructing a new one parallel to it is ruled out.

4. ENGINEERING DESIGN

4.1 The total length of the bridge is 224m as per the GAD. Proposal includes spans of 7x32m.

4.2 The proposed approach as per the report is with a slope of 1in 30 on both Kannur and Kozhikode side with a length of 150m, tracing the existing alignment throughout.

4.3 The GAD attached shows details of span arrangement, pile arrangement, pier, reinforcement and liner requirements, etc.

4.4 The alignment plan of the proposed bridge is enclosed with the report.

4.5 The proposal consists of bowstring superstructure supported on piers and founded on piles socketed in hard rock.

4.6 Typical cross section of the road is given in the report with thickness of various layers designed based on the traffic survey conclusions.

5. O&M PLAN

5.1 The DPR explains O&M as per which, the maintenance is planned to be carried out based on provisions of IRC SP 35, IRC SP 18, IRC 52, etc.

6. FINANCIAL ESTIMATES & COST PROJECTIONS

6.1 The estimate details attached in the report is based on PRICE, 2016 DSR rates and a cost index of 37.25% and the total cost is reported to be around Rs. 28 crores.

6.2 The cost of dismantling existing bridge is reported as around Rs.3.67 crores.

6.3 Total cost of construction for bridge proper works out to be Rs. 7.83 lakh/m span approximately.

6.4 The cost corresponding to operation and maintenance expenses are excluded from the estimate.

6.5 The cost required for shifting utilities as arrived in consultation with KSEB is reported as Rs. 9.84 lakhs.

7. COST BENEFIT ANALYSIS

7.1 The As per the DPR, the cost -benefit analysis is conducted based on factors as reduction in air pollution, reduction in noise pollution, savings in passenger travel time, etc.

7.2 The CBR of the project is reported as 1.384 and ERR as 40.27%.

8. VALUE ENGINEERING OPTIONS

8.1 The design proposed in the DPR is generally observed to be acceptable.

9. IMPLEMENTATION SCHEDULE & WBS

9.1 The report mentioned about the completion time as 21 months starting from Jan 18.

9.2 Bar/PERT/CPM chart for project execution and cash flow is furnished in the report.

10. PROJECT MANAGEMENT ORGANIZATION PLAN

10.1 T□□ DPR r□por□□ □a□□□□ pro□□□□□ □□□□ □□ p□□□ □n□d □□ro□□□ □R□□ □or □□ra□a P□ D and □ □□□□□ □□□□□□□d □□ro□□□ N□ □□n□o□P□ D□

11. CONTRACT MANAGEMENT PLAN

11.1 The methodology and system of contract is documented in the DPR.

11.2 The DPR points out that the work will be arranged through work contract system and bidding shall be done in line with standard item rate bid document as followed in the Ministry of Road Transport and Highways. The work shall be executed as per the standards specified by MoRTH and in accordance with the procedures stipulated in the Kerala PWD Manual.

12. STATUTORY CLEARANCES

12.1 The DPR is has identified and tabulated the various statutory clearances required.

13. ENVIRONMENTAL ASPECT & SUSTAINABILITY

13.1 The report states that, the proposed bridge will not come under hilly terrain or ecologically sensitive areas and hence the project will not attract EIA notification 2016.

14. QUALITY MANAGEMENT PLAN

14.1 The report states that as per the clause 2401 and 2406 of revised PWD manual -2012, a three-tier quality control system is recommended and the same shall be followed.

15. RISK ASSESSMENT AND MITIGATION MEASURES

15.1 The project has identified potential risks including traffic diversion during dismantling and construction and its assessment carried out. Plans to mitigation the anticipated risk are described in the report.

16. REMARKS AND INFERENCES

16.1 The project has satisfied all the basic requirements for consideration for financial assistance from KIIFB

16.2 The parameters studied with regard to the demand are in favour of the proposed project.

16.3 The functional design is matching with the requirement and demand along with the standards.

16.4 The preliminary design and details proposed are satisfactory.

16.5 The O& M plan proposed is satisfactory.

16.6 The estimate prepared and submitted is meeting all basic requirements.

16.7 The investment criteria like CBR meet the target standards.

16.8 The proposed preliminary engineering design seems satisfactory and optimized.

16.9 The implementation schedule is provided in the report and period of completion is realistic.

16.10 The project management organization plan is furnished in the DPR.

16.11 The contract management plan is furnished in the DPR.

16.12 The statutory clearances required for the project are addressed in the report and is satisfactory.

16.13 Environmental clearances are not applicable for the project, as per the report.

16.14 Quality management plan detailed in the DPR based on PWD QC Manual seems satisfactory.

16.15 The report identifies potential risks and its mitigation measures.

17. RECOMMENDATIONS AND SUGGESTIONS

17.1 The project may be considered for funding by KIIFB subject to the execution of tripartite agreement.

17.2 Upon recasting of the estimate, in section 6.4 above the amount to be considered for sanction works out to be **Rs.28 Crores** (based on cost index 54.9%).

17.3 The detailed estimate submitted shall be reviewed by the TS authority considering the applicability and correctness of items in 6.4 above, the relevance of Cost Index and adherence of latest PRICE schedule.

17.4 The Technical sanction by competent authority is mandatory before schedules are added to the Tripartite agreement.

17.5 The cost provisions for work alone shall be utilized for execution of work. The savings or anticipated savings from LA, QC, shifting utilities etc. shall not be re appropriated for meeting expenditure of work proper.

17.6 While entrusting the maintenance activities to the contractor, it shall be ensured that the obligation under defect liability shall be performed without any additional cost. Hence no maintenance expenditure is considered under the original work.

17.7 The identified revenue streams if any shall be communicated while signing the tripartite agreement.

Detailed Project Report

Construction of Coastal Highway in Malappuram District: Reach-III between Tanur Mohiuddin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC

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SALIENT FEATURES OF THE PROJECT

1.	Title of the project	KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach-III between Tanur Mohyudhin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.
2.	Department	Public Works Department
3.	Details of project location	
	i. District	Malappuram
	ii. Taluk	Tirur
	iii. Corporation/Municipality/Panchayath	Tanur
	iv. Assembly Constituency	Tanur
4.	Implementing agency/SPV	KRFB
5.	DPR prepared by	PWD, NH Section, Kuttippuram Under Kuttippuram Sub division.
6.	Project outlay	Appendixes, 1) Appendix A: Improvements to the Carriageway, 2) Appendix B: Drainage Works, 3) Appendix C: Road Safety Measures including retaining walls. 4) Appendix D: Landscaping & Compensation for Afforestation 5) Shifting of Utilities Electric Posts ,Transformers, Pipe lines etc
7.	Budget provision	2600 Lakhs
8.	Budget speech reference	Budget Speech 2017-18, Page No:62,Sl No:152
9.	Administrative sanction	Order No:- GO(Rt)No-942/2017/PWD Dated - 10-07-2017 Sl No : 2
10.	Nature of the project (New formation/ widening/ strengthening/ widening and strengthening/ new formation, widening and strengthening)	Strengthening of the carriageway, Road safety measures, drainage works, Landscaping & Compensation for Afforestation
11.	Present status of roads, if any	Crust and width of road is not adequate to accommodate heavy traffic.

12.	Need for the project	Strengthening and widening of the road to accommodate the high traffic density and also for proper drain out of rain water due to low elevation and high water table.
13.	Details of proposed roads	
	i. Length of road	4 KM from 23/190 to 27/040.
	ii. Carriage way width	7m carriageway, 1.5m Paved shoulder on both sides, 2m Cycle track.
	iii. Thickness of layers	GSB 200 mm WMM 260 mm DBM 50 mm BC 40mm
	iv. Details of cross drainage works	Culverts, Cross drains
	v. Other details	Cycle Track, Side protection walls
14.	Details of investigations/surveys conducted	
	i. Traffic	Traffic Analysis for 7 days. Present Traffic count Traffic Volume study Projected Traffic for 10years (Reports attached)
	ii. Geotechnical	CBR tests Benkelman Beam Deflection Studies (Reports attached)
15.	Whether Land Acquisition involved?	Yes
	If yes, furnish details	Land Acquisition for Bridge Approch of Kettungal Bridge in Pariyapuram Village of Tirur Taluk.
16.	Total estimated cost and item wise cost break up and details of Schedule of Rates	2600 Lakhs
	Whether detailed estimate attached?	Yes
17.	Details of revenue streams	Funding from KIIFB
18.	Details of Cost Benefit Analysis (CBR value)	Details attached with DPR
19.	Details of project risks	Completion of Shifting of utilities and land acquisition in time.
20.	Details of project management organisation strategy	Work will be executed under the supervision of PWD (NH) Engineers

21.	Details of contract management strategy	Through approved contracting agencies by inviting competitive bids
22.	Details of Project Implementation Schedule (PIS) & Work Breakdown Schedule(WBS) Proposed duration to complete the project	Expected that the work can commence during 2019-20 and completed by 2020-21 Proposed duration is 18 months from the date of commencement
23.	Details of statutory clearances	Statutory approval will be obtained from concerned departments before commencement of the work.
24.	Quality control infrastructure and mechanism	Contractor will be responsible for Setting up of QC lab and first tier QC tests. Second and third tier QC tests will be conducted/monitored by quality control wing of PWD.
25.	Operations & Maintenance (O&M) arrangements of the project after completion	36 months DLP period for rectifying damages. No separate claim for the contractor within DLP period.
26.	Details of attached drawings	Road alignment drawings, Cross section of road, drain, culvert and Irish drain
27.	Other attachments	Investigation report, Photos of existing road, Bar chart, Levels drawings

1. INTRODUCTION

Tippu Sulthan Road, which forms an integral part of coastal highway alignment through Malappuram district is an important MDR traversing through the coastal belt of Malappuram district connecting Ponnani and Kozhikode. This DPR is prepared for the improvements of the Tippu Sulthan Road for the high traffic density stretch of the road between Tanur Mohiyudhin Mosque to Ottumppuram Coastal highway standards, for a length of 4 KM and the stretch passes completely through the NATPAC identified alignment of the coastal highway.

The proposed stretch connect Tanur and Parappangadi harbours through Kettungal Bridge which is constructed recently by harbour Engineering department. In order to facilitate traffic through the bridge, construction of approach road including the embankment in Tanur side and formation of new approach road in Parappanagadi side of the bridge is included in the DPR.

After opening of Chamravattom- Regulator cum bridge, the road distance between Ernakulam- Kozhikode has been reduced about 30 kms through Chamravattom-Tirur-Tanur-Kadalundi Route. As the road traverses through a plain terrain without tolls or speed interceptors, commuters choose this route including container trucks, tankers etc. Consequently, the traffic density has increased enormously through this route and traffic jams are common in town and narrow stretches. Even though the proposed stretch is an integral part of Coastal highway, the proposed stretch also facilitate as an alternative route to Calicut by bypassing Tirur, Tanur and Parappangadi towns through newly constructed Kettungal Bridge.

The present crust and width of road is not adequate to accommodate the high intensity of heavy traffic. Hence strengthening the surface and widening the road to the coastal highway standards are essential and proposed in this

project. Due to the low elevation of the road and higher water table of the locality, the rain water flowing through the road surface/stagnated at road side during the rainy season. In order to drain out rain water properly, construction of drains at required chainages are very essential and proposed in the estimate. Raising of road at required locations to maintain proper slope for draining out the rain water is also proposed in this project. A cycle track with a width of 2m is proposed as per the norms of the coastal highways.

This estimate of the project is classified as three Appendixes, 1) Appendix A: Improvements to the Carriageway, 2) Appendix B: Drainage Works, 3) Appendix C: Road Safety Measures including retaining walls. 4) Appendix D: Landscaping & Compensation for Afforestation Total cost for the proposal comes to Rs-1550 Lakhs

2. PROJECT DEFINITION, CONCEPT AND SCOPE

(a) Land availability:- This road have an average 15.00 metre right of way with an existing carriage way of 5.50m from 23/190 to 27/040.There is no hindrance for the implementation of this project. Land acquisition for the approach road is proposed in Tanur side of already constructed Ottumpuram Bridge.

(b) Design: - The existing carriage way surface with BM and BC are damaged due to the heavy vehicular traffic after opening of Chamravattom regulator cum bridge. This road traverses through coastal belt having sandy soil and level terrain and it requires sufficient drainage system. Due to the lack proper improvement and upgradation works to the road and lack of sufficient drainage system, this road damage rapidly during the monsoon.

A detailed investigation was conducted over this road by Sri N Kunhalavi, PWD Contractor, Melmuri P.O, Malappuram through NSS college of Engineering, Palakkad.

BBD test, CBR test**,** Traffic study etc. was conducted for the pavement design.Asper the investigation and traffic studies it is proposed the road improvement works with 200mm Granular sub base (GSB), 260mm Wet Mix Macadam (WMM), 50mm thick Dense Bitumen Macadam (DBM) and 40mm thick Bituminous Concrete (BC).New formation of road with proper longitudinal and cross profile is proposed with 7.00m carriage way with 1.5m paved shoulder on both sides of the road. Cycle track with 2m width is also proposed in this stretch. 200 mm thick GSB and 260mm WMM asper the investigation is proposed for the formation of road.

(c) If this road is improved to the standards with side drains, then the journey through this road will increase the riding comfort. Travel time and operation cost will be reduced which will be beneficial to the public and Government. Even though the proposed stretch is an integral part of Coastal highway, the proposed stretch also facilitate as an alternative route to Calicut from Chamravattom by bypassing Tirur, Tanur and Parappangadi towns through newly constructed Kettungal Bridge.

3. PROJECT BACKGROUND

The Proposed road improvement works are planned by upgrading existing TippuSulthan road from Tanur Mohyudhin Mosque to Ottumppuram from 23/200 to 26/200.Which forms the Reach-3 of proposed coastal highway in Malappuram Dist. Proposed stretch is having an average ROW of 15m.

4. PROJECT DETAILS

The road improvement works are proposed forTanur Mohyudhin Mosque ToOttumppuram section of Padinjarekkara–Unniyal-Tanur-Ariyallur-Kadalundi road which connects Cochin and Calicut through the shortest route through Ponnani.

Proposed coastal highway stretch passes through the coastal belt of Tanur. Tanur is a small town in the Tirur Taluk of Malappuram district of Kerala state, located on the coast, 9 kilometres towards the north of Tirur. There are many libraries attached to mosques giving a rich source of Malabar histories and culture. It is on the Shoranur–Mangalore section of the railway line. Tanur is also a major regional trading centre for fish and has an average elevation of 1 metres from MSL. The small coastal fishing town of Tanur was one of the oldest Muslim settlements in India. Many ancient mosques are situated here. This was once a Portuguese colony. It is believed that St. Francis Xavier visited Tanur in 1546 AD.

Many ancient mosques are situated here. Shri Ram Chandra Mission's Asaram, Famous tourism spots like District Tourism Promotion council's "Thoovaltheeram" Park, Ottumpuram beach, Kettungal Azhimugam beach etc are located on the proposed stretch of the coastal highway.

Ponnani, one of the oldest centres of Islamic culture &education and important fishing Harbour. Thunjath Ezhuthachan Malayalam University, Thunjamn memorial Govt. College etc. are located on the coastal highway at nearby stretches of this Project.

Development of this road will ease the access to the nearby tourist and pilgrim spots like Thirunavaya, the classic medieval centre of Vedic learning; Kottakkal, home of Ayurvedic medicine; Thunchan parambu a memorial for the great Malayalam poet Thunjath Ramanujan, Wagon tragedy hall in memorial of the wagon tragedy during British rule etc.

This project is not a newly alignment road. In this project strengthening the surface and widening of existing roads with drainage systems are proposed. Shifting charges of utilities are included in this project.

5. OBJECTIVE AND SCOPE OF THE WORK

This project is proposed as part of Coastal highway development funded by KIIFB. As the road traverses through coastal belt it devoid hilly terrain and there by steep profiles. If this road is improved to the standards then the journey through this road will be very pleasant and comfortable. The travel time and operation cost will be much less compared to other adjacent highways which pass though hilly terrains and will be much beneficial to the public transport and for freight movement through this flat terrain. Hence this road will benefit the overall development of Tanur LAC. This coastal highway comprise of cycle track which will be a major attraction for tourists and cyclists and this will be a major boom in the tourism map of Tanur. The road will benefit the fishermen and poor publics in the coastal belt. It will also serve as the main connecting road to the Tanur fishing harbour which is already under construction.

The road is proposed with 7m carriage way and 1.5m paved shoulder on both sides of the road. 2m cycle track. Improvement of existing road by providing GSB, WMM, DBM& BC is proposed in this project. Construction of proper drainage systems, Culverts and traffic safety measures are mainly includes in this project.

6. FEASIBILITY STUDIES

A detailed investigation studies are conducted over this road by Sri N Kunhalavi, PWD Contractor, Melmuri P.O, Malappuram through NSS Engineering college Palakkad. Traffic analysis, Present traffic count, projected traffic for 10 years, CBR tests, Benkelman Beam Deflection studies etc. are conducted as part of the investigation studies. Investigation studies and Pavement design Proposes surface improvement with 50mm thick Dense

Bitumen Macadam and 40 mm thick Bituminous Concrete are essential for the surface improvement.

7. REQUIREMENT / DEMAND ANALYSIS

(a) After opening of Chamravattom- Regulator cum bridge, the road distance between Ernakulam- Kozhikode is reduced about 30 kms through proposed coastal route. This road traverses through a plain terrain through coastal areas without sharp curves. Also, the route devoid of tolls and speed interceptors. Due to easement of driving, commuters choose this route including container trucks, tankers etc. Consequently, the traffic density has increased enormously through this route and hence improvements to the road including the sub base is essential to accommodate high intensity of heavy traffic.

(b) The proposed work will be benefited to the fishermen, natives of the locality and farmers and is very essential to the overall development of the Municipality and nearby Panchayaths in particular.

(c) Most of the people living in this area are low income group fishermen. Tanur fishing harbour is under construction and located on this coastal road. Improvement of Tippusulthan road and opening of traffic through already completed Kettungal Bridge is having vital importance to transport the perishable goods from the fish harbour to the remote destinations easily and speedily. This project will become a boost in the fishing sector of Tanur and will benefit the coastal belt and the fishermen in particular.

(d) The road will also benefit the farmers of the locality. Major crops are coconut, Areacanut, Betal leaf, vegetables etc. Now they have to carry these agricultural products to reach the marketing centres such as Malappuram, Kottakkal, Ponnani, Calicut etc. by travelling through damaged road which cause heavy expenditure. If this road is improved

including the sub-base and by DBM & BC road and providing proper drainage, the farmers can easily fetch the marketing centres with less expenditure and reduce travelling time and fuel.

(e) A traffic study was conducted for seven days and PCU comes to 8112/day. Which is separately attached with this DPR. Both side of this stretch highly populated area.

8. FUNCTIONAL DESIGN

(a) This road is one of the important MDR in Malappuram district, starts from Padinjarekara to Kadalundi which leads to Calicut. The existing carriage way surface with BM&BC are damaged due to the heavy vehicular traffic and the non-maintenance of road except the ordinary repairs, hence this project is proposed.

(b) Detailed investigation studies are conducted accordingly the pavement designs are prepared. The detailed estimate prepared for the improvement of the work of this road is as per the current Delhi schedule of rates for 2016 and MoRTH specifications.

(c) This project is improvements to existing road. If this road is improved to the standards and executing side drains, then the journey through this road will be much comfortable and pleasant and the travelling time and operation cost be reduced which will be much beneficial to the public.

(d) The operation of this work will be entrusted to the Kerala Public Works Department (National Highways). Due to the fulfilment of this project the expenditures and benefit of transportation expenditure due to the fuel savings. The government have a huge savings of approximately Rs. 50.00 Lakhs per year from the yearly maintenance of this road.

(e) This road traverses through coastal belt having sandy soil and level terrain and it requires sufficient drainage system. Due to the lack proper

improvement and upgradation works to the road and lack of sufficient drainage system, this road damage rapidly during the monsoon. Construction of proper drainage system,traffic safety measures are includes in this project.

(f) A traffic study was conducted for seven days and PCU comes to 8112/day. The detailed project report prepared for the improvement of the work of this road is as per the current Delhi schedule of rates for 2016 and MoRTH specifications.

(g) A detailed investigation conducted over this road by Sri N Kunhalavi , PWD Contractor , Melmuri P.O , Malappuram with the assistance of NSS college Palakkad. As per the pavement design the road surface improvement with 50mm thick Dense Bitumen Macadam and 40 mm thick Bituminous Concrete are essential for the surface improvement. For improving the foundation/sub base of the road are constructing with 200mm GSB and 260mm WMM are also proposed asper the investigation and test results.

9. ENGINEERING SURVEYS AND INVESTIGATIONS

Detailed investigation and surveying conducted over this road by Sri N Kunhalavi, PWD Contractor, Melmuri P.O, Malappuram. Details are mentioned in investigation report, which are attached with this DPR.

10. ENGINEERING DESIGN

(a) A detailed topographical and geotechnical investigation conducted over this road by Sri N Kunhalavi, PWD Contractor, Melmuri P.O, Malappuram. Details are mentioned in investigation report. Design and cross section of road which is separately attached with this DPR.

(b) <u>Existing ROW Details</u>

i. This road have an average 15.00metre right of way with a 5.50m carriage Way from 23/190 to 27/040.

ii. The height of existing embankment is average 0.50 in many stretches and the present condition is very bad in some stretches. Raising is

proposed in the estimate as per the investigation studies and topographical map.

iii. Location of drainage details clearly mentioned in the detailed estimate. Present condition of existing drainage is not good.

iv. The present condition of existing side drain is bad. As the road traverse through level terrain, it is difficult to connect the Outlet of existing side drain with natural streams and culverts. Hence raising of existing road levels are proposed at required locations in the estimate.

v. There are large number of deferent types of trees and utilities like underground cable and KWA pipe lines along and across within the boundary.

vi. There is no existing bus bay locations in this stretch. Present condition of existing road safety measures are nil or completely damaged.

vii. Approach road for the Kettungal Bridge with sufficient retaining walls are proposed in this project.

viii. Water stagnation on major parts of the road are observed during rainy season. Many cross roads are present in this road. Since the existing road is not a designed one proper camber is not available for drainage of storm water.

(c) A detailed investigation is conducted over this road by Sri N Kunhalavi , PWD Contractor , Melmuri P.O , Malappuram. Pavement design and surface improvements are done based on the investigation results and as per IRC specification and MoRTH specifications.

(d) In this work 36 months DLP period is implemented for rectifying damages. No separate claim for contractor within DLP period.

(e) Drawings of side drain and retaining wall are separately attached with DPR.

11. FINANCIAL ESTIMATES & COST PROJECTIONS

(a) Estimate amount comes to Rs 26.00 Crores, An amount of Rs 6500.00 Crores included in the Budget Speech 2017-18, Page No:62,Sl No:152

(b) The detailed estimate prepared for the improvement of the work of this road is as per the current Delhi schedule of rates for 2017 and MoRTH specifications through PRICE.

(c) Cost of investigation is including in this DPR.

(d) Provision for land acquisition charge for the approach road is included in this DPR.

12. REVENUE STREAMS

(a) Roadway costs include public expenditures to build and maintain roadway facilities, including land, road construction, maintenance, and operations. Cost recovery refers to the portion of roadway costs that are borne by users through special user fees and taxes, such as road tolls, special fuel taxes, and vehicle registration fees.

(b) Government organizations today generate revenue through the sale of goods—through existing retail operations, the sale of government assets and the sale of seized or forfeited assets. This strategy is particularly appropriate for agencies with existing retail operations or a large base of underutilized assets. Agencies that do already sell goods could generate additional non-appropriated revenue by developing innovative products and improving go-to-market strategies.

i. Advertising Agencies can also generate non-appropriated revenue through advertising. With the constraints associated with the traditional advertising model of selling space loosening, organizations can think more broadly about where and how they can sell advertising. An agency with publicly visible assets or an ongoing marketing campaign can find creative ways of providing value for the agency, the public and its private sector partners.

ii. Using four strategies-sale of goods, value-based fees, collection of rents and advertising public sector organizations are testing the waters and discovering the potential for generating no appropriated revenue. By exploring examples of federal agencies that have already taken steps to generate non-appropriated revenue, we can highlight when these strategies can be applied and uncover opportunities for further innovation.

13. COST BENEFIT ANALYSIS & INVESTMENT CRITERIA

Cost benefit analysis details of the projects are attached with this Detailed Project Report.

14. ENVIRONMENTAL AND SUSTAINABILITY ASPECTS

Environmental issues are not anticipated during this project as this Project is for the improvements to existing road. The trees cut for the widening of the carriageway will be compensated by planting trees. Provision for the same has been incorporated in the estimate.

15. RISK ASSESSMENT AND MITIGATION MEASURES

The work will be implemented by the Public Works Department with all responsibilities. During the defect liability period of this works, the contractor is responsible for all the rectification of defects.

16. PROJECT MANAGEMENT ORGANISATION

Monitoring committee organized for asses this project. The project will be arranged by the Kerala Public Works Department (NH) and will be carried out through approved contracting agencies by inviting competitive bids. Work execute under the proper supervision of PWD (NH) Engineers.

17. CONTRACT MANAGEMENT STRATEGY

(a) The project will be arranged by the Kerala Public Works Department (NH) and will be carried out through approved contracting agencies by inviting competitive bids.

(b) The detailed project report for the improvement of the work of this road is as per the current Delhi schedule of rates for 2016 and MoRTH specifications.

(c) No arbitration clauses will existing in public works department inforce.

(d) Additional financial commitments will be met from lump sum amount provided in the DPR.

18. IMPLEMENTATION SCHEDULE & WBS

(a) Time bound work schedule will be prepared for this project before executing agreement, which is an important part of this project, which helps in better handling of project in planning, implementation of all works.

(b) Date of commencement of work will be implemented after executing agreement. Bar chart and project schedule will be prepared before executing agreement.

(c) Proposed work scheduled as per agreement schedule, in each phase work is monitoring by monitoring committee. Work execute under the proper supervision of PWD (NH) Engineers.

(d) It is expected that the work has to be completed within 18 months from the date of commencement and the work can commence during 2019-20 and completed by 2020-21.

(e) Detailed project report should provide a time bound action plan including tendering, appointment of contractors, construction schedule, quality assurance and separate quality wing (PWD) for monitoring the project in each stage. Work execute under the proper supervision of PWD (NH) Engineers. Work will be implemented by the Public Works Department with all responsibilities. . During the defect liability period of this works contractor is responsible for all the rectification of defects.

19. STATUTORY CLEARANCES

(a) Statutory clearance will be obtained from KSEB, KWA and BSNL before the commencement of work. Shifting charges for utility items provided in the Detailed Project Report.

(b) Statutory approval will be obtained from concerned departments before the commencement of work.

20. QUALITY MANAGEMENT PLAN

(a) Quality assurance and separate quality wing (PWD) for monitoring the project in each stage.

(b) Three type of method adopted to ensure quality checking in PWD wing.

   a. First tier quality checking (contractor)
   b. Second tier quality checking
   c. Third tier quality checking.

(c) As per the direction of PWD officials, contractor has to setup first tier quality testing lab at site. All materials quality checked before commencement of work.

(d) As per clause 2406 of the revised PWD Manual 2012, Technical audit shall be done by an external agency/expert empanelled for the purpose after the construction of a project is completed. This will form the third tier of QC system. Technical audit shall be done for projects, estimated cost of which is above Rs 5 crores. All tests carried out in the first-tier and second-tier QC testing shall be reviewed during technical audit.

(e) Technical Audit shall be completed within six months from the date of completion of construction. Non-destructive testing techniques shall be adopted if conventional testing techniques cannot be applied.

21. OPERATIONS & MAINTENANCE PLAN

(a) In this project operation and maintenance will be implemented by the Public Works Department (National Highway Division) with all responsibilities.

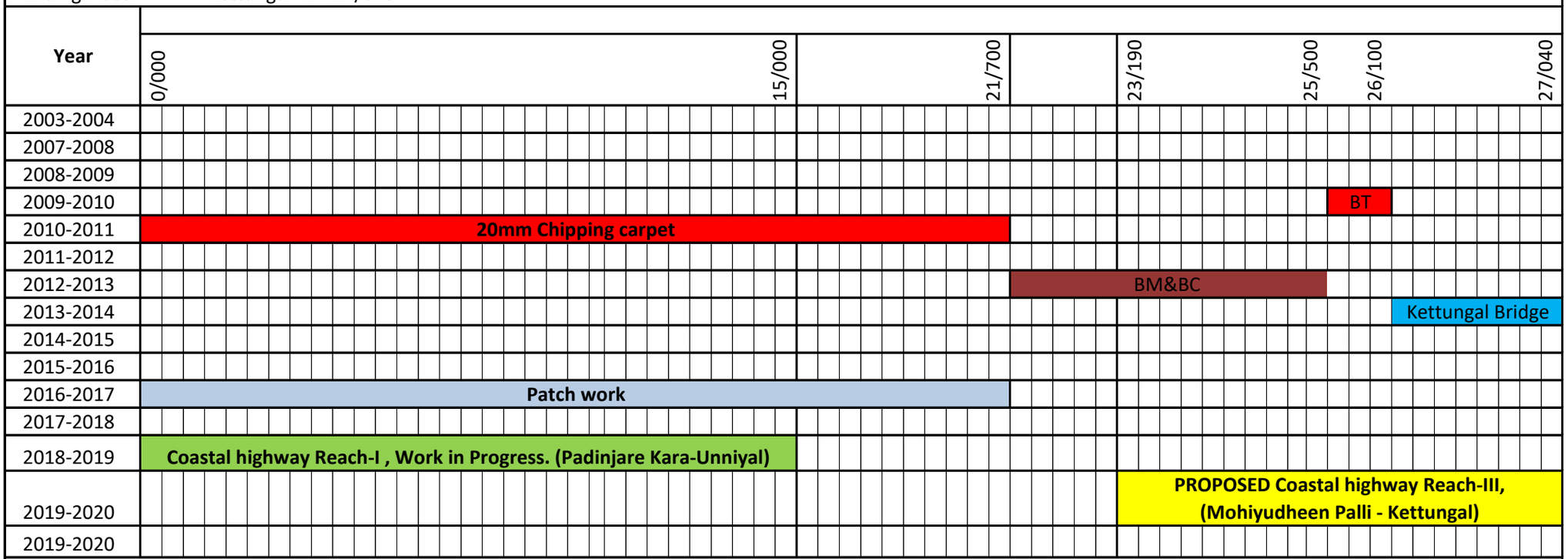
(b) In this project 36 month DLP is included for rectifying crack or damages. No separate claim for contractor within DLP period.

(c) Operation and maintenance amount are not included in this project since defects if any during the DLP period of 36 months will be rectified by the contractor.

KERALA PUBLIC WORKS DEPARTMENT

BAR CHART OF WORKS

Name Of Road	Tippusulthan Road	Division	Malappuram
Category	MDR	Sub-Division	Kuttippuram
Starting Place	Tanur Mohyudhin Palli km KM 23/190	Section	Kuttippuram
Ending Place	Kettungal Km 27/040		



Asst. Engineer

Asst Exe. Engineer

Exe. Engineer

Exe. Engineer

Exe. Engineer

COST - BENEFIT SHEET (QUICK SHEET)

NET PRESENT VALUE (NPV) of COSTS **5850**

NET PRESENT VALUE (NPV) of BENEFITS **7734**

COST BENEFIT RATIO (B/C) **1.322**

DEPARTMENT:	KERALA PUBLIC WORKS DEPARTMENT	NAME OF SPV:	KIIFB - 2018-19	PROJECT NAME:	KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur Mohyudhin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.	PROJECT ID:	PWD-OO4

COST ANALYSIS

(in years from commencement of incurring costs)	7

Remarks:
1. If costs will be incurred beyond five years OR for an infinite or longer time horizon, enter an approximate figure for the other years as percentage of cost for the first year for each item.
2. Include Recurring costs like Annual Maintenance Costs if known.
3. If Units and Rates are not known with reasonable degree of accuracy, please enter the Units as '1' and then the total Amount in the Rate column
4. Group activities into not more than 10 sets of COSTS for simplicity of computation.
5. Enter value of year from the picklist given by the side of the cell.

	Year 1 =				Year 2 =				Year 3 =				Year 4 =				Year 5 =				Year 6 and beyond
Item	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	approximate percentage of cost for that item to the cost incurred in
1	15.0	Improvements of road	390	5850								0				0				0	
2				0				0				0				0				0	
	TOTAL FOR YEAR 1 =			5850	TOTAL FOR YEAR 2 =			0	TOTAL FOR YEAR 3 =			0	TOTAL FOR YEAR 4 =			0	TOTAL FOR YEAR 5 =			0	

BENEFIT ANALYSIS

Period for which BENEFITS will be derived: (in years from first year of start of getting benefits of the project)	7

Remarks:
1. If benefits will be derived beyond five years OR for an infinite or longer time horizon, enter an approximate figure for the other years as percentage of benefits for the first year for each item
2. If Units and Rates are not known with reasonable degree of accuracy, please enter the Units as '1' and then the total Amount in the Rate column
3. Group activities into not more than 10 sets of BENEFITS for simplicity of computation
4. Enter value of year from the picklist given by the side of the cell.

	Year 1 =				Year 2 =				Year 3 =				Year 4 =				Year 5 =				Year 6 and beyond
Item	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	Units	Description/Remarks	Rate (Rs. Lakh/Unit)	Amount	(Enter as approximate percentage of cost for that item to the
1	3	Benefit on savings consumption of fuel	18	54	3	Benefit on savings consumption of fuel	20	60	3	Benefit on savings consumption of fuel	21	63	3	Benefit on savings consumption of fuel	20	60	3	Benefit on savings consumption of fuel	28	84	200
2	3	Benefit on repair of road	40	120	3	Benefit on repair of road	52	156	3	Benefit on repair of road	60	180	3	Benefit on repair of road	70	210	3	Benefit on repair of road	78	234	200
3	3	Social benefits	400	1200	3	Social benefits	435	1305	3	Social benefits	460	1380	3	Social benefits	475	1425	3	Social benefits	480	1440	200
4				0				0				0				0				0	
	TOTAL FOR YEAR 1 =			1374	TOTAL FOR YEAR 2 =			1521	TOTAL FOR YEAR 3 =			1623	TOTAL FOR YEAR 4 =			1695	TOTAL FOR YEAR 5 =			1758	

EXTENT OF LAND (Land Acquisition detail)

KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur Mohyudhin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.

TALUK	VILLAGE	REQUIRED AREA OF ACQUISITION IN SQM	REQUIRED AREA OF ACQUISITION IN ACRE
Tirur	Pariyapuram	4000	0.9883

KIIFB Works 2018-19: Constructionof Coastal Highway in Malappuram District:Reach- III between Tanur Mohyudhin Palli and Kettungal(KM 23/190 to 27/040) in Tanur LAC.

CERTIFICATE

Certified that I have personally inspected the site of the proposed work KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur MohyudhinPalli and Kettungal (KM 23/190 to 27/040) in Tanur LAC and the estimate is corrected incorporating the observation issued by the Chief Technical examiner vide observation note file No 376172/I&PW-B1/2017/Fin Dt.27.01.2017

KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur MohyudhinPalli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.

LAND AVAILABILITY CERTIFICATE

Certified that the Land is available for the work KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur MohyudhinPalli and Kettungal (KM 23/190 to 27/040) in Tanur LAC, except at the approach of Kettungal bridge in Tanur side. Provision for acquisition of land is included in the estimate for the bridge approach.

PROFORMA

NAME OF WORK	:	**KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur Mohyudhin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.**
ASSAMBLY CONSTITUENCY	:	**TANUR**
DIVISION UNDER THE WORK	:	**PWD NH - MALAPPURAM**
CHAINAGE(STARTING&ENDING IN WHICH THE WORK IS PROPOSED TO BE TAKEN UP	:	**KM 23/190 to 27/040**
LENGTH TO BE COVERED IN CASE OF ROAD WORK	:	**3.95 KM**
CATOGORY OF ROAD WHETHER NH,SH,MDR	:	**MDR**
ESTIMATED COST OF WORK	:	**2600.00 Lakhs**
BUDGET PROVISION	:	**650000.00 Lakhs**
PAGE NO AND ITEM NO IN THE BUDGET	:	**Budget Speech 2017-18, Page No:62,Sl No:152**
HEAD OF ACCOUNT	:	**3054-80-800-92-00-00**
DETAILS OF AS (IN THE CASE OF PROPOSAL OF SPECIAL SANCTION)	:	**Budget Speech 2017-18, Page No:62,Sl No:152**

ASST ENGINEER **ASST. EXE. ENGINEER** **EXECUTIVE ENGINEER**

KERALA PUBLIC WORKS DEPARTMENT

WORK BOUND SCHEDULE(WBS) FOR THE YEAR 2017-18

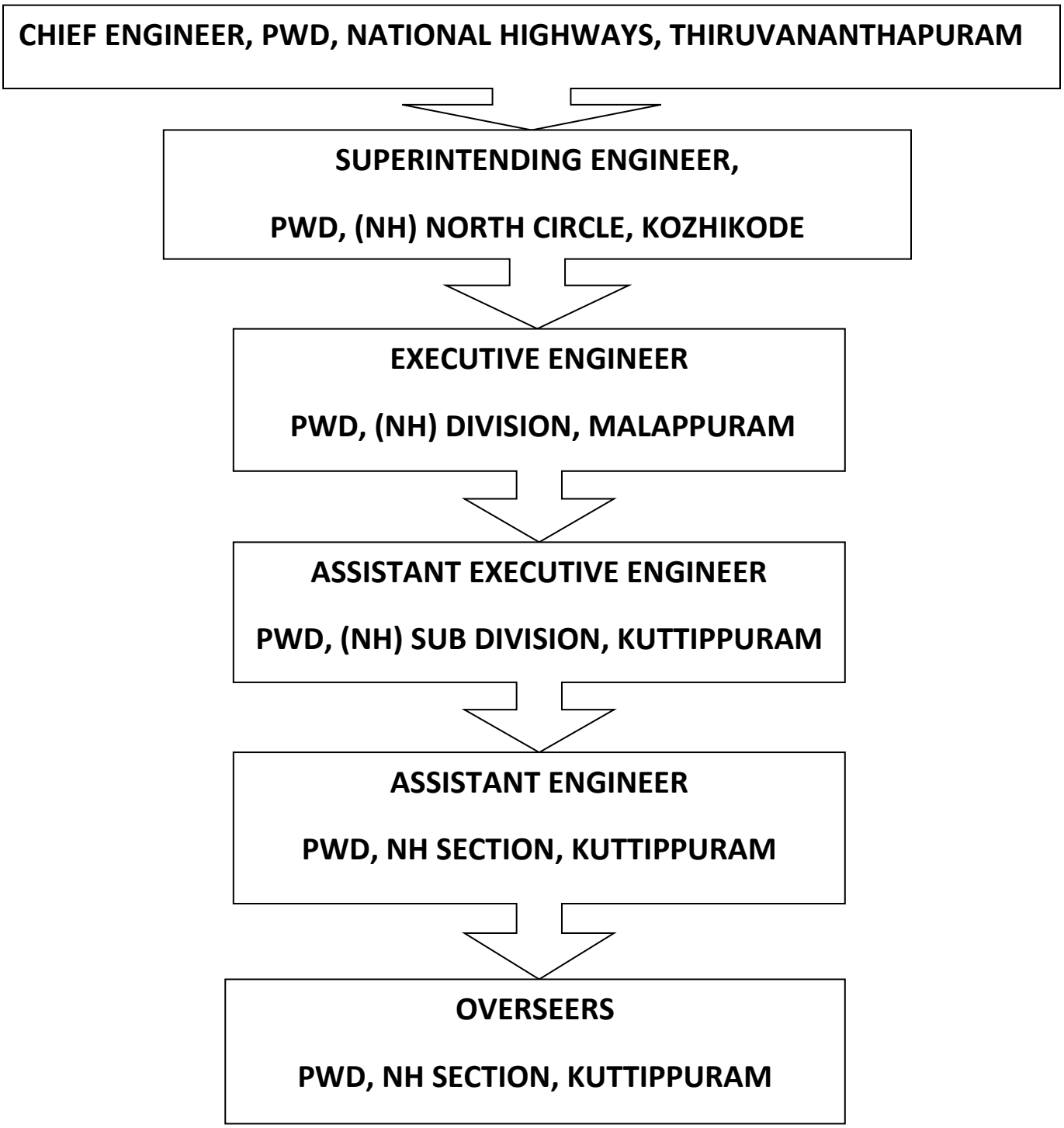
Name Of Road	Coastal Highway	Circle	PWD, NH North Circle, Kozhikode.
Category	MDR	Division	PWD, NH - Malappuram
Starting Place	Muhayudhin Palli 23/190	Sub division	PWD, NH- Kuttippuram
Ending Place	Kettungal 27/040	Section	PWD, NH- Kuttippuram

Sl No:		month-I	month-II	month1	month2	month3	month 4	month5	month6	month7	month8	month9	month10	month11	month12	month13	month14	month15	month16	month17	month18
	AS, FS, TS, Tendering & Agreement execution																				
	Culvert, Drain, Protection wall																				
1	excavation																				
2	P.C.C																				
3	Sidewall																				
4	Cover slab																				
	Road surface																				
1	Mobilisation, Levels, working dwgs, Approvals																				
2	scarifying																				
3	excavation																				
4	GSB																				
6	WMM																				
7	DBM																				
8	BC																				
9	Road safety items																				

ORGANISATION STRUCTURE

OF CONSTRUCTION MANAGEMENT

KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur Mohyudhin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.

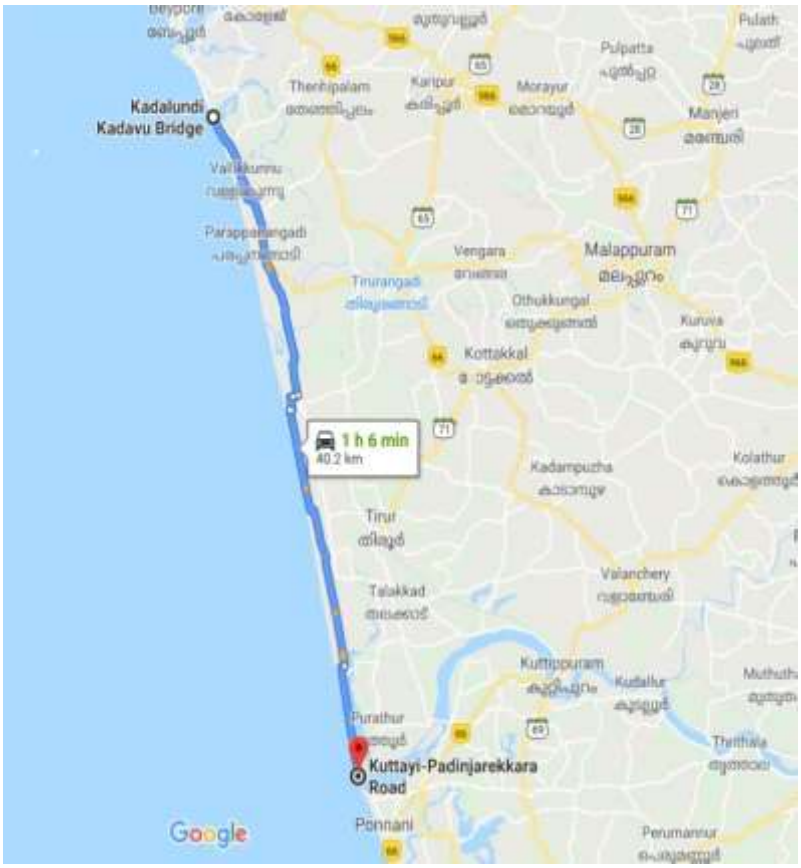


PROJECT LOCATION

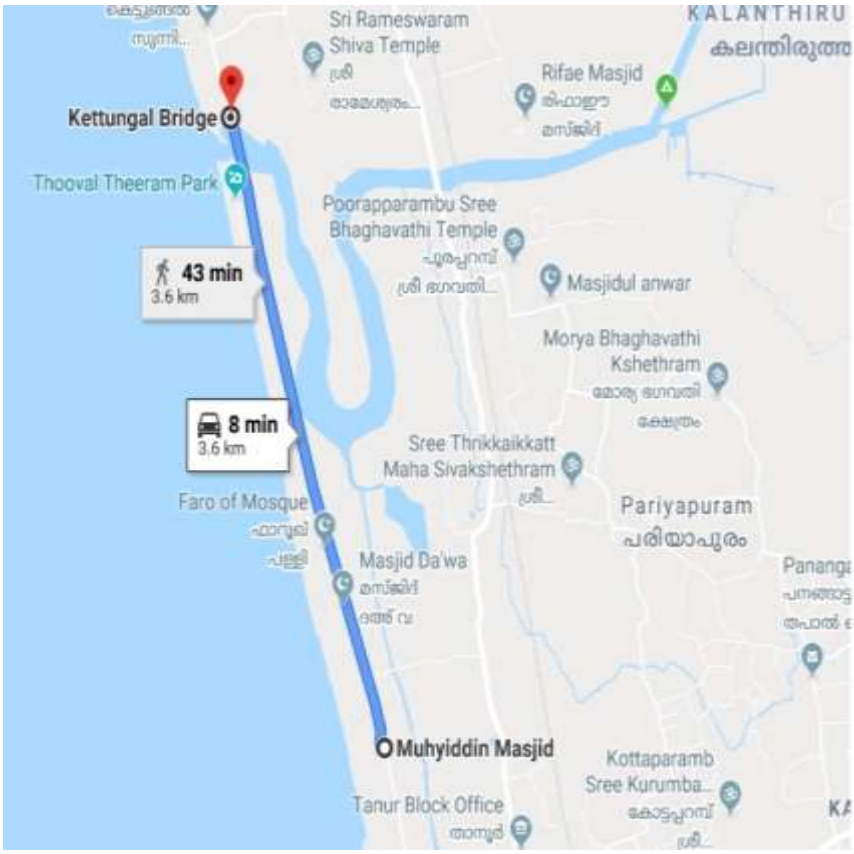
The project is located in Malappuram district as shown below

PROJECT ROAD

The proposed coastal highway in Malappuram road starts from Padinjarekara to Kadalundi via Kootayi, Unniyal ,Tanur, Parappanangadi and ends at Kadalundi Bridge in Tirur - Kadalundi road.



Blue line shows the coastal highway project under consideration which is from Tanur Mohyudhin Palli to Kettungal (Km 23/190 to 27/040) in Tirur LAC.



(Muhayidhin Palli to Kettungal stretch of proposed coastal highway)

Name of the Project: KIIFB Works 2018-19: Construction of Coastal Highway in Malappuram District: Reach- III between Tanur Mohyudhin Palli and Kettungal (KM 23/190 to 27/040) in Tanur LAC.

	Chainage	Ch: 23/190 to Ch: 23/500	Ch: 23/500 to Ch: 24/000	Ch: 24/000 to Ch: 24/500	Ch: 24/500 to Ch: 25/000	Ch: 25/000 to Ch: 25/500	Ch: 25/500 to Ch: 26/000	Ch: 26/000 to Ch: 26/440	Ch: 26/440 to Ch: 26/700	Ch: 26/7000 to Ch: 27/040	Remarks
Project Details	Name of town/Village	MohyudeenPalli/ Pariyapuram	Albazar/ Pariyapuram	Corman kadappuram/ Pariyapuram	Company Pady/ Pariyapuram	Farooq Palli/ Pariyapuram	Ottumpuram beach/ Pariyapuram	Thooval theeram / Pariyapuram	Kettungal bridge/ Pariyapuram	Kettungal beach/ Neduva	
	Location Description	MohyudeenPalli	Albazar	Corman kadappuram	Company Pady	Farooq Palli	Ottumpuram beach	Thooval theeram	Kettungal bridge	Kettungal beach	
Design Basis	MSA	12.127	12.127	12.127	12.127	12.127	12.127	12.127	12.127	12.127	
	CBR(%)	13	13	13	13	13	13	13	13	13	Design CBR-13.00%
	Characteristic Deflection (BBD)	0.455936,	0.26602	0.239202	0.433468	0.936806	0.159468	0.24134	0.24134	0.24134	
	CVPD	895	895	895	895	895	895	895	895	895	
	Traffic Data (PCU)	8112	8112	8112	8112	8112	8112	8112	17319	17319	
Existing Road Details	Average Carrige way width	5.5	5.5	5.5	5.5	5.5	5.5	5.5	7.5	8.5	
	Average ROW	14	16	15	16	16	16	15	14	12	
	GSB	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Metalling with graded stone
	WMM	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	Metalling with graded stone
	DBM	BM	BM	BM	BM	BM	NIL	NIL	NIL	NIL	
	BC	BC	BC	BC	BC	BC	NIL	NIL	NIL	NIL	
	Chipping Carpet	NIL	NIL	NIL	NIL	NIL	BT	NIL	NIL	NIL	
Functional requirement	4 lane / 2 Lane	2 lane	2 lane	2 lane	2 lane	2 lane	2 lane	2 lane	2 lane	2 lane	
	Cutting	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	
	Filling	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	As given in levels	
	Slab Culverts(Existing / Proposed)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	
	Box Culverts(Existing / Proposed)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	
	Drain Type (OD/FC/ID/LD)	OD	OD	OD	OD	OD	OD	OD	OD	OD	
	Drain Length (L/R)	200L/200R	500L/500R	500L/500R	500L/500R	500L/500R	500L/500R	100L/200R	NIL	NIL	
	Ducts Types (Transverse Duct/Transverse Duct for landing)	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	cross ducts at every 500m	
	RCC retaining wall 1 to 2m (L/R)	NIL	NIL	NIL	NIL	NIL	400m Left	300m Left, 300m Right	NIL	NIL	
	CC retaining wall upto 1m (L/R)	NIL	NIL	NIL	NIL	100L	NIL	NIL	NIL	NIL	
Pavement design	GSB	0.20	0.20	0.20	0.20	0.20	0.20	0.20	NIL	0.20	
	WMM	0.25	0.26	0.26	0.26	0.26	0.26	0.26	NIL	0.26	
	DBM	0.05	0.05	0.05	0.05	0.05	0.05	0.05	NIL	0.05	
	BC	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	
Road Furniture	Traffic Sign, Road Marking and Other Appurtenances	8-sign boards road markings	12-sign boards road markings	6-sign boards road markings	6-sign boards road markings	6-sign boards road markings	8-sign boards road markings	8-sign boards road markings	4-sign boards road markings	8-sign boards road markings	
	Boundary Stone laying	30	40	40	40	40	40	30	Nil	20	
	Bus Shelter	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Repairs and Miscellanious	Extension of Bridge	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
	Repair and Rehabilitation of	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
	Land Acqusition (L/R) m^2	Nil	Nil	Nil	Nil	Nil	Nil	4000 m^2	Nil	Nil	Rs- 1,50,000/ cent
	Utility Shifting (EP/TP/TF/PUB.TAP)	EP-18	Transformer-1, EP-28	Transformer, EP-26	EP-28	Transformer-1, EP-27	Transformer-1, EP-26	EP-12	Nil	Nil	

DETAILED APPRAISAL REPORT

DETAILED APPRAISAL REPORT FOR CONSTRUCTION OF COASTAL HIGHWAY IN MALAPPURAM DISTRICT REACH-III: BETWEEN TANUR MOHYUDHIN PALLI & KETTUNGAL (KM23/190 to 27/040) IN TANUR LAC. (LINK IN MLPM BEFORE KETTUNGAL BRIDGE, KETTUNGAL BRIDGE, AND A SHORT LENGTH AFTER KETTUNGAL BRIDGE).

Rep No. AR-2019-TRAN15-PWD014-12

1. SALIENT FEATURES

1.1 Project details in brief

Name of Project	Construction of Coastal Highway in Malappuram District Reach-III: Between Tanur Mohyudhin Palli& Kettungal (Km 23/190 - 27/040) in Tanur LAC
District	Malappuram
Project Outlay	Rs. 27.57 Crore (Revised from 38 crore)
Report Prepared by	PWD, NH Division, Malappuram.
SPV/Implementing Agency	KRFB
Administrative Sanction	GO(Rt)No-942/2017/PWD Dated - 10-07-2017
Budget Speech Reference	Budget Speech 2017-18, Para:152 (Coastal Highway)
Length (kms)	3.85 KM
Existing RoW	15.6 m (As per DPR)
Existing Carriageway Width	5.5 M
Road Type	MDR
Features	Existing road is BM & BC
Proposed RoW	15.6 m
Road Category as per KIIFB Guidelines	Coastal Highway
Cross section details of Kettungal bridge and approach road	Not mentioned
Land Availability	Available (As per DPR) However, Land for amenity centre and will be service road for kettungal bridge is to be acquired. The cost for which is included in this proposal.
Proposed Carriageway Width	7 m
Shoulders	1.5 m wide shoulder on both sides
Drains (Width / Length)	1.30 m wide drain for a length 2.34 km and1.17 m height on both sides.
Leading Drain	1.6 m wide and 1.3 m height at chainages 24/190 LHS 250 m

	25/140 LHS 200 m 25/590 LHS 200 m 25/990 LHS 250 m
Footpath	Cover slab for drain shall act as footpath of 1.5m wide
Cross duct	4 numbers provided at 24/190, 25/140, 25/590, 25/990
Locations of Retaining Wall (On both sides)	1 m height-25/990 to 26/070, 26/935 to 27/040& 26/126 to 26178 (RHS) 2 m height – 26/070 to 26/126, 26/835 to 26/935 (LHS) & 26/815 to 26/935 (RHS) 3 m height – 26/126 to 26/250 (LHS) & 26/178 to 26/250 (RHS) 4 m height- 26/250 to 26/300 5 m height – 26/300 to 26/354
Existing PCU	6238 PCU/day (to be cross verified by TS Authority)
Projected traffic 2031 (15 years)	14016 (Total Vehicle)- PCU not calculated
Growth % Adopted	7.50% provided
Design Speed as per IRC/ Adopted (Km/hour)	Not provided
No. of Horizontal Curves / No. of curves meeting design standards	2 Nos.-23/190 to 23/270 (R=120 M, e=7%) & 26/190 to 26/240 (R= 150 M, e=1%)
Speed Restrictions provided	Not mentioned
No: vertical curves provided	Not furnished
Gradient profile correction / Cutting/Filling Volume	Not furnished
CVPD	774
MSA	16.64
Design MSA	16.64
Design Life	15
CBR of existing soil	13.5 % to 18.1%

Design CBR	13.5 %
Soil Improvement if any	Not provided
Subgrade thickness	Embankment of varying thickness is provided for raising / strengthening of waterlogged areas
Pavement Thickness Total	545 mm as per IRC 37:2018 Plate 7
GSB	200 mm
WMM	250 mm
DBM	55 mm
BC	40 mm
Road Formation Type	Scarifying and providing all pavement layers from GSB, WMM, BM and BC
Drawings Provided	Pavement cross section, Cross duct, Culvert, Horizontal curvature, Junction, Retaining wall, Road marking, Bus bay, Septic tank, service road, Roadside amenity center, Strip plan, Side road drain and Land acquisition.
Utility Shifting proposed	Rs.27.36 Lakhs
Road Furnishings	Guard post, retro reflectorized cautionary, informatory and mandatory signs, median markers, object hazard markers, reflective road studs
Bus Bays / Bus shelters	6 Bus bays (3 Bus bays for each direction)

1.3 The Proposed road improvement works starts from Mohyudhinpalli at chainage 23/190 and end at after Kettungal Bridge at chainage Km 27/040. This forms the Reach-III of proposed coastal highway in Malappuram Dist.

1.4 The existing road is an intermediate carriage way with the average width of pavement as 5.5 m and the road surface consists of BM & BC

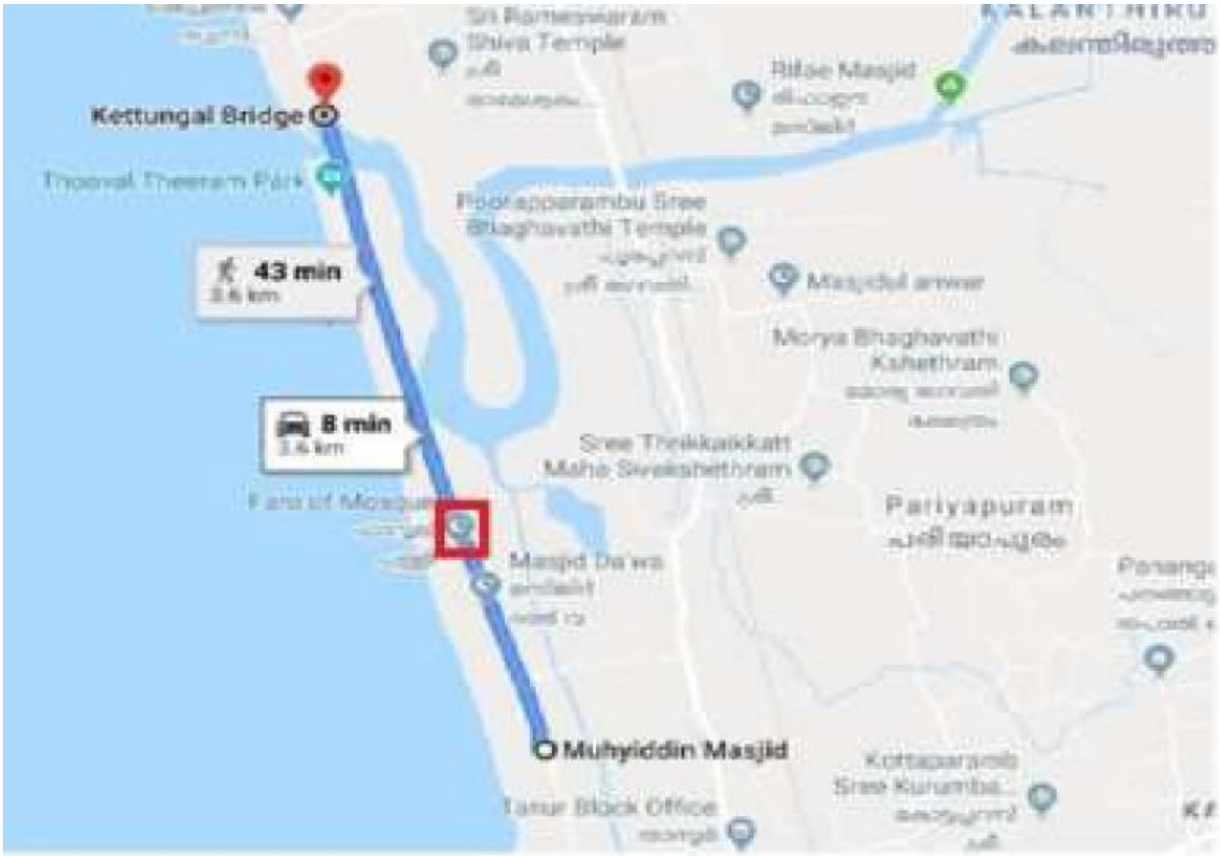
1.5 The project road traverses through a plain terrain through coastal areas without any sharp curves.

1.6 2.4 KM of road (23/190 to 25/590) with a carriage way of 5.5 m is in good riding condition.

1.7 The proposal includes scarifying existing road and construction of 3.85 km road stretch, construction of drains, traffic safety works, including construction of service roads (550 m each) on both sides of Kettungal bridge approach, Construction of Amenity centre etc.

1.8 Drains of width 1.3m are proposed for a length of 2.34 km in each direction.

1.9 The layout of the proposed road is as given below:



2. REQUIREMENT / DEMAND ANALYSIS

2.1 The report states that improvements to the road including the subbase is essential to accommodate present high intensity of traffic

2.2 The proposed work will be very useful for fishermen community and it leads overall development of the Municipality.

2.3 If the road is improved, the farmers can easily fetch the marketing centers with less expenditure and reduced travel time and cost.

3. FUNCTIONAL DESIGN

3.1 The DPR contains traffic volume study data, and CBR test results.

3.2 Detailed traffic survey study was conducted for 5 days and details regarding the same is submitted along with DPR. PCU/day arrived at for the proposed stretch is 6238. Projected traffic for 15 years has also submitted along with DPR. The data shall be reviewed by TS authority.

3.3 The proposed road is a BM&BC road with a width a carriage way width of 7m.1.5m paved shoulders on both sides, 2m (2.2 m may be provided if possible) wide cycle track, 1.55 m foot path on west side and 1.8 m Foot path on east side, and 0.25 m curb on east side which satisfies the cross sectional requirement for Coastal Highway as per KIIFB Planning and Design Manual. Boundaries of the proposed RoW are to be demarcated with boundary stones.

3.4 ROW of the proposed road is 15.6 m.

3.6 Drains of width 1.3 m are proposed for a length of 2340 m.

3.7 Footpaths and road safety features includes necessary warning signs, chevron signs, direction boards, road marking, road studs etc. which are provided to avoid accidents.Provision of road furniture shall be evaluated by the TS committee prior to sanction.

4. ENGINEERING DESIGN

4.1 The pavement design has been carried out using the data from traffic study & CBR

4.2 Detailed soil investigation report with CBR test results is furnished along with the DPR

4.3 CBR value of the existing subgrade varies from 13.5 % to 18.1 %.

4.4 Detailed design report of horizontal curve and vertical curve (if any) shall be prepared and the same shall be evaluated by TS committee prior to sanction

4.5 CVPD value as per traffic data comes around 774 and cumulative number of standard axle loads comes around 16.64 msa. TS authority may confirm the CVPD values before according TS.

4.6 The Proposed thickness of sub base (GSB) is 200 mm and thickness of wet mix (WMM) is 250 mm. The thickness of bituminous layers of DBM is 55mm and BC is 40mm. Design CBR value is 13.5 % and design traffic in msa comes to 16.64. Pavement has been designed as per provisions in IRC 37:2018 (PLATE :7) with a total thickness of 545 mm.

4.7 Cross sectional and Longitudinal sectional drawings are submitted along with DPR.

4.8 Full-fledged alignment plan in the required scale with all levels and chainages marked to assess the topographical features for quantity estimation of cutting and filling shall be prepared prior to TS.

5. O&M STRATEGY

5.1 Operation and maintenance will be implemented by the Public Works (NH) Department with all responsibilities.

5.2 Rectification works due to construction defects shall be covered by the contractor under the Defect Liability Period, which is three years.

6. FINANCIAL ESTIMATES & COST PROJECTIONS

6.1 The detailed estimate is prepared based on PRICE software with cost index of 31.06%.

6.2 Estimate report, abstract estimate, detailed estimate and data analysis are given.

6.3 Total length of proposed road is 3.85 km (Including already constructed Kettungal bridge of length 200 m for which improvement measures required) and total estimated cost is Rs. 27.57 Cr. (Apart from these 3.85 kms the cost of constructing service road for a length of 1.1 Km is also included in the project cost.)

6.4 Average unit cost per km comes around 6.51 Crore, including land acquisition, retaining wall and drainage facilities, service road, bus bay/bus shelters and unforeseen amount.

6.5 Service road of 550 length is proposed on both sides of Kettungal bridge approach. The cost is estimated as Rs. 1.3298 Cr including 12% GST.

6.6 Detailed estimate for utility shifting is submitted and the same shall be verified by TS committee prior to sanction

6.7 Detailed level calculations for earthwork, GSB, WMM, BM & BC with length, width and depth are prepared and TS committee shall ensure that the quantities are proposed as per the given pavement design, prior to sanction.

6.8 TS committee shall ensure that GSB and WMM are not used for raising/strengthening of water-logged areas. This shall be done by bringing in borrow soil.

6.9 TS committee shall ensure that CBR of the borrow soil used for raising/ strengthening waterlogged portions is 13.5% or higher.

6.10 The provisions for road safety furniture shall be evaluated by TS committee prior to sanction. In general, the provision for this is on the higher side. This has to be curtailed to reasonable levels or proper justification given by the TS Authority.

6.11 Estimate provisions for Bus shelter is on a higher side. TS committee shall evaluate the same prior to sanction.

6.12 For a distance of 3.85km, providing 6 number of bus bays (105 m) is not feasible as bus bays are usually provided near crowded and heavily inhabited areas, near schools and major junctions. TS Committee shall evaluate the necessity of bus bays along the proposed stretch and propose accordingly prior to sanction. On any account this need not exceed 4 numbers considering that the length of the road is 3.85 Kms.

6.13 The summary of cost sought for funding and the recommended cost is provided below:

	Item	Cost as per Revised DPR	Recommended Cost
1	**Improvement works to the Roadway from KM 23/190 to 25/590**		
	Improvements to the Carriage way	6,71,74,220	6,71,74,220
	Drainage works	3,30,71,818	3,30,71,818
	Road safety measures	51,47,573	51,47,573
	Sub Total	**10,53,93,611**	**10,53,93,611**
2	**Improvement works to the Roadway from 25/590 to 27/040**		
	Improvements to the Carriageway	3,40,26,202	3,40,26,202
	Drainage, side protection and retaining wall	4,20,00,734	4,20,00,734
	Road Safety Measures	49,28,495.95	49,28,495.95
	Sub Total	**8,09,55,432**	**8,09,55,432**
3	Landscaping & Compensation for Afforestation	11,35,505	11,35,505
4	Construction of Bus shelters	48,37,843	48,37,843
5	Construction of service road to Kettungal bridge	1,18,73,285	1,18,73,285
6	Restoration for KWA	49,34,187	49,34,187
7	Construction of Amenity Centre	14,61,173	14,61,173
8	Shifting of utilities, electric posts, Transformers and Pipelines	27,36,534	27,36,534

19	Land acquisition of Kettungal bridge at Tanur side	3,26,89,500	3,26,89,500
10	LS for electrification of Amenity Centre	1,20,000	1,20,000
	Total	**24,61,37,072**	**24,61,37,072**
	GST@12%	2,95,36,449	2,95,36,449
	Round off	26,479	26479
	Total	**27,57,00,000**	**27,57,00,000**

Total Recommended Cost – Rs. 27.57Crore

TS Committee shall evaluate the revised estimate prior to sanction

7. COST BENEFIT ANALYSIS

7.1 The Cost Benefit Analysis has been done with a cost benefit ratio of 1.322

8. VALUE ENGINEERING OPTIONS

8.1 There exist a 2.4 Km BM-BC stretch having a carriage way of 5.50 m in good riding condition. This was constructed recently, and no damages occurred anywhere on the surface. As such this pavement need not be disturbed at all and only extra widening need be done on either side. BC layer can be covered over this surface also. Thus, the cost of GSB, WMM, and DBM etc. can be saved considerably. TS Authority should evaluate this aspect before according Technical Sanction.

8.2 Provisions towards road markings seems to be on the higher side. This should be a strictly as per IRC 35.

8.3 No designs are seen carried out for the construction of concrete retaining wall and the provisions in the estimate are appeared to be too high. All the provisions should strictly be as per design and standards.

8.4 For the service road almost the same pavement composition as that of main road is seen given in the estimate. There is no need of such a huge composition as far as this service road is concerned as the possibility of traffic is remote. As such pavement composition for this stretch need review or justification. This will also reduce the project cost.

8.5 The land acquisition cost is taken as Rs. 1.5 Lakh per Cent which is said to be the market value, even this appear to be on the higher side. While according TS fair value alone need to be considered in arriving at the LA cost.

9. IMPLEMENTATION SCHEDULE & WBS

9.1 Implementation schedule of the proposed has been furnished. The work is scheduled to be completed in 24 months.

9.2 A time-bound action plan including tendering, appointment of contractors, construction schedule, quality assurance & quality control and post-construction activities, including project delivery shall be prepared prior to TS.

10. PROJECT MANAGEMENT ORGANIZATION STRATEGY

10.1 The project management of projects with KRFB shall be taken up by the project management unit of KRFB

10.2 The project execution will be under the proper supervision of PWD (NH) Engineers

11. CONTRACT MANAGEMENT STRATEGY

11.1 The project will be arranged by the Kerala PWD (NH) and will be carried out through approved contracting agencies by inviting competitive bids.

11.2 TS committee shall evaluate the Contracting methodology prior to sanction.

12. STATUTORY CLEARANCES

12.1 Statutory clearances will be obtained from KSEB, KWA and BSNL before the commencement of work.

12.2 The necessity of following clearances shall be evaluated by TS committee prior to sanction, if applicable.

- Environmental Clearances
- Clearances for shifting of utilities
- NOC and Consents under the Water (Prevention & Control of Pollution) Act
- NOC and Consents under the Air (Prevention & Control of Pollution) Act
- Noise Pollution (Regulation and Control) Rules 2000.
- The Kerala Conservation of Paddy Land and Wetland Act, 2008

13. ENVIRONMENTAL ASPECTS & SUSTAINABILITY

13.1 Environmental issues are not anticipated during this project as this project is for the improvements to existing road.

13.2 The trees cut for the widening of the carriage way will be compensated by planting trees.

13.3 Detailed Environmental Plan shall be prepared and the same shall be evaluated by the TS committee prior to sanction

14. QUALITY MANAGEMENT PLAN

14.1 PWD quality wing/quality assurance will monitor the project in each stage of construction.

14.2 Quality checking will be done in three level

- First tier quality checking-before commencement of work (Contractor)
- Second Tier quality checking
- Third tier quality checking (Technical audit after the completion of the project)

15. RISK ASSESSMENT AND MITIGATION MEASURES

15.1 The major risks associated with the project are identified and proper mitigation measures proposed.

16. REMARKS AND INFERENCES

16.1 The project has satisfied all the basic requirements for consideration for financial assistance from KIIFB

16.2 The parameters studied with regard to the demand are in favor of the proposed project.

16.3 The functional design is matching with the KIIFB standards. TS committee shall evaluate the availability of RoW as per requirements and ensure that the RoW as per KIIFB Planning and Design guidelines is adopted, prior to sanction

16.4 The engineering design and details proposed are satisfactory. TS committee shall ensure that the CBR values are verified and also evaluate the pavement design prior to TS.

16.5 The O& M strategy has been mentioned in the report.

16.6 Cost benefit analysis is submitted, and cost benefit ratio is obtained as 1.322.

16.7 The estimate shall be revised according to the comments stated in Para of Value Engineering Option. TS committee shall evaluate the revised estimate prior to sanction

16.8 The investment criteria like CBA shall be modified based on the revised estimate.

16.9 The optimization options like CBR, improvement for pavement redesign, Full Depth Reclamation etc. shall be confirmed well before issuing TS.

16.10 Though the period of completion is realistic, sequencing of activities with most likely durations are to be determined.

16.11 The project management organization plan is submitted and seems satisfactory.

16.12 The contract management plan is furnished, and TS committee shall evaluate the Contracting methodology prior to sanction.

16.13 TS committee shall evaluate the necessity of required statutory clearances prior to sanction

16.14 TS committee shall evaluate the detailed Environmental Management Plan prior to sanction

16.15 The quality management plan is satisfactory.

16.16 The major risks associated with the project shall be identified and mitigation measures for the same is proposed.

16.17 Pavement design is done based on IRC 37:2018. The same shall be reviewed by TS authority.

16.18 Detailed estimate for utility shifting is prepared after joint inspection by the concern departments and same is submitted with DPR. The same shall be verified by TS committee prior to sanction

16.19 TS authority may confirm the CVPD values before according TS. TS authority shall also confirm that all pavement lanes are designed on basis of the above.

16.20 The following documents are prepared and submitted along with DPR. TS authority shall verify all the submitted drawings prior to the sanction

16.20.1 Cross sections of Coastal Highway, Cross section of Service road, Cross sectional and Longitudinal sectional drawing including levels, Details of Culvert, Details of drain, Cross Duct, Horizontal curve details, Junction improvement plan, Leading Drain, details of retaining wall, Road signage plan, Strip plan, Side road drainage, Land acquisition plan, Bus bay details.

16.21 Design of retaining wall shall be obtained and evaluated by TS committee before issuing Technical Sanction

16.22 Full-fledged alignment plan in the required scale showing existing carriageway, existing tar edge, proposed carriageway, RoW, all levels and Chainages shall be submitted prior to TS.

17. RECOMMENDATIONS AND SUGGESTIONS

17.1 The project can be considered for funding by KIIFB provided the tripartite agreement is entered after ensuring adequate clarity in the above observations.

17.2 Upon recasting of the estimate, considering all the items including carriage way improvement, retaining walls and drainage works, bus bays and bus stops, service road, amenity center, Road sign and markings, land acquisition, utility shifting, lighting etc. the total amount to be considered comes to **Rs. 27.57 Crores.**

17.3 TS Committee should ensure that the updated cross section of Coastal Highway is followed in preparing the estimate.

17.4 The detailed estimate submitted shall be reviewed and optimized by the TS authority. Latest DSR and Cost Index shall be followed. The applicability of GST and other taxes shall be as per the prevailing norms and rules.

17.5 Cross section of service roads (both sides of Kettungal bridge approach road) is appeared to be on higher side. TS authority shall assess and optimize the proposed cross section for service roads prior to sanction.

17.6 The foundations shall be based on the actual geotechnical investigation so that the foundation design is optimum. The soil report and structural drawings shall be reviewed by the TS authority so as to analyses possible options for optimal design.

17.6 Detailed drawings of the proposed bus bay and bus shelters along with chainage shall be prepared and got sanctioned while according TS.

17.7 Estimate of Electrification for Amenity center is given as LS provision. The detailed estimate shall be obtained before issuing TS.

17.8 The Technical sanction by competent authority is mandatory before initiating tendering process. Technical sanction shall be issued by the SPV only after incorporating the suggestions indicated in this report and the compliance may be communicated to KIIFB prior to issuance of tenders.

17.9 The cost provisions for work alone shall be utilized for execution of work. The savings or anticipated savings from LA, QC, shifting utilities etc. shall not be re appropriated for meeting expenditure of work proper.

17.10 While entrusting the maintenance activities to the contractor, it shall be ensured that the obligation under defect liability shall be performed without any additional cost. Hence no maintenance expenditure shall be considered under original work.

17.11 SPV and its TS authority shall ensure the availability of land for amenity center and service road that to be acquired in line with the construction schedule. There shall not be any idling of contractor's resources on account of non-availability of land.

DETAILED APPRAISAL REPORT

DETAILED PROJECT REPORT FOR THE CONSTRUCTION OF COASTAL HIGHWAY IN KOZHIKODE DISTRICT-FROM KODIKKAL TO KOLAVIPPALAM IN KOZHIKODE DIST.

Rep No. AR-2021-TRANS 19-PWD014-14

Date : January 2021

1. SALIENT FEATURES

1.1 Project details in brief

Name of Project	Construction of Coastal highway from Kodikkal to Kolavipalam in Kozhikode District
District	Kozhikode
Constituency	Koyilandy
Project Outlay	Rs 64.47 Cr against the original DPR cost of Rs 116.00 Cr
Report Prepared by	PWD NH Division Kozhikode
SPV/Implementing Agency	KRFB
Administrative Sanction	GO(Rt) No 942/2017/PWD Dtd 10/07/2017
Budget Speech Reference	2015-16
Budget provision	Funded by KIIFB
Total length of road	7.50 Km
Overall width & Carriageway	15.60m, 7.00 m
Foot Path	1.55 m wide on both sides at essential locations
Other Details on Proposed road	**2.25** m wide Cycle Track with kerb on coastal side of road (in line with carriage way),Street lights, Road furniture, Hand rails, Drain and Duct.
Land to be acquired & structures affeted	11.79 Hectares, 2 Nos
CVPD	450

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MSA	33 msa
Design MSA	33
Design Life	15
CBR of existing soil	10 % (assumed)
Design CBR	10%
Soil Improvement if any	Not provided
Subgrade thickness	Embankment of varying thickness is provided for raising / strengthening of waterlogged areas
Pavement Thickness Total	**558 mm as per IRC 37:2012 Plate 4**
GSB	200 mm
WMM	250 mm
DBM	68 mm
BC	40 mm
Details of bridges	2 Nos of Bridges: 1) 24.40 m span & 2) 34.40 m span
Overall & carriage way width	15.10 m & 8.50 m with a cycle track of 2.20 m on one side and foot path of 1.50 m on either side
Foundation Details	Pile foundation 1000mm dia piles @ 35.00m average depth
Statutory clearances	CRZ clearance under E(P) act 1986

1.2 The road is proposed as part of Coastal Highway- from Kodikkal to Kolavipalam in Kozhikode District.

1.3 Admn. sanction was accorded for the work as per GO(Rt) No 942/2017/PWD Dated 10/07/2017 for the construction of coastal Highway in the state.

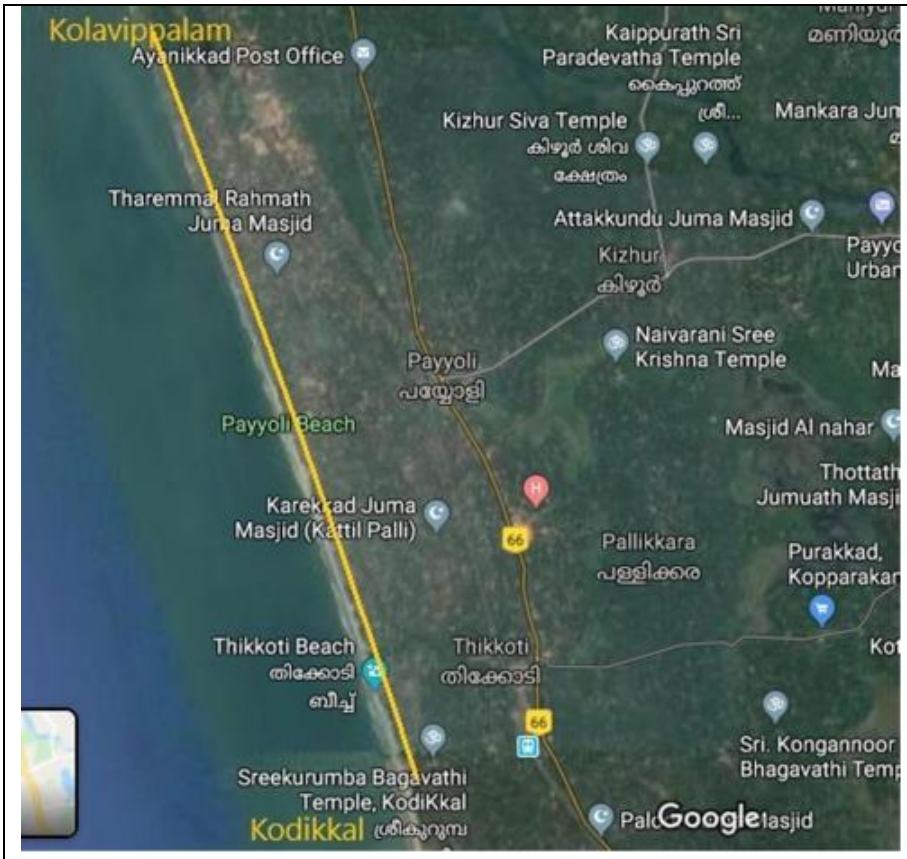
1.4 The Detailed Project Report is prepared by PWD NH Wing Kozhikode which comprises project description, engineering surveys and investigation details,

Geometric design and General Arrangement Drawing (GAD), Project cost estimation and Cost benefit Analysis. The report acknowledge that all activities related to field studies, design and documentation were done as per the prevailing IRC/KIIFB guidelines. The report also states that the on completion of the project, it would improve the connectivity of the area, reduce the traffic congestion along NH 66.

1.6 Total length of road is 7.50 km, with 15.60m RoW, 7.00 m carriageway, footpath of 1.55 m wide on both sides at necessary locations, 0.325m height Kerb.The DPR comprises all necessary Traffic study data, GAD, Geotechnical data, Cost estimate, Socio-economic analysis etc. in support of the arguments favoring the project.

1.7 Along with the road stretch 2 Nos of Bridges having 24.40 m and 34.40 m span respectively are also to be constructed.

1.8 The map of the study stretch is as given below.



Project Influence corridor

2. REQUIREMENT / DEMAND ANALYSIS

2.1 The stretch is a part of the proposed Coastal Highway having a length of 655.60 Kms connecting Poovar (Tvm) &Kunjathoor(Ksgd) covering 9 coastal districts.

2.2 Promoting Tourism, Spots, Fisheries Development, Easy Cargo Movement & Reducing

2.3 congestion in NH are the objectives of this highway in addition to providing transport facilities to the coastal areas/ports. The proposed project is implemented through KIIFB funding.

2.4 In addition to the above objectives, on completion of the entire reaches of coastal highway in this district, it would decongest the NH 66 between Kozhikode and Kannur. The average daily traffic (ADT) for the base year worked out is 1283. The design traffic with a vehicle damage factor of 3.9 & lane distribution factor of 0.50 comes to 33 msa.

2.5 . This stretch comes in the south of the already approved Kunhalimarakkar Bridge by KIIFB in the Kozhikode District. The proposed Kolavipalam -Kunhalimarakkar stretch Joins the Kodikkal-Kolavipalam stretch and the Kunhalimarakkar bridge.

3. FUNCTIONAL DESIGN

3.1 The functional design is carried out based on the requirement analysis through field studies and documentation as per IRC & KIIFB guidelines. Designs are strictly as per geometric standards. The alignment drawing has been finalized based on the topographic and geotechnical studies done by NH division &horizontal design in consultation with NATPAC.

3.2 The alignment is selected in such a way that the land acquisition and rehabilitation is minimum.

3.3 It is reported in the DPR that this alignment is verified and vetted by the NATPAC team also.

3.4 The DPR contains traffic volume study data, BBD & CBR test results.

3.5 The proposed road pavement is with DBM&BC with a carriage way width of 7m.

3.6 ROW of the proposed road is 15.6 meters.

3.7 The proposed road has a carriageway width of 7m**,** 1.5m paved shoulders on both sides, 2.25 m wide cycle track and 1.5 m wide drain on both sides of the road (as applicable) with average RoW of 15.6 meters, which satisfies the minimum requirement for Coastal Highway as per KIIFB Planning and Design Manual. Boundaries of the proposed RoW are to be demarcated with boundary stones.

3.8 Drains are also proposed wherever necessary.

3.9 Footpaths and road safety features including necessary warning signs, chevron signs, OHM, direction boards, road marking etc. are provided to avoid accidents. Provision of road furniture shall be evaluated by the TS committee prior to sanction.

3.10 Detailed drawings of the proposed bus bay and bus shelters along with chainage shall be prepared prior to TS.

4.ENGINEERING DESIGN

4.3 The pavement design has been carried out using the data from traffic study &CBR.

4.4 Detailed soil investigation report with CBR test results is furnished along with the DPR.

4.5 Pavement condition survey report is furnished along with the DPR.

4.6 CBR value of the existing subgrade varies from 24.6% to 36 %

4.7 Provision for Embankment filling is included in the estimate.

4.8 Detailed design report of horizontal curve and vertical curve shall be prepared and the same shall be evaluated by TS committee prior to sanction.

4.9 CVPD value as per traffic data comes around 450 and cumulative number of standard axle loads comes around 7.9msa. TS authority may confirm the CVPD values before according TS. TS authority may also confirm that all pavement lanes are designed on basis of the same.

4.10 The Proposed thickness of subbase GSB is 200 mm and thickness of wet mix (WMM) is 250 mm. The thickness of bituminous layers of DBM is 68mm and BC is 40mm. Design CBR value is 6% and design traffic in msa comes to 10. Pavement has been designed as per provisions in IRC 37:2012 (Plate :4) with a total thickness of 555 mm.

4.11 As per KIIFB Planning and Design guidelines, the design CBR for the roads shall be 8%. A CBR of 10 is adopted for the entire stretch.

4.12 Longitudinal and cross-sectional drawings of the proposed road to assess the quantity of cutting and filling shall be prepared prior to TS.

4.13 Full-fledged alignment plan in the required scale with all levels and chainages marked to assess the topographical features for quantity estimation of cutting and filling shall be prepared prior to TS.

5. O&M STRATEGY

5.1 Construction and maintenance of the coastal Highways in Kerala is under the control of PMU KRFB. The defects if any during the defect liability period will be done by the original project contractor with the supervision of KRFB.KRFB will stipulate necessary conditions in the agreement for the same.

5.2 The DLP period of the project will be **5** years.

5.3 All the activities in connection with the O&M strategy are explained in the DPR.

6. FINANCIAL ESTIMATES & COST PROJECTIONS

6.1 The estimated cost is based on MoRTH specifications and DSR 2016 arrived at as per PRICE with cost index of 31.06 of Kozhikode District.

6.2 As per revised DPR 4.1.1 page 88, it is mentioned that- total extent of land to be acquired is 11.79 Ha. Out of this, 8.253 Ha, nearly 70% of land is private properties and the remaining 30% is govt. own land.

6.3 After scrutiny total cost of the project as per DPR comes to **Rs 6447.00 L**

6.4 The summary of cost sought for funding and the recommended cost is provided below:

	Item	Cost as per Revised DPR(lakhs)	Recommended Cost (in Lakhs)	Remarks
1	For Land Acquisition	1010.05	1010.05	
2	For the construction of Bridge	704.19	704.19	
3	Approach road and Carriageway	3736.22	3736.22	
4	For Utility shifting	10.00	10.00	

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6	Road Safety works	398.79	398.79	
7	For GST 12%	703.12	580.71	GST for LA excluded
8	Unforeseen & LS	7.53	7.04	
9	Total	**6570**	**6447**	

Total Recommended Cost – Rs. 64.47 Cr

TS Committee shall evaluate the estimate prior to sanction.

7. COST BENEFIT ANALYSIS

7.1Cost Benefit analysis (CBA) are well detailed and documented in the report.

7.2 This route will decongest the traffic snarled in NH 66 between Kozhikode & Kannur. Also, reduction in air pollution, noise pollution, travel time savings of passengers, savings in fuel consumption etc are the benefits documented in the report.

7.3 Development of tourism will be a major benefit of the proposed project.

7.4 Cost benefit ratio worked out comes to 1.25 and EIRR is 24.63%

8.VALUE ENGINEERING OPTIONS

8.1 The alignment is selected in such a way that the land acquisition and rehabilitation will be minimum.

8.2 It is reported in the DPR that this alignment is verified by the NATPAC team.

9.IMPLEMENTATION SCHEDULE & WBS

9.1 A detailed Work Program Schedule is furnished in Annexure.

9.2As per DPR, physically the work of the project was proposed to be commenced on 02-12-19

9.3 The schedule have to be re-worked as the preparatory work itself has delayed considerably.

10.PROJECT MANAGEMENT ORGANIZATION STRATEGY

10.1 KRFB has been appointed as the Special Purpose vehicle (SPV) for the implementation of the project.

10.2 Newly formed Engineering wing of the KRFB will implement the project

11.CONTRACT MANAGEMENT STRATEGY

11.1 The strategy has been explained in the DPR.

11.2 Tenders will be invited by KRFB as per prevailing practice under two cover and normally the price of the lowest bidder will be accepted.

11.3 The work will be implemented through KRFB/PWD NH Engineering wing.

12.STATUTORY CLEARANCES

12.1 Administrative sanction has already been accorded for the construction coastal road as per GO(Rt) No 942/2017/PWD dated 10.07.2017

12.2 As the project is close to coastal belt, CRZ clearance is also inevitable.

12.3 It is reported that PWD have already moved for CRZ clearance.

13.ENVIRONMENTAL ASPECTS & SUSTAINABILITY

13.1 It is reported that the project is not coming under protected areas such as Forest/Sanctuary/National Park etc, prior clearance is not applicable under Forest Conservation Act. This shall be confirmed by the SPV as the road stretch is passing close to Arabian sea

13.2 But the project falls under coastal area and as such CRZ clearance is inevitable for the implementation of the project.

14.QUALITY MANAGEMENT PLAN

14.1Quality management plan and strategies are also covered in the DPR contemplated in the PWD manual.

14.21st tier quality management will be the responsibility of the contractor and will be done in consultation with the supervising agencies.

14.3The 2nd tier quality management will be done by the PWD through reputed lab.

14.4The 3rd tier QC checking shall be arranged by the external agency empaneled for the purpose.

15.RISK ASSESSMENT AND MITIGATION MEASURES

15.1The DPR has covered and assessed the possible risk associated with this work and suggested measures for the mitigation.

15.2 Detailed work program schedule, statement towards cash flow for mitigating financial risk, construction management strategy, strategy for utility shifting etc are covered in this report.

16.REMARKS AND INFERENCES

16.1 The project report has satisfied all the basic requirements for consideration for the financial assistance from KIIFB. The revised alignment proposal for the coastal highways in Kozhikode District have been approved by the government vide G1/196/2020-PWD dated 11/10/2020.

16.2The parameters studied as per the demand are regarding this project itself and the functional design is matching with the actual requirements and are as standards.

16.3The GAD, Horizontal and vertical design particulars are to be furnished before obtaining TS and the TS authority shall verify the same. It is to be noted by the tendering authority that the bidders require a high degree of technical inputs at bidding stage as well as during execution stage to make reliable assessment and to achieve coordination between design and execution. The estimate prepared and submitted is as per the alignment proposal & GAD and meets all the basic requirements.

16.4 The traffic considered for the stretch is same as that of the National Highway, the expected traffic through this route must be worked out before obtaining TS and the pavement design based on the expected traffic is to be got revised as per the new msa and available CBR.

16.5It is also to be ensured by the client that the estimate for the electrical work shall also be in PRICE mode.

16.6The quantity of embankment material should be verified at the time of the submission of the Detailed drawing prior to issuing TS.

16.7Rectification of defects and maintenance requirements are to be handled in a unified manner within the DLP and after expiry of DLP and a foolproof strategy to be framed before tendering.

16.8 CBR and EIRR meets the targeted standards.

16.9 The period of completion targeted is realistic and the WBS is based on the rational sequencing of activities with most likely durations. If re-scheduling is warranted the same shall be submitted to KIIFB as early as possible.

16.10 The contract management plans are acceptable provided the procedures and the documentations shall strictly be as per the prevailing norms.

16.11 The risk factors in obtaining statutory clearances from other department shall strictly be monitored by KRFB and delay avoided.

16.12 Need for environmental clearances shall also be verified and confirmed at the time of commencement of work.

16.13 The risk management plan shall be one which eliminates and mitigates all the risk factors associated with the work. It is the responsibility of KRFB to make available majority of ROW at the beginning of the execution and the timely shifting of utilities, so as to avoid possible chances of time extension.

16.14 As the design, execution and quality control of different items are to ensure by contractor also, all the personnel deployed by the contractor should be well qualified and experienced to achieve desired output.

17. RECOMMENDATIONS AND SUGGESTIONS

17.1 The project may be considered for funding by KIIFB provided the tripartite agreement shall be entered after ensuring adequate clarity in the observations 16.3 to 16.14.

17.2 In view of the replies to TAR, furnished by KRFB the amounts to be considered for sanction comes to **Rs 64.47 Cr.**

17.3 The detailed estimate shall strictly be reviewed and scrutinized by the TS authority. In order to avoid any ambiguity during execution, the TS authority should confirm that the estimate is not an inflated one, satisfies all the design standards & specifications and yardstick for various provisions are not exceeded. Also, it should be ensured that the electrical estimate is under PRICE mode.

17.4 Technical sanction is mandatory before tendering and executing agreement

17.5 The cost provisions earmarked against work alone shall be utilized for execution of work. The savings or anticipated savings from LA, QC, shifting utilities etc. shall not be re- appropriated for meeting expenditure of work proper.

17.6 The identified revenue streams if any shall be communicated while signing tripartite agreement.

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GOVERNMENT OF KERALA

Kerala Public Works Department

National Highways

DETAILED PROJECT REPORT

Construction of coastal highway in Kozhikode district from Kodikkal to Kolavipalam

`Financial Assistance from

KERALA INFRASTRUCTURE INVESTMENT FUND BOARD

Implemented through

KERALA ROAD FUND BOARD
We build track that lead to torque

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1 SALIENT FEATURES

1	Title of the project	Construction of Coastal highway from Kolavipalam to Kodikkal beach in Kozhikode District
2	Department	Public works Department
3	Details of project location	
	i. District	Kozhikode
	ii.Taluk	Kozhikode
	iii. Corporation/Municipality/Panchayath	Payyoli Municipality& Thikkodi Panchayath
	iv. Assembly Constituency	Koyilandy
4	Implementing agency/SPV	KIIFB & KRFB
5	DPR prepared by	PWD National Highway Division, Kozhikode
6	Project outlay	Construction of DBM&BC road as per the design with all road furniture Drain, Duct, Cycle Track and footpath works Traffic Safety Works: Provision of sign boards, Kerbs, delineator posts, Object Hazard Marker etc. Construction of Two Minor Bridges comes in the alignment Shifting utilities- Electricity, Telephone, Water Supply lines
7	Budget provision	
8	Budget speech reference	budget speech for financial year 2015-16
9	Administrative sanction	GO (Rt)No.942/2017/PWD dt.10.07.2017
10	Nature of the project (New Road/Improvement of existing road Strengthening of existing road/widening and Strengthening of existing road))	Construction of Coastal Highway from Kolavipalam to Kodikkal beach in Koyilandy LA constituency in Kozhikode District
11	Present status of existing roads	For a length of 2.5 km there exists a village road of 3.5 m width without footpath. In some stretches there exists mud road. The land to be acquired for the

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		Construction of this Coastal Highway
12	Need of the project	The Proposed coastal highway will be a parallel road to overcrowded NH66 and It will also boost the tourism
13	Type of road	Flexible Pavement of two lane divide carriage way
	Total length of road	7.50 Km
	Overall and carriage way widths	15.60m, 7.00 m
	Provision of footpath	1.55 m wide on both sides with 0.25m Kerb
	IRC loading class	70R
	Other details of proposed road	2m wide Cycle Track on coastal side of road (in line with carriage way),Street lights, Road furniture, Hand rails, Drain and Duct.
14	Details of investigations/surveys conducted	
	i. Topographical	Yes
	ii. Hydraulic	Yes
	iii. Geotechnical	Yes
	iv. Traffic	Yes
	v. Others	
15	Whether Land Acquisition involved? If yes, furnish details	Yes,
16	Total estimated cost and item wise cost break up and details of Schedule of Rates	116 Crores SOR 2016
17	Whether detailed estimate attached?	Yes
18	Details of revenue streams	KIIFB
19	Details of Cost Benefit Analysis (CBA value)	Attached
20	Details of project risks	Land acquisition Timely shifting of utilities Public involvement Availability of construction materials Mandatory approval and clearance from authorities like CRZ
21	Details of project management organization strategy	Work to be implemented through KRFB and Work to be executed by National Highway wing of Kerala

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		PWD
22	Details of contract management strategy	Work to be executed by competent and approved contracting firms through open competitive tender
23	Details of Project Implementation Schedule (PIS) & Work Breakdown Schedule (WBS) - Proposed duration to complete the project	Expecting the work to start during the financial year 2019-2020 and complete by 2021-22 Duration of project- 19 months
24	Details of statutory clearances	Will be obtained from concerned departments before execution of work
25	Quality control infrastructure and mechanism	Quality Control mechanism will be as per the PWD Quality Control Manual. Contractor has to set up Quality Control lab and responsible for 1st tier QC, 2nd and 3rd tier QC to be done/monitored by QC wing of PWD as
26	Operations & Maintenance (O&M) arrangements of the project after completion	Defect liability period is 36 months after completion of project
27	Details of attached drawings	General Alignment Drawing Design drawings
28	Other attachments	LA Plan and Proposal.

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2 EXECUTIVE SUMMARY

2.1 GENERAL

Government of Kerala has accorded administrative sanction for the construction of coastal highway vide GO (Rt)No.942/2017/PWDdt.10.07.2017. The construction of Coastal highway from Kolavipalam to Kodikkal beach in Payyoli municipality and Thikkodi Panchayath in Kozhikode district comes in the alignment of above proposal.

Kozhikode formerly known as Calicut is a coastal and metropolitan city in the south Indian state of Kerala. Kozhikode is the third-most-populous town and the largest urban area in the state and 192nd largest urban area in the world. The city lies about 374 kilometres north of 'Thiruvananthapuram' the state capital.

The proposed coastal highway from Kolavipalam to Kodikkal beach is a part of road which connects the Vadakara and Koyilandy taluks. Vadakara and Koyilandy are coastal towns in Kozhikode district. Vadakara has great historical importance. Historically Vadakara has been known as Kadathanadu. There are many tourist places such as Sargalaya, Sandbanks, Kunhali Marakkar Museum and Velliyamkallu.

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorised to implement the proposed coastal highway project in Kozhikode district.

Kerala has a network of 11 National Highways, 72 state highways, many district roads and is having a long stretch of coastal line. Kerala has narrower national highways compared to other parts of India; hence the present road network is not in a position to accommodate the increasing traffic. So the government has been planning to revive the coastal highway project that runs parallel to the National Highway 66 to reduce the traffic

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conjunctions. The alignment of the proposed Coastal Highway which will traverse through nine districts from Thiruvananthapuram in the south to Kasaragod in the north of Kerala state. The project is conceived not just to meet the transportation need of the state, but also to develop the coastal economy and living standards of the community living there.

The Kerala coast is 590 km long, laying in the direction of North-Northwest to South-Southeast, with many special features like sea cliff formed by the action of waves on the coast. Distributed on the coast, there are long patches of sandy beaches. The coast acts as major resource for coastal tourism development in the state. Nine out of fourteen districts of Kerala have coastline. Construction of coastal highway in Kerala is taken as a Government Policy. The coastal highways since it passes through the coastal area will provide better connectivity between fishing harbours and fish landing centres which will be giving a major savings in fuel costs and will promote tourism. It is seen that the traffic is increasing at a rate of 7% per year and the major corridors of the district are presently suffering from traffic congestion through most hours of the day.

As per the feasibility study report submitted by NATPAC the proposed length of the coastal highway is 657Km in which a length of 80.12 Km falls in Kozhikode District. The coastal highway project has been divided into three phases. And the construction of coastal highway from Kolavipalam to Kodikkal beach is comes under first phase of project. It is having a total length of 7.5 Km which is planned along the coastal belt of Payyoli municipality and Thikkodi Panchayath. The proposed coastal highway is almost parallel to the National Highway 66. It is expected to divert a major share of the traffic from the National Highway on completion and is also aimed at improving the road connectivity of the coastal belt of the State for the tourism development, transshipment of goods and sea foods. Besides reducing the congestion in the National Highway corridors and in the cities, the Coastal Highway is expected to boost the tourism sector and help better integration with various other modes of transport, especially water transport.

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Since the proposed road is to be constructed in the coastal line it is necessary to obtain permission from **C**oastal **R**egulation **Z**one. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in this stretch.

2.2 PROJECT DESCRIPTION

The newly proposed Coastal highway from Kolavipalam to Kodikkal beach has two lanes having total length of 7.5 km. The recommended width of the proposed coastal highway is 15.6 meters. While the carriage way will be 7m wide with two footpaths each having 1.5m width will be constructed on both sides of the road. And pedestrian guard rails shall be provided on both sides of the carriage way along the edge of the footpath. More over a 2m wide Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors. As the road passes through an entirely new alignment, geometry of the road has been designed as per the IRC standards. The proposed alignment is a green field alignment. The alignment in this stretch is fixed in a way that. the land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum.

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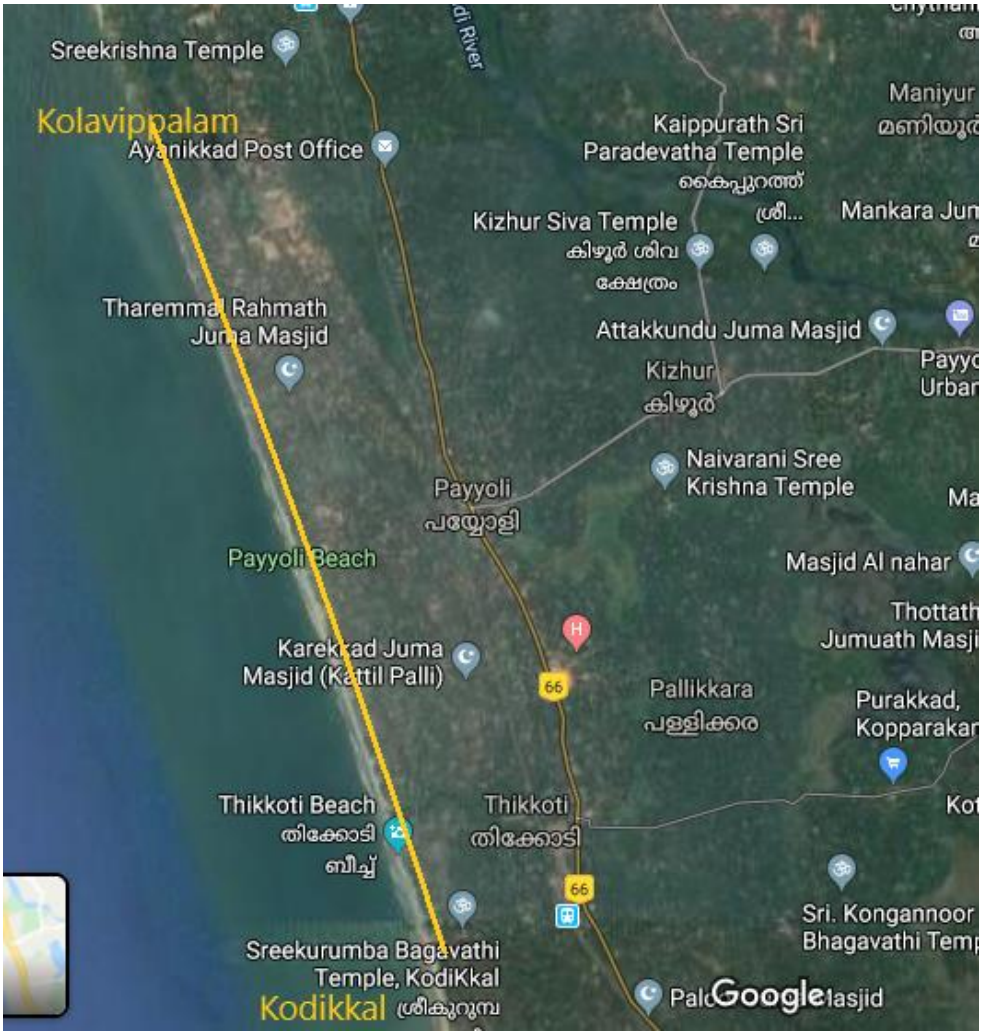

Figure 2.1 Location of the proposed road

2.3 APPROACH AND METHODOLOGY

Our Approach towards the project is in accordance with the project objectives and MoRT&H guide lines. All activities related to field studies, design and documentation are done as per the latest revisions and amendments of relevant guidelines of MoRT&H, referring to the publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS) and 'Guidelines for Planning and Design for Roads & Highway Projects Funded by KIIFB'

2.4 NEED FOR THE PROJECT

Kerala's coastal belt is relatively flat, teeming with paddy fields, groves of coconut trees and heavily crisscrossed by a network of interconnected

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canals and rivers. The Kerala coastal area is the centre for many economic activities like agriculture, aquaculture, fishing, fish processing industry, chemical industry, mining and tourism. Beaches and backwaters are the major attraction of the tourists in this area.

The motor transport sector is an important and integral part of the State economy. The growth of vehicle population in Kerala is eight per cent over the previous year. The growth of motor vehicles creates traffic congestion and pollution. The proposed road is an alternative route to National Highway 66 from Kozhikode to Vadakara. There will be savings in time and fuel, if vehicles can ply over the new road without stopping and waiting.

The coastal highway project was designed not only as a mere road project but as means to transform the coastal economy of the state. It will serve as a second transportation route for container and goods movement from major and other minor ports of the state. And it will also provide a boost to the tourism sector relying on its beautiful beaches and coasts.

The road from Kolavipalam to Kodikkal beach passes along the coastal belt of Payyoli municipality and Thikkodi panchayath. The proposed road is planned almost parallel to the National Highway 66 to divert a major share of the traffic from the National Highway. Development of the road into a coastal highway standard can help the passengers to travel without traffic congestion in addition to the tourism development. There will be savings in time and fuel, if vehicles can move without stopping and waiting. More over a 2m Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

The proposed road is a link which connects the two taluks Vadakara and Koyilandy. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali marakkar memorial museum is located at kottakkal which is very near to the kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly

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and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

2.5 SURVEY AND INVESTIGATION FOR DESIGN

All activities related to field studies design and documentation are done by National Highway By pass Sub-Division Kozhikode as per the latest revisions and amendments of relevant guidelines of MoRTH, referring the publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). International standard practices have been followed for aspects not covered under IRC / BIS All notations, abbreviations and symbols used in the reports, documents and drawings are as per IRC: 71-1977 the latest edition with amendments.

2.6 QUALITY ASSURANCE PLAN

The provisions of the IRC SP-19-2001, "Manual for survey, investigation and preparation of road projects" have been adhered for the rectification of the Design Engineering and report preparation of this project. For the quality control during execution of the project latest version of "PWD Quality Control Manual" and relevant IRC codes and BIS standards will be followed.

2.7 REVIEW OF DATA AND DOCUMENTS

All the available data and information relevant for the study, like climate, road inventory, geotechnical data etc. have been collected and analysed.

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2.8 TRAFFIC SURVEYS

Traffic data is collected as per IRC: SP 19-2001. The traffic survey location for conducting the traffic volume count was identified at Puthiyappa as the location resemblance to the proposed Alignment and Puthiyappa is also a part of coastal highway. A volume counts for 3 days within 10th April 2018 to 12th April 2018 was taken for 24hrs duration each. The method adopted was manual Classified Traffic Volume Count. Traffic surveys have been carried out on the project corridor in order to identify present and likely future scenarios so as to device suitable remedial measures and to evolve appropriate design method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement over the road.

2.9 RECONNAISSANCE AND ALIGNMENT

An in-depth study of the available land width (ROW), topographic maps, satellite imageries etc. have been done for the project area. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in this stretch. The detailed ground reconnaissance was taken up immediately after the study of maps and other data collected.

The proposed coastal highway from Kolavipalam to Kodikkal beach passes along the coastal line of Payyoli municipality and Thikkodi Panchayath in Kozhikode district. Kolavi beach at Payyoli is a beautiful stretch that border Velliyamkallu, the rocky island which can be reached by 1-hour boat drive. The rare species of olive ridely turtles are found in Kolavipalam beach side. The proposed coastal highway may enhance the possibility of Thikkodi drive-in-beach.

The proposed road is a link between the two taluks Vadakara and Koyilandy. Vadakara Sand banks beach is where locals and tourists throng to view the confluence of the Kuttiyadi River and Arabian Sea. Kunhali marakkar memorial museum is located at kottakkal which is very near to the kolavipalam. Sargalaya arts and craft village is an initiative of Department of

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tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

Some portions of the beach in the proposed locations are protected by sea wall. The houses in the beach side are mostly made of brick and lime/cement walls and clay-tile roofs. Traditionally there occupies a fishing community. Like any other typical coastal village, this community too draws its major source of income from fishing in the sea. And the seashell mining is also added to the small incomes of some of the families. Mainly coconut plantations are occupied in the spaces between the houses and the beach stretches.

Figure 2.2 Proposed Project Location

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2.10 TOPOGRAPHIC SURVEYS

The basic objective of the topographic survey was to capture the essential ground features along the alignment identified during the reconnaissance survey, for finalizing the alignment. The cost of improvements, rehabilitation and upgrading also can be worked out based on details from topographic survey. A length of 7.5 Km along the road was surveyed using total station, a precision instrument required for finalizing alignment along the proposed route. Longitudinal sections and cross sections have been prepared on the basis of the detailed topographic surveys conducted.

2.11 GEOTECHNICAL INVESTIGATIONS AND SUB SOIL EXPLORATIONS

CBR test and all other relevant laboratory and field tests on soil samples obtained were conducted. The CBR test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. For determining the CBR ratio, the measured pressure is then divided by pressure required to achieve an equal penetration on a standard crushed rock material. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

As the alignment passes through the coastal belt, Sub soil boring has been taken at every 1km in the entire stretch of the proposed road to a depth of 15m for obtaining a good idea about the sub soil. This has been considered for making decision regarding the soil improvement methods and protection works.

2.12 DESIGN STANDARDS OF ROAD AND PAVEMENTS

Design Standards and material specifications have been evolved, primarily from IRC publications and MoRT&H specifications. The Design Standards evolved for the project have covered all aspects of detailed design

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including the design of geometric elements, design of road, pavement design, traffic safety, drainage system and materials.

Pavement Design of the proposed road has been done according to IRC 37 (code for Tentative Guidelines for the Design of Flexible Pavements), IRC 067 (Code of Practice for Road Signs) and

IRC: 35-1997 Code of Practice for Road Markings. For pavement design CBR for the filled earth has been assumed as 9%.

2.13 ESTIMATION OF QUANTITIES AND PROJECT COSTS

Detailed estimates for quantities (considering designs and conveyance of materials) and the project cost (civil packages wise), including the cost of environmental and social safeguards, have been taken based on MoRT&H's Standard Data Book, latest Kerala PWD schedule of rates and PWD Project Information and Cost Estimation (PRICE) software. The estimation of quantities is based on detailed design of various components of the projects. The estimation of quantities and costs are worked out separately for each civil work Package. The total project cost comes to Rs 116.00 crores

Table 2.1 Abstract of Total Project Cost

Sl No	Heading Description	Amount
1	Road Work	539923604.36
2	Retaining wall	25086750.00
3	Bridge Work	140552525.69
4	Traffic Safety	72582319.81
5	Cross drainage work	13501079.45
6	Utility Shifting	1000000.00
7	Land Acquisition - cost of land	188287662.00
8	Land Acquisition Procedures @ 5% of cost of land	9414383.00
9	CRZ and other clearances @ 5 % of the estimate cost	39587314.00
Estimate Total		**1029935638.32**
GST @12%		123592276.60
Lumpsum Roundoff		6472085.08
Rounded Total		**1,16,00,00,000**
Rupees One Hundred and Sixteen Crore Only		

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2.14 COST BENEFIT ANALYSIS

Though the construction of coastal highway brings about a variety of benefits enjoyed practically by all sectors of the society, the prevailing condition of resource scarcity necessitates an economic evaluation of projects so that only the projects which are worth be taken up for implementation. The Indian Roads Congress special Publication No.30, Manual on Economic Evaluation of Highway Projects, contains the detailed procedures for economic evaluation and that is referred as guidance. The Economic Cost of the road works out to Rs 8239.48 lakhs against the Financial Cost of Rs. 10299.35 lakhs. The coastal highway project has various benefits and costs, which can be expressed in monetary terms, and which are difficult to be expressed in monitory terms. The period of analysis is taken as 20 years. All social benefits and costs possible to be expressed in monitory terms in accordance to IRC: SP: 30-2009 are tabulated and analysed. From the analysis, the road yields a Cost Benefit Ratio of 1.252 and Economic Rate of Return of 28.36 %.

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3 CHAPTERS

3.1 INTRODUCTION

3.1.1.1 General

Kerala is fairly well networked in the matter of transport. With a well-connected road network a rail the connecting all but two districts of the State, four international airports (at Thiruvananthapuram, Cochin ,Kozhikode and Kannur), National Waterway III consisting of the vast stretches of backwaters and canals, 17 seaports, international Transshipment Container Terminal at Vallarpadam, Cochin, Vizhinjam deep sea Transshipment Container etc., Kerala is poised to become the commercial and travel hub not only to the country but to the world all over. Kerala can be proud of having developed a good road network compared to other states in India. At present Transportation Infrastructure of Kerala consists of 3.72 Lakh km of road, 1257 km of railways, 1687 km. of inland waterways, 111 statute miles of airways and 18 ports. Even though it is comparatively better placed than most of the other states as regards to the road length, the quality and service level of many of these roads are poor.

During classical antiquity and the Middle Ages, Kozhikode was dubbed the "City of Spices" for its role as the major trading point of eastern spices. It was the capital of an independent kingdom ruled by the Samoothiris (Zamorins) in the Middle Ages and later of the erstwhile Malabar District under British rule. Arab merchants traded with the region as early as 7th century, and Portuguese explorer Vasco da Gama landed at Kozhikode on 20 May 1498, thus opening a trade route between Europe and Malabar. A Portuguese factory and fort was intact in Kozhikode for short period. the English landed in 1615 (constructing a trading post in 1665), followed by the French (1698) and the Dutch (1752). In 1765, Mysore captured Kozhikode as part of its occupation of the Malabar Coast. Kozhikode, once a famous cotton-weaving centre, gave its name to the 'Calico cloth'.

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The proposed road is a link between the two taluks Vadakara and Koyilandy. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali Marakkar memorial museum is located at kottakkal which is very near to the Kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

Figure 3.1 View of Sargalaya

The construction of Coastal highway from Kolavipalam to Kodikkal beach passes along the coastal belt of Payyoli municipality and Thikkodi Panchayath. Kolavipalam also known as Kotta Kadapuram, is located in Iringal village of Payyoli municipality in Quilandy taluk of Kozhikode District. Kolavipaalam beach is situated 46 km north of Kozhikode. The nearest town is Payyoli, presently which can be reached by private buses plying from Kozhikode.

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A good infrastructure facility is an essential pre-requisite for the growth and development of a region. Government of Kerala has decided to construct coastal highway along the coastal belt of Kerala. For the above work the fund will be allotted by KIIFB. For implementing the project KRFB is entrusted as SPV. National highway wing of Public Works Department will be executing the Project. At road junctions, considerable time is lost due to traffic congestions during signals. The traffic congestion resulting from the stop signal increases the loss towards fuel and precious time of lots of people.

Based on the Economic Review Report 2015, the total road length in Kerala increased from 3,31,372.261 Km in 2014-15 to 3,72,472.216 Km in 2015-16 Road density in the state is 8534 Km./100 sq.km. and the far ahead of the national average of 387 Km./100 sq.km. Road transport acts as the feeder service to rail, air and inland water transport. The vehicle density of the State is very high compared to many other States in India. The road freight services in the state are wholly owned and operated by the private sector. The transport system in Kerala is consumer oriented and passenger movements account for major portion of transportation. Goods transport in the State is mostly carried out through road transport. The tremendous increase in volume of road traffic in recent years caused increase in road accidents. The high vehicle population along with the under developed road network has resulted in high vehicle operating cost (VOC) and high level of environment pollution and road accidents.

Even though Kerala is graced with a good network of transportation the lack of a reliable and efficient road transport which is the feeder service to all other system, has adversely affected the growth prospects of the State. The inability to develop good quality transport infrastructure has stagnated both industrial and service sector and the GDP growth. Kerala State has got nearly 3% of the country's population, but it has recorded nearly 12% of country's road traffic accidents. The increasing trend of road accidents is a matter of great concern. The accident rate of Kerala is the highest in the country with 15 accidents per 1000 vehicles, twice that of all India average.

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Even bigger States the Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan and Andhra Pradesh have reported far less number of accidents compared to Kerala. Having got an average, better than the national and still lagging behind in the quality of the roads is a very serious concern of the public.

3.1.1.2 Transport and Industrial

Generally, two transportation objectives are usually taken into consideration when firms make their choices of location namely: 1) low transportation cost and 2) satisfactory transportation service. Firms that consider transportation cost to be of major significance usually locate at places where the cost of supplying raw materials is minimized. Availability of an effective and efficient (satisfactory) transport system is also important to firms as it helps facilitate production by increasing accessibility and mobility.

When these two transportation objectives (low transportation cost and satisfactory transportation service) are available in regions, there is high attractiveness to investors because they are assured of lower distribution cost and improved access for both employees and customers. Thus, investing in transport yields growth in a number of firms and expansion of the already existing ones and firm growth implies more job opportunities.

Expansion of existing firms will lead to greater profitability and or increased market share, and as a result, employment and income will increase as the firms grow. Furthermore, expansion of existing businesses together with the just-created ones will demand more raw material and components from their suppliers. Retail and wholesale businesses can expand as employees will spend more as a result of their additional income.

3.1.1.3 Socio-Economic-Significance of Transports:

Transport system is catalyst of the Socio-economic development.

1. Promotes industrialization.
2. Provides access to rural area.

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3. Provides the vital linkage between production and consumption.
4. Is the key factor to link dispersed areas.
5. Increase the economic efficiency of resources.
6. Provides mobility of labour and boost Tourism Industry.
7. Creates competitive environment.
8. Promotes social welfare.
9. Helps to stabilize prices.
10. Curbs monopoly of the trader.
11. Discovery of new market.
12. Provides large employment opportunities.
13. Adequate transport facilities in a country help to combat the natural calamities.
14. Is helpful in funding revenue to the Govt.

Traffic congestion, longer travel time and high level of air pollution are just some of the growing problems faced by the people today. The intensity of traffic in the State High ways, National Highways as well as in the Major District Road is very high; it not only delays the traffic but also invites fatal accidents.

3.1.1.4 Aim and Significance

The coastal highways since it passes through the coastal area will provide better connectivity between fishing harbors and fish landing centers which will be giving a major savings in fuel costs and will promote tourism. It is seen that the traffic is increasing at a rate of 5% per year and the major corridors of the district are presently suffering from traffic congestion through most hours of the day.

The road from Kolavipalam to Kodikkal beach passes along the coastal belt of Payyoli municipality and Thikkodi panchayath. The proposed road is planned almost parallel to the National Highway 66 to divert a major share of

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the traffic from the National Highway. Development of the road into a coastal highway standard can help the passengers to travel without traffic congestion in addition to the tourism development. There will be savings in time and fuel, if vehicles can move without stopping and waiting. Also, road accidents can be considerably reduced once the vehicle starts plying through the new road. More over a 2m Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

The above factors necessitate the formation of the coastal highway as per MoRTH standards.

3.1.2 PROJECT DEFINITION, CONCEPT AND SCOPE

An in-depth study of the available land width (ROW) using topographic maps, satellite imageries etc. have been done at the proposed road location. Other available relevant information is collected for the proposed Green field alignment. Having received the information needed efforts is made for minimizing land acquisition and number of families to be rehabilitated as far as possible. The detailed ground reconnaissance was taken up immediately after the study of maps and other data collected from various sources.

3.1.3 PROJECT BACKGROUND

3.1.3.1 General

Government of Kerala has accorded administrative sanction for the construction of coastal highway vide GO (Rt)No.942/2017/PWD dt.10.07.2017. The proposed coastal highway from Kolavipalam to Kodikkal beach is a link between the Vadakara and Koyilandy taluks in Kozhikode district comes in the alignment of above proposal.

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorized to

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implement the proposed coastal highway project in Kozhikode district. On behalf of KRFB National Highway Bypass Sub Division Kozhikode has done detailed investigation and prepared Detailed Project Report for the construction of coastal highway from Kolavipalam to Kodikkal beach for onward submission to KIIFB for approval.

3.1.3.2 Road construction Background Information

The coastal highway project first began with a study conducted by National Transportation Planning and Research Centre (NATPAC). The newly proposed coastal highway from Kolavipalam to Kodikkal beach passes along the coastal belt of Payyoli municipality and Thikkodi in Kozhikode district, which holds vast potential in the tourism.

The proposed coastal highway stretch has two lanes and a total length of 7.5 Km. The recommended width of the proposed coastal highway is 15.6 meters. While the carriage way will be 7m wide with two footpaths each having 1.55m width will be constructed on both sides of the road. More over a 2m Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

3.1.3.3 Materials for Construction

On the sea side gabion retaining walls is proposed for the construction of embankment. The soils on both the sides are of sandy nature and unequal settlements are expected at this region. In order to overcome the damages due to this gabion retaining walls are proposed.

Dense Bituminous macadam and bituminous concrete provided as per IRC 35, codes for guidelines on design of flexible pavement. For the construction of duct, drain and footpath RCC grade M20 is proposed.

Samples of 20mm broken stone, M sand WMM and GSB has been collected from different quarries and put under testing. Most suited and relevant to corresponding codes has been identified. Test results have been kept as appendix VI.

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As the locality is very near to sea and is of saline nature, the water for all construction activity and curing purpose has to be collected from Payyoli cheerp. Test results have been kept as appendix VI.

For ensuring the quality of concrete, contractor can arrange a ready mix plant in the vicinity of project area.

All the concrete works has to be carried out in an extreme exposure condition it is also recommended to use PSC grade cements for underground structures.

3.1.3.4 Additional works

- The carriage way parameters are designed based on field data and projected 20-year traffic.
- Required road furniture like mandatory/cautionary and informatory signage is proposed in the estimate. Road marking with retro reflective point at center, edge line and reflective studs are proposed in the estimate based on Road Safety Audit. 2m wide cycle track is provided along the carriage way
- footpath having 1.55m width will be constructed on both sides of the road along with the kerb
- The minimum land acquisition for the construction of proposed road
- Steel handrail will be provided at the outside wall of foot paths for the safety of pedestrians.

3.1.4 PROJECT DETAILS

The road from Kolavipalam to Kodikkal beach passes along the coastal belt of Payyoli municipality and Thikkodi panchayath in Kozhikode District. The road can be a connecting link in the proposed Coastal highway. The tourism and fisheries sectors in the district are likely to get a boost with the construction of Kolavipalam to Kodikkal beach road.

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The coastal highway which is planned almost parallel to the national highway 66 is also expected to divert a major share of the traffic from the NH on completion. The land to be acquired and the number of families to be relocated for the construction of proposed road is minimum. The newly proposed coastal highway has two lanes and a total length 7.5 Km along with 1.55 m footpath on both sides and a cycle track of 2m wide on costal side.

The proposed road is a link between the two taluks Vadakara and Koyilandy. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali marakkar memorial museum is located at kottakkal which is very near to the Kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

This project helps a major growth to the tourism industry in the area with the development of coastal highway. Some portions of the Kolavipalam beach in the proposed locations are protected by sea wall. The houses in the beach side are mostly made of brick and lime walls and clay-tile roofs. Traditionally there occupies a fishing community. Like any other typical coastal village, this community too draws its major source of income from fishing in the sea. And the seashell mining is also added to the small incomes of some of the families. Mainly coconut plantations are occupied in the spaces between the houses and the beach stretches.

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3.1.5 OBJECTIVE AND SCOPE OF THE WORK

3.1.5.1 Objective

The main objective of the work is to establish the technical and environmental viability of the project with a view to construct a coastal highway from Kolavipalam to Kodikkal beach and to prepare the detailed project reports with designs estimates and drawings. The major objectives covered under the proposal are

- Engineering and economic studies of the proposed road
- Engineering design of proposed road
- Estimate the cost of the project
- Cost benefit analysis
- Detailed Project Report for construction of Kolavipalam to Kodikkal beach road
- Land acquisition proposal

3.1.5.2 Scope of the Work

- To carry out reconnaissance survey to assess all the engineering characteristics of the existing project including but not limited to carriageway details, geometrics, terrain, soil and drainage condition and cross drainage details.
- To assess and forecast traffic using data from traffic studies and Reports
- To carry out surveys to identify sources of materials having adequate quantity and quality required for the works
- To carry out preliminary design for the project.
- To prepare cost estimates with prevailing schedule of rates

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- To identify utility services and their likely cost of shifting based on the rates of the respective utility agencies.
- To prepare GAD for road and other structures
- To prepare alignment plan and profile.
- To carry out all engineering surveys in detail viz. topographical, geo-technical, traffic etc. along the accepted alignment and requisite tests of the materials at identified sources to ensure quality & quantity of materials.
- To carryout economic evaluation of the project improvements based on road user cost analysis.
- To acquire the land for the construction of road and its components from private land owners.

3.2 STATUS FEASILBILTY STUDIES

During the initial stage of Discussion of Coastal Highway, the alignment was proposed along the existing village road by NATPAC. During the preliminary investigation it is found that the proposed alignment was having large number of 90degee curves as all these roads has been developed from footpaths. More over this alignment is passing through thickly populated area which invites large scale of rehabilitation process.

Considering all these alternate green field alignments along the costal belt was identified and discussed with MLA and other public representatives. This alignment is widely accepted.

3.3 REQUIREMENT/ DEMAND ANALYSIS

Kozhikode or Calicut is a city in the state of Kerala in southern India on the Malabar Coast. It is the third most populous city in the Kerala state. The proposed road from Kolavipalam to Kodikkal beach lies in coastal belt of

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Vadakara in Kozhikode district. It also connects the two taluks namely Vadakara and Koyilandy.

Historically Vadakara has been known as Kadathanadu. This place has a great cultural heritage. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali marakkar memorial museum is located at kottakkal which is very near to the Kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

Vadakara is also an important trade center other than Kozhikode. The traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this road. People from the nearby Panchayath depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion.

Area near by the project location, especially Kolavipalam beach portions in the proposed locations are occupied by fishing community. Like any other typical coastal village, this community too draws its major source of income from fishing in the sea. And the seashell mining is also added to the small incomes of some of the families. Beneficiaries of this project includes all the above including the daily commuters. The project will have much positive impact for the beneficiaries in terms of saving in travel time, safety, tourism developments and finally it will lead to overall development of the area.

Overhead and underground power cables, water line, telecommunication line, etc. which come in the way of the road alignment

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have to be relocated or re-routed before the commencement of the project. Prior information to be given to concerned departments and the people of the affected area before the start of work. The information to public regarding the work will be given though paper notification.

3.4 ENGINEERING SURVEYS AND INVESTIGATIONS

3.4.1 TOPOGRAPHIC SURVEY

3.4.1.1 GENERAL

The basic objective of the topographic survey is to capture the essential ground features along the alignment in order to consider improvements and for working out improvements, rehabilitation and upgrading costs. The detailed topographic survey was taken up after the completion of reconnaissance surveys.

The work of topographic survey has been entrusted to M/s RTF Infra Pvt.Ltd.,Trivandrum. Sufficient area near the Road was surveyed for a length of 7.5 Km along road using total station, a precision instrument required for finalizing alignment along the proposed route. Longitudinal sections and cross sections have been prepared on the basis of the detailed topographic surveys conducted.

3.4.1.2 Standards and Codes of Practises

All activities related to field studies, design and documentation are done as per the latest revisions and amendments of relevant guidelines of MoRTH and publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). For aspects not covered by IRC and BIS, international standard practices are followed. All notations, abbreviations and symbols used in the reports, documents and drawings shall be as per IRC: SP 19-2001

3.4.1.3 Quality Assurance Plan

The provisions of the IRC: SP 19-2001 (Manual for survey, investigation and Report preparation of Road Projects) have been adhered to.

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3.4.1.4 Survey

The topographic survey is one of the most important and crucial field tasks under the project. The detailed field survey is carried out using high precision instruments i.e. Total stations. The data from the topographic surveys is made available in (x, y, z) format for use in a sophisticated digital terrain model (DTM). The survey plan is attached. The detailed field surveys essentially included the following activities.

- Topographic Survey along the alignment options identified in the reconnaissance survey for sufficient width of 50m (at least two times the width of proposed Right of Way as required for finalizing alignment) by running a continuous open traverse along the proposed alignment, and fixation of all cardinal points such as horizontal intersection points (HIP's), centre points and transit points etc. and properly referencing the same with a pair of reference pillars fixed on either side of the centreline at safe places within the Right of Way.
- Collection of details for all features such as structures (bridges, culverts etc.) utilities, existing roads, demarcation stones, electric and telephone installations, buildings, fencing and trees (with girth greater than 0.3 metre) etc. falling within the extent of survey.

3.4.1.5 Longitudinal and Cross Sections

- The topographic surveys for longitudinal and cross-sections cover the following:
- Longitudinal section levels along final centre line at suitable locations of curve points, small streams, and intersections and at the locations of change in elevation.
- Cross sections at required interval in full extent of survey covering sufficient number of spot levels on the proposed bridge location and adjacent ground for profile correction course and

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earth work calculations. Cross sections shall be taken at closer interval at curves.

- Longitudinal section for cross roads for length adequate for design and quantity estimation purposes.
- Longitudinal and cross sections for river

Recommendations contained in IRC Special Publication No. 13 (Guidelines for the Design of Small Bridges and Culverts), IRC 35 (code for Road Markings), IRC 67 (Code of Practice for Road Signs) and IRC 37(guidelines on design of flexible pavement). Detailed topographic survey was conducted along the alignment of the proposed road from Kolavipalam to Kodikkal beach.

3.4.2 SOIL INVESTIGATION

Soil investigation surveys were carried out on all the selected corridors. The trial pit investigation surveys will show the composition of the existing layers and the sub grade soil collected was used to estimate the CBR vale of under laying soil. The CBR test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. For determining the CBR ratio, the measured pressure is then divided by pressure required to achieve an equal penetration on a standard crushed rock material. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

As the alignment passes through the coastal belt, Sub soil boring has been taken at every 1km in the entire stretch of the proposed road to a depth of 15m for obtaining a good idea about the sub soil. This has been considered for making decision regarding the soil improvement methods and protection works.

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3.4.3 TRAFFIC SURVEYS AND ANALYSIS

3.4.3.1 Introduction

Traffic studies are the initial step of any Road project. These studies play important role in fixing components such as carriage way width, lane width etc. Since the project is through a new alignment the traffic census taken at Puthiyappa which is a point in the existing coastal highway stretch in Kozhikode District is used for analysis and design purpose. Survey is conducted for three days and 24 hours in April 2018. The procedure for conducting survey and the data collection are briefly dealt in following sections

3.4.3.2 Project Background

The proposed coastal highway from Kolavipalam to Kodikkal beach connects Vadakara and Koyilandy taluk in Kozhikode district which can be a connecting link in the proposed Coastal highway.

Vadakara is also an important trade center other than Kozhikode. The traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this road.

People from the nearby Panchayath depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion. Area near by the road is a developing fish landing center and tourism sector. Beneficiaries of this project includes all the above including the daily commuters.

The tourism and fisheries sectors in the district are likely to get a boost with the construction of Kolavipalam to Kodikkal beach along coastal highway in Koyilandy taluk in Kozhikode district.

The coastal highway which is planned almost parallel to the national highway 66 is also expected to divert a major share of the traffic from the NH on completion. Hence, the road accidents can be considerably reduced once the vehicle starts plying through the new road. The land acquisition for the

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construction of road is minimum and there is no direct effect on residential, commercial buildings and other establishments.

This project helps a major growth to the tourism industry in the area with the development of coastal highway. Vadakara sandbanks, kunhali marakkar museum, Sargalaya arts and crafts village and boating facilities at Kottakkal are major destinations along this coastal line.

Traffic census data reveals that PCU is 9235 at the location. Cycle tracks are recommended along the proposed road to offer a high degree of safety and to promote tourism. This track separates the cyclist from motorized traffic. In proposed road a modern bus shelter unit with toilets, police aid post, cafeteria etc are provided which increases passenger comfort and revenue

3.4.3.3 Purpose of Traffic Study

Traffic surveys have been carried out on the project area in order to identify suitable remedial measures and to evolve appropriate design method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement along the road. All the traffic surveys and further analysis is carried out as per the guidelines given in IRC: SP 19-2001, IRC: 108-1996, IRC SP: 41-1994, IRC: 102-1988 and IRC: 09-1972. For making the proper assessment of traffic volume, base year traffic and its projection necessary traffic surveys and investigations are carried out in the location. The base year traffic data is the primary input for determination of future traffic demand. With a view to estimate the base year traffic volume in respect of goods and passenger carrying vehicles, the Classified Traffic Volume Count (CTVC) Survey was conducted. For the purpose of traffic estimation and projections, the year 2018 is taken as the base year.

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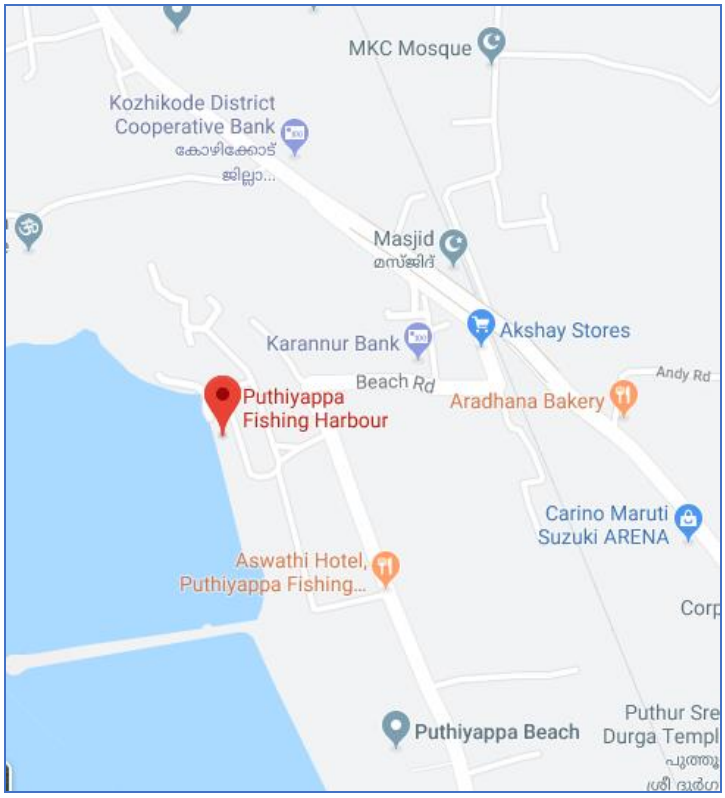

Figure 3.2 Traffic Survey Location

3.4.3.4 Traffic Survey Schedule

The survey schedule was prepared as per the requirements of the study. The schedule of Traffic Surveys and locations are given in Table 3.1

Table 3.1 Schedule of Traffic Surveys

Item No.	Type of Survey	Survey Location	Direction	Duration	Date of Survey
1	Classified Traffic Volume Count Survey (CTVC)	Near Puthiyappa Harbour	Kozhikode to Kannur & Kannur to Kozhikode	3 Days, 24 hours	10-04-2018, 11-04-2018, 12-04-2018

The traffic survey is carried out in accordance with the guidelines specified by IRC: 9-1972 and IRC: 102-□□□□□T□□ □ □□□odo□o□y adop□□d □or □□□ □ra□□□ □□□dy □□d□□a□□d □□□o□

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3.4.3.5 Methodology Adopted For Traffic Surveys

3.4.3.5.1 Classified Traffic Volume Count (CTVC) Survey

The Classified Traffic Volume Count survey was conducted at proposed road. The count was conducted for 3 days and 24 hours as per IRC: SP: 19 – 2001, 'Manual for Survey, Investigation and Preparation of Road Projects'. Fig 3-2 shows the traffic survey location for carrying out the traffic count survey. The vehicles were grouped under the following categories as given in Table 3-2. For the purpose of smooth counting, a day was divided into three shifts of 8 hours each and groups of enumerators with a supervisor were assigned for each shift in both directions.

Table 3.2 Vehicle Classification System (Fast & Slow)

Fast moving vehicles	
Two wheelers: Motor Cycle, Scooter etc.	
Car/ Jeeps/ Taxies/Van/Three Wheelers (Autorickshaw)	
Passenger Car	Car, jeep, taxi & van (Old & new technology vehicles)
Bus	Mini Bus
	Govt. Bus
	Private Bus
	Two axle truck and Tanker
	Multi axle trucks, tanker trailors etc.
Other Vehicles	Agriculture Tractor, Tractor & Trailer
Slow moving vehicles	
	Bicycle
	Cycle Rickshaw
	Animal drawn (Bullock cart/Horse cart/)

3.4.3.6 Data Analysis

The classified traffic volume survey data of coastal highway from Francis road junction to Puthiyappa in Kozhikode District, Proposed Road location is analysed in order to obtain the following traffic characteristics:

- Average Daily Traffic (ADT) Volume
- Average Hourly Variation of Traffic Volume
- Daily Variation of Traffic volume

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- ➢ Peak Hour Factor
- ➢ Average Composition of Traffic

Daily and hourly variation of classified traffic flow is recorded by conducting 3-day continuous traffic count at Puthiyappa which is a location in the existing beach road in Kozhikode District and □□ra□□d □ro□ IRC□□□ – □990, 'Guideline□ □or Capa□□y o□Road□ □n Rural Areas'.

Table 3.3 Vehicle Classification along with their PCU factor

Vehicle Type	PCU Factor
Motorized Vehicle	
Car, Jeep, Van	1.0
Two-Wheeler (Motor Cycle)	0.5
Three Wheeler (Auto-Rickshaw)/ Mini LCV	1.0
Mini Bus	1.5
Govt. Bus	3.0
Private Bus	3.0
School Bus	3.0
Light Commercial Vehicle (LCV)	1.5
2-Axle Truck	3.0
3-Axle Truck	3.0
Multi Axle Vehicle (MAV)	4.5
Agricultural Tractor	1.5
Agricultural Tractor with Trailer	4.5
Non-Motorized Vehicle	
Cycle	0.5
Cycle Rickshaw	2.0
Animal Drawn Cart	6.0

(*Source: IRC: 64-1990)*

3.4.3.6.1 **Average Daily Traffic (ADT)**

The traffic volume data collected during the survey was averaged to arrive at the Average Daily Traffic (ADT) on the project location. The summary of ADT in terms of vehicles and PCU is presented in table 3.4. After the completion of the coastal highway full connectivity will be attained and traffic from Puthiyappa which is location in existing beach road is expected to ply through the bridge. Hence the traffic count observed at Puthiyappa is 9235 (8377 PCU).

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Table 3.4 Average Daily Traffic Volume (ADT)

Type of Vehicles		ADT in Nos	PCU factor	ADT in PCUs
Fast Moving Vehicles	Two-wheeler (Motor Cycle, Scooter etc.)	4151	0.5	2076
	Car/ Jeeps/ Taxies/Van/Three Wheelers (Auto)	3799	1	3799
	LCV (Light commercial vehicle eg.Mini truck)	402	1.5	603
	Bus	2	3	6
	Two axle truck and Tanker	674	3	2022
	Multi axle trucks, tanker trailors etc.	205	4.5	923
	Agriculture tractor with trailor	0	4.5	0
Slow Moving Vehicles	Cycle	1	0.5	1
	Bullock cart/Horse cart/Other animal powered	0	6	0

3.4.3.6.2 **Average Hourly Variation of Traffic Volume**

The analysis has been carried out to study the hourly variation and peak hour traffic characteristics. The morning peak hour is observed between 9 am to 10 am and the evening peak hour is observed between 3 pm to 4 pm at the count location. The Peak Hour share is defined as the ratio of the number of vehicles counted during the peak hour to the total vehicles counted in a day. The peak hour share on the survey location is 7.70 % for morning and 8.12 % for evening. The hourly variation of traffic at the location is illustrated in Figure 3.3

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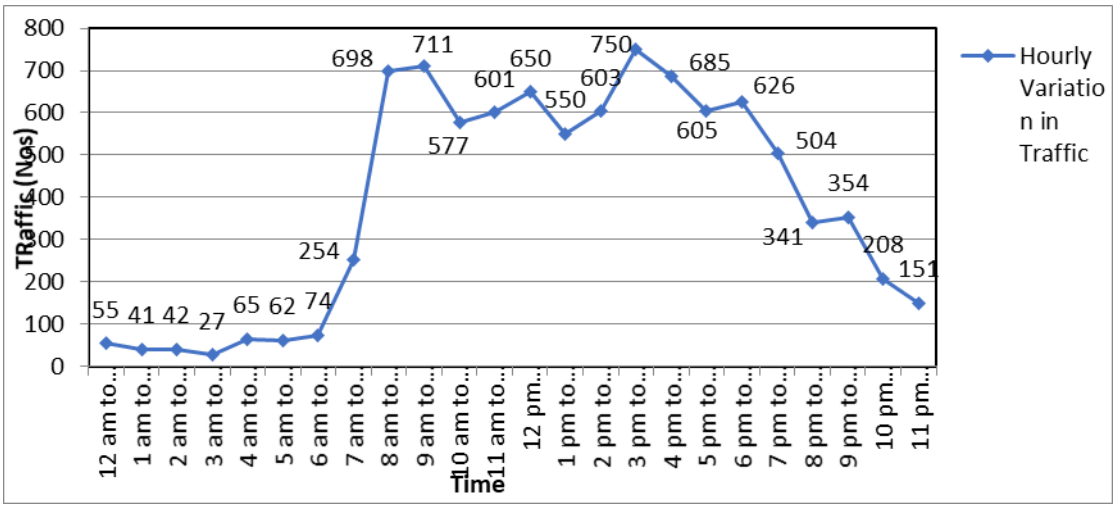
Figure 3.3 Hourly Variation of Traffic



3.4.3.6.3 **Daily Variation of Traffic Volume**

Daily variation of traffic at the count location is presented in Table 3.5. At the location, daily variation of traffic with respect to ADT is generally not noticeable as most of the daily volume being near to ADT volumes. The maximum traffic is observed on Thursday with 9494 Vehicles (8655 PCU).

The daily traffic varies with total traffic being lowest on Tuesday with 8971 Vehicles (8102 PCU) and highest on Thursday with 9494 Vehicles (8655 PCU) and is illustrated in Figure 3.5

Table 3.5 Daily Variation of Traffic for 3 days

Day	Date	Total Vehicles in Numbers	Total Vehicles in PCU
Day 1 (Tuesday)	10-04-2018	8971	8102
Day 2 (Wednesday)	11-04-2018	9239	8373
Day 3 (Thursday)	12-04-2018	9494	8655

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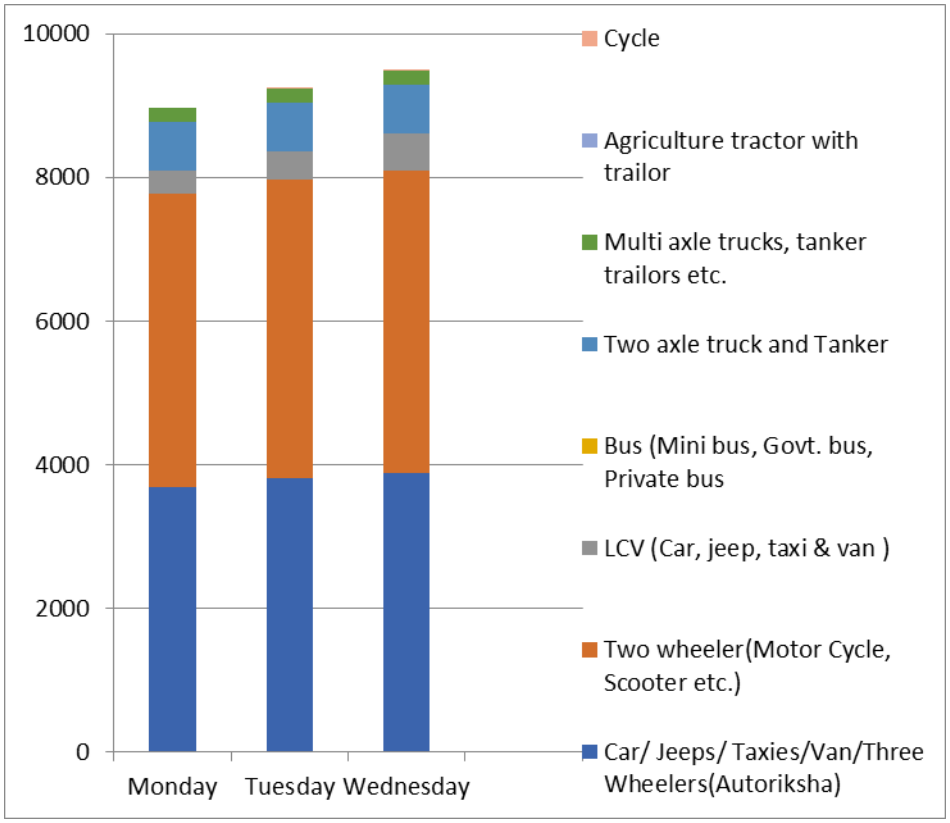

Figure 3.4 Daily Variation of Traffic for 3 days

3.4.3.6.4 **Composition of Traffic**

The traffic composition observed shows that major portion of the vehicles passing proposed road are fast moving passenger vehicles which includes Car, Bus and two wheelers. 46% of the traffic comprises of Car, Jeeps, Taxies, Van, Three Wheelers (Auto) and 41% is of Two-wheeler traffic. Two axle truck and Tanker contribute major share of commercial vehicle traffic. Figure 3.5 shows the traffic composition observed.

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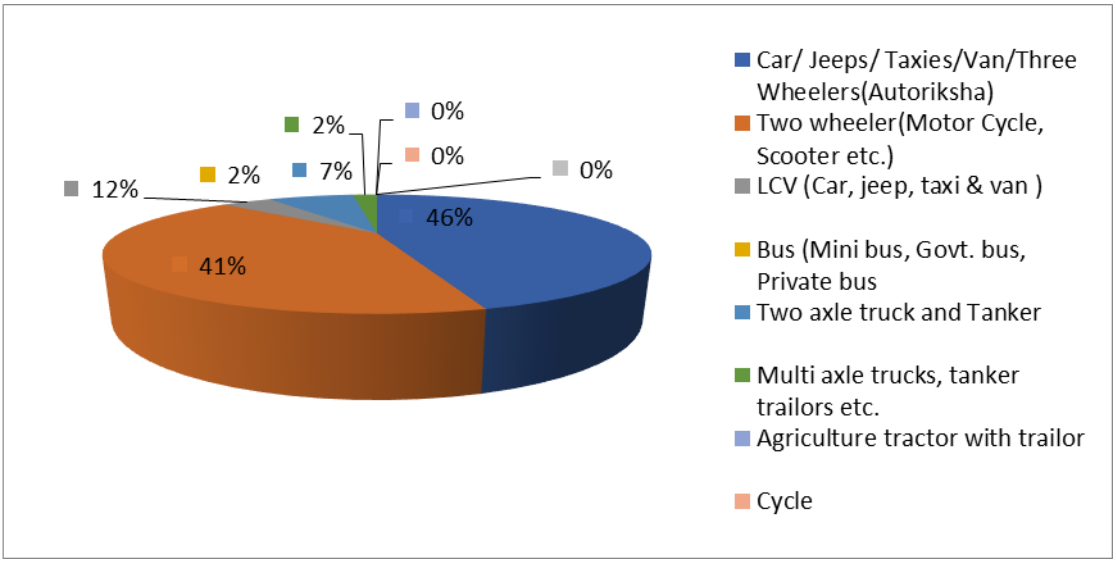

Figure 3.5 Traffic Composition Observed

3.4.3.7 TRAFFIC FORECAST

The traffic growth rate is normally established by studying the past trends in traffic growth and socio- economic parameters. In the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic. Annual growth rate of 5% is considered for the projection of traffic.

3.4.3.8 CONCLUSION

Construction of coastal highway in this reach is useful for diverting the long route traffic from the already congested National Highway. More than this it is providing transport facility to the coastal areas without any present transport facility.

3.4.4 PAVEMENT DESIGN

Deign of the pavement is an important part of detailed engineering study. Flexible pavement has been designed incompliance with IRC: 37-2018 "Guidelines for the design of flexible pavement". Flexible pavement has been proposed for the coastal highway.

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3.4.4.1 Design of Flexible Pavement

3.4.4.1.1 **Introduction**

New Pavement composition has been estimated on the basis of various factors such as traffic loading, Subgrade strength and environmental characteristic. Proposed new □o□ po□□□on □ □□□□arry □□□ ra□□□ oad□n□ □or □□□ d□□□□n p□r□od and □□o□d pro□d□ □□ oo□□ and □a□□ r□d□n□ □□r a□□□ S□r□n□□□□n□n□ o□□□□□□□n□ pa□□□ □n□□ o □□□ □□□□□o□n□□ □on□r□□□□on □a□ □□□n d□□□□n□d □□□p□n□ □n □□□□ o□ □□□ □□□□□□n□ pa□□□ □n□□o□ po□□□on□ □□□ □rad□ □□r□n□□□ and □□□□□□n□ pa□□□ □n□ □ond□□on T□o□an□ □□o□□ay □arr□a□□□ay □on□□□□ra□□on□ □a□□ p□ann□d □or □□□ □□□□□on□□

The following three main steps have been followed in designing the new flexible pavement.

- Estimating the volume of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life of 20 years.
- Assessing the strength of the sub grade soil over which the road is to be built.
- Selecting the most economical combination of pavement materials and layer thickness that will provide satisfactory service for the design life of the pavement.

3.4.5 DESIGN PARAMETERS

3.4.5.1.1 **Initial Traffic**

As per IRC 37-2018, one of the important design parameters for pavement design is the project traffic which is indicated in terms of million standard axles (MSA). For the design of flexible pavement, only commercial vehicles with gross weight above 3000 Kg are considered out of the spectrum of vehicles counted in the traffic volume count. Accordingly, from the 3 day 24 hours classified traffic volume count data average daily traffic plying on the

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project location is estimated. The estimated Average Daily Traffic (ADT) is presented in Table 3.6 for the base year 2018.

Table 3.6 Base Year Traffic (ADT)

Sl No	Vehicle Type	ADT
1	Bus	2
2	LCV	402
3	Two axle	674
4	Multi axle	205
Total		1283

3.4.5.1.2 **Design Period**

The design period to be adopted for pavement design is the time span considered appropriate for the road pavement to function without major rehabilitation. It is recommended that a design period of 20 years may be adopted for the structural design of pavements for National Highways, State Highways and Urban Roads. Hence a design life of 20 years has been considered here for the design of pavement

3.4.5.1.3 **Traffic Growth Rate**

For estimating the cumulative traffic expected to use the pavement over the design period, it is necessary to estimate the rate(s) at which the commercial traffic will grow over the design period. The traffic growth rate is normally established by studying the past trends in traffic growth and socio-economic parameters. The present-day traffic has to be projected for the end of design life at growth rates (r) estimated by studying and analysing the following data:

- Past trends of traffic growth
- Demand elasticity of traffic with respect to macro-economic parameters (like GDP or SDP) and expected demand due to

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specific developments and land use changes likely to take place during design life period.

As per IRC 37-2018 cl 4.2.2, in the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic. Hence an annual growth rate of 5% has been assumed.

3.4.5.1.4 **Vehicle Damage Factor (VDF)**

The Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration into the number of repetitions of Standard axle load of magnitude 80 kN. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration and axle loading.

As per IRC:37-2018 Cl 4.4.6, For small projects, in the absence of weigh pad, the axle loads of typical commercial vehicles plying on the road may be estimated approximately from the type of goods carried. Where information on the axle loads is not available and the proportion of heavy vehicles using the road is small, the indicative values of vehicle damage factor given in Table 4.2 can be used. These indicative VDF values have been worked out based on typical axle load spectrums and taking into consideration the legal axle load limits notified in the Gazette of India dated 16th July 2018. Assumed values of VDF values are appended below in Table 3.7.

Table 3.7Indicative VDF Values

Initial Traffic Volume in Terms of Commercial Vehicles Per Day	Terrain	
	Rolling/Plain	Hilly
0-150	1.7	0.6
150-1500	3.9	1.7
More than 1500	5.0	2.8

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Since total commercial vehicle per day comes in between 150-1500 Category and project location falls in plain terrain, a VDF value of 3.9 has been assumed for the design of flexible pavement.

Lateral distribution

Lateral distribution of commercial traffic on the carriageway is required for estimating the design traffic (equivalent standard axle load applications) to be considered for the structural design of pavement. As per IRC:37-2018 Cl 4.5.1.3, for Two-lane two-way roads the design should be based on 50 per cent of the total number of commercial vehicles in both directions.

3.4.5.1.6 **Subgrade Strength**

The strength of sub grade is assessed by California Bearing Ratio (CBR) tests. The select soil forming the subgrade should have a minimum CBR of 8 per cent for roads having traffic of 450 commercial vehicles per day or higher. Minimum CBR of 15% is considered for the design of flexible pavement. Hence, borrow material used for filling the approaches of the bridge should have a minimum CBR of 15%.

3.4.5.2 Design Traffic

The design traffic is calculated in terms of the cumulative number of standard axles to be carried during the design life of the proposed road. It requires the estimation of initial commercial vehicles per day, lateral distribution of traffic, traffic growth rate, the design life and the vehicle damage factor (number of equivalent standard axle for commercial vehicle) to convert commercial vehicles to standard axles.

The following equation has been used to calculate the design traffic

$$N = \frac{365\{(1+r)^n - 1\}}{r} \times A \times D \times F$$

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Where,

N = the Cumulative number of standard axles to be catered in the design

A = Initial traffic, in the year of completion of construction, in term of the number of commercial vehicles per day duly modified to account for lane distribution.

$A = P(1 + r)^x$

Where P number of commercial vehicles per day as per last count, In this case P = 1283 as per traffic census conducted during April 2018

x is the number of years between the last count and the year of completion of construction taken as 3 in this case.

r = Annual growth rate of commercial vehicles taken as 5%

n = Design life in years taken as 20 years

D= Lane distribution factor taken as 0.50

F = Vehicle damage factor i.e. number of equivalent standard axles per Commercial vehicle. Here 3.9

The design traffic calculated using the above formula is 33 msa.

3.4.5.3 Proposed Pavement Thickness – Approach Road

Based on the traffic (33 msa) and the assumed CBR value (10%), the thickness of flexible pavement has been obtained by interpolation from IRC: 37-2018, Cl.10.1, Plate 6 and proposed layer thickness is given in Table 3.8 and illustrated in Figure 3.6. Plate 6 of IRC 37-2018 is given as Figure 3.7.

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Table 3.8 Estimated and Proposed Pavement Compositions

Crust Details	Thickness (mm)		Remarks
	Estimated	Proposed	
BC	40	40	
DBM	68	68	
WMM	250	250	
GSB	200	200	
Subgrade	500	500	

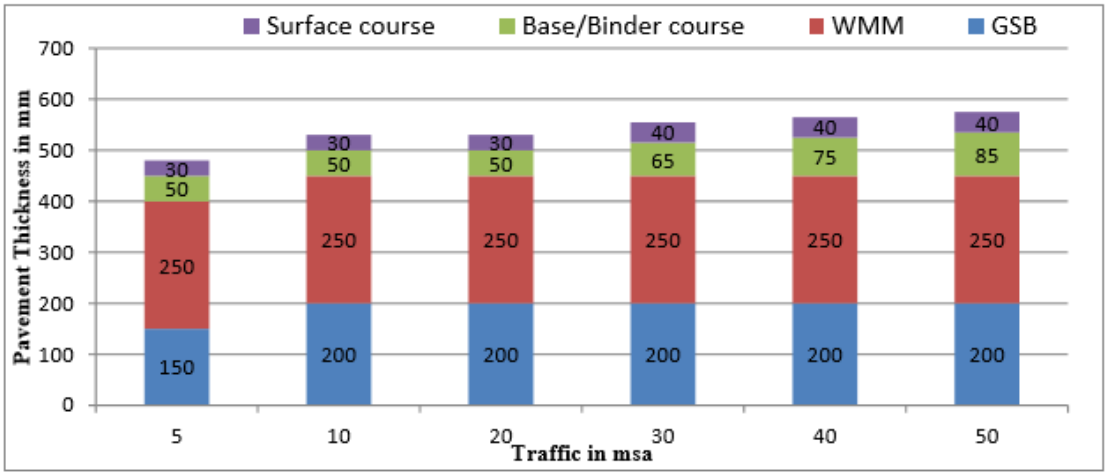

Figure 12.8 Catalogue for pavement with bituminous surface course with granular base and sub-base - Effective CBR 15% (Plate-8)

Figure 3.6 Catalogue for pavement as per IRC:37-2018

3.5 FUNCTIONAL DESIGN

The functional design of the project is mainly achieved through field study and documentation using existing information and specification from various standards. The field study includes all engineering studies viz. reconnaissance survey, topographic survey, geotechnical investigation, traffic survey etc. Documentation is done as per the latest revisions and amendments of the relevant guidelines of the MoRTH/IRC/BIS standards.

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The new alignment of the coastal alignment is passing through the coastal belt of Calicut district. . The alignment is proposed in such a way that to minimise the land acquisition and rehabilitation.

3.6 ENGINEERING DESIGN

The proposed alignment of coastal highway stretch is verified by the expert team of NATPAC team at KIIFB. This alignment passes over small streams called "AVI". Two Bridges is proposed over these streams. The structural design for the above bridge is done by DRIQ board of Kerala Public Works Department.

3.6.1 STANDARDS AND CODES OF PRACTISES

All activities related to field studies, design and documentation is done as per the latest revisions and amendments of relevant guidelines of MoRTH/ Indian Railways and publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). All notations, abbreviations and symbols used in the reports, documents and drawings are as per IRC: 71-1977 latest edition with amendments.

3.6.2 GEOMETRIC DESIGN

The geometric design conforms to the relevant IRC codes. The design for geometric elements has covered the major aspects including Typical Cross Section and Plan and profile drawings. Geometric improvements are kept to a minimum land acquisition is proposed for the corridors. The horizontal alignment is kept as same for the existing road at the location. Camber for carriage way is 2.5%.

3.6.3 ALIGNMENT SELECTION

The proposed road is located in Payyoli municipality and Thikkodi Panchayath in Kozhikode district can be a connecting link in the proposed Coastal highway. General Arrangement Drawing (GAD) and Alignment Plan showing the salient features of the road and structures proposed to be constructed are covered under the study. These salient features such as

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alignment, overall length, cross section, are finalized based on the detailed topographic and geotechnical studies. The alignment of the newly proposed road includes minimum land acquisition and rehabilitation cost.

The total length of the two lanes road is 7.5 km. A footpath of 1.5m is provided along with drainage facilities. A width of 2m is allocated for cycle track. The estimated cost of the Project is 11600.00 lakhs.

3.6.4 DESIGN OF FLEXIBLE PAVEMENT

Pavement design follows IRC 37-2012(guidelines on design of flexible pavement) for new pavement or pavement at widening section. The proposed coastal highway has two lanes and a total length of 7.5 Km. The recommended width of the proposed coastal highway is 15.6 meters. While the carriage way will be 7.0m wide, two footpaths each having 1.55 m width will be constructed on both sides of the road. There will not be additional space for a separate cycle track. Hence a 2m cycle track is provided along the carriage way.

3.7 FINANCIAL ESIMATES AND COST PROJECTIONS

3.7.1 GENERAL

The project cost estimates have been prepared considering various items of works associated with the identified improvements. Detailed estimates for quantities (considering preliminary designs and conveyance of materials) and cost for the entire project (civil packages wise), is worked out based on Standard Data Book of MoRT&H and latest Kerala PWD schedule of rates as per PWD Project Information and Cost Estimation (PRICE) software.

The estimate is based on PWD PRICE and cost index of 31.06% of Kozhikode district as on 20/11/2019. Where the data is not available, rates are worked out based on market rates.

Project Information and Cost Estimation (PRICE) software is a total solution for estimate preparation and online approval. It is developed for the

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Public Works Department Kerala. PRICE is based on CPWD Schedule of Rates, Specification, Rate Analysis and cost index.

The project cost estimates have been prepared considering the various items of works associated with Identified improvements so as to assess financial and economic costs for evaluating viability of the Project.

3.7.2 APPROACH AND METHODOLOGY

3.7.2.1.1.1The cost estimate is grouped as follows.

- Part 1: Road work -safe dismantling of the various components like culverts, retaining walls, guard rails, road pavement layers, Traffic signs, etc and construction of DBM-BC road as per the design come under this.
- Part 2: Retaining wall – DR and gabion retaining walls at necessary locations comes under this.
- Part 3: Bridge Work – Construction two single span bridges comes under this
- Part 4: Traffic Safety work: Construction of cement concrete kerb, Installation of signboards, Object Hazard Marker, delineator post, median marker, hand rails, streetlight, road studs and thermoplastic etc comes under this
- PART 5: Cross drainage work- Construction of box culverts are provided under this.
- PART 6: Utility Shifting is approximated as Rs 10000000.00
- PART 7: Cost of land acquisition comes under this head
- PART8: Cost of land acquisition procedures is included in this
- PART 9: Expenditure of CRZ and other clearances is included in this

3.7.3 ESTIMATION OF QUANTITIES

The quantities of major items of work for the Project Road have been estimated on the basis of geometric designs, pavement designs and preliminary structural designs. The quantities of the following major items of works have been estimated separately.

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- Site Clearance and Earth Work
- Granular Pavement Courses
- Bituminous Courses
- Two minor Bridges and its approach road
- Culverts
- Kerbs, Drainage and Protective works
- Road Furniture and Safety Works
- Relocation of Utilities
- The total length of the New road will be 7.527 Km
- Footpath of width 1.55m is considered on both the sides
- Carriage way width is 7m
- Cycle track of width 2m

Detailed estimate is given as Annexure I

Table 3.9 Abstract of Estimate

Sl.No.	Description	Amount
1	Road Work	539923604.36
2	Retaining wall	25086750.00
3	Bridge Work	140552525.69
4	Traffic Safety	72582319.81
5	Cross drainage work	13501079.45
6	Utility Shifting	1000000.00
7	Land Acquisition - cost of land	188287662.00
8	Land Acquisition Procedures	9414383.00
9	CRZ and other clearances cost	39587314.00
	Total	**1029935638.32**
	GST @ 12.0%	123592276.60
	Total with GST	1153527914.92
	Lumpsum Round off	6472085.08
	TOTAL	**1160000000.00**
		116 Crores

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3.7.4 COST OF THE PROJECT

Administrative Sanction has been issued by the govt. of Kerala vide order no: GO(Rt) No.942/2017/PWD dated 12-10-2017. By funding from KIIFB.

3.7.5 COST OF CONSTRUCTION OF COASTAL HIGHWAY

The cost of coastal highway includes the cost of Road work, Drain, Duct and footpath works, Traffic Safety, Construction of minor bridge, Amenities and Horticulture. This works out to Rs.79.16 lakhs for the project as detailed below.

Table 3.10 Cost of Construction

Sl No	Heading Description	Amount
1	Road Work	539923604.36
2	Retaining wall	25086750.00
3	Bridge Work	140552525.69
4	Traffic Safety	72582319.81
5	Cross drainage work	13501079.45
Total Construction Cost		**791646279.30**

3.7.6 COST OF SHIFTING OF UTILITIES

Overhead and underground power cables, water line, telecommunication line, etc. which come in the road way have to be relocated or re-routed. The detailed estimate for shifting utility is required to KSEB. The total amount for shifting of electric posts, cables, transformers ec comes to be Rs. 1000000.00/-..

3.8 REVENUE STREAMS

Levee may be imposed from service providers for using the utility duct proposed.

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3.9 COST-BENEFIT ANALYSIS (CBA)

3.9.1 GENERAL

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the project is worthy of investment keeping in view the benefits to the society. Economic analysis is not concerned about past events and investments.

The Economic Analysis Proposal for the reconstruction of the proposed road is to assess the benefits accrued to the society. The very basis of economic analysis being the selection of the most attractive option and it is necessary that evaluates a number of possible alternatives. The basic alternative is the 'do-nothing', or the continuation of the present situation. All other alternatives are evaluated against this basic condition.

Economic analysis estimates future traffic, costs and benefits. The Cost Benefit Analysis (CBA) is the implicit or explicit assessment of the benefits and costs (i.e., advantages and disadvantages) associated with an investment project. Benefits and costs may be nonmonetary and monetary.

Some of the non-monitory benefits, which are difficult to be expressed in monitory terms through construction of the proposed road, are reduction in air pollution and noise pollution as described below;

3.9.2 COST-BENEFIT ANALYSIS (CBA)

3.9.2.1 Reduction in Air Pollution

An Air Quality Index (AQI) up to 50 is regarded as good while the 51-100 range is considered moderate. A reading exceeding 100 is considered unhealthy for □n□□□□□ □ro□p□□□□□ a□ □□o□□ □a□n□ □□n□ d□□□a□□□□

The air is unhealthy for the people if the AQI is in the range of 151-200. AQI in the 201-300 range indicates very unhealthy air. A reading above 300 is hazardous. Aggregation of vehicles at stoppage at the locality where

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the road is proposed while traffic block leads to high quantum of air pollution and thereby causes various health issues for the people in the nearby areas. The proposed construction of the road will reduce the air pollution in the area due to seamless flow of vehicles.

3.9.2.2 Reduction in Noise Pollution

The noise pollution in the road during traffic block is at an alarming rate. If a bus horn honks, it creates 92-94 decibels (dB) of sound, and hearing it repeatedly can cause hearing loss. Noises, which are below 75 dB, are harmless. But constant exposure to noise levels of 80-85 dB can increase the risk of hearing loss. The magnitude of sound of a two-wheeler horn is between 81 and 85 dB, and that of a car horn is between 83 and 88 dB. During congestion honking of horns by the vehicles is high and there by the noise Pollution in the area is also high. Through the construction of the proposed road, there will have seamless flow of vehicles and hence can avoid the noise pollution in the area.

Economic Rate of Return (ERR) and Cost Benefit Ratio (Benefit / Cost) are some of the measure to arrive at the social benefits from any infrastructure project. The financial analysis appraises the project in terms of return on investment while the economic analysis appraises the project contribution to the social and economic welfare of the city, region or country.

Though all the cost and benefits from an infrastructure project is not possible to be expressed in monitory terms, all possible costs and benefits are being measured in monitory terms and evaluated to arrive at a conclusion whether an infrastructure project is worth to the society. There are various methods to evaluate the economic benefits from any infrastructure projects. The economic evaluation of the proposed road project is carried out based on the IRC SP 30, 2009, which describes about "Economic Evaluation of Highway Projects in India". The Economic Evaluation carried out based on IRC SP 30, 2009 for the reconstruction of the proposed road is detailed in the following section.

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3.9.3 BASIS FOR ARRIVING AT COST AND BENEFITS

All the cost and benefits are taken at constant price without factoring the inflation so as to have better overview. The basis for arriving at each component of costs and benefits from the construction of the proposed road based on IRC SP 30, 2009 is detailed below

3.9.3.1 Project Cost

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices, as these are not real costs to the economy, but are only transfer payments.

All financial costs have been converted into economic costs by applying a Standard Conversion Factor (SCF) of 0.80, as suggested in IRC: SP: 30-2009. The cost for the project consists of two main components:

- Capital cost
- Operation and Maintenance cost

3.9.3.2 Capital Cost

The capital cost includes the cost of improvement of road, construction of drain footpath, amenities, street lighting, cost of traffic diversion and supervision charges during construction etc. These are estimated in financial terms i.e. at market prices. The total project cost worked out is amounting to Rs.11600.00 lakhs with cost for land acquisition and construction amounting Rs 10299.35 lakhs. The capital cost of all the project in financial and economic terms are summarized below.

Total Cost	Finance Cost (Lakhs)	Economic Cost (Lakhs)
Construction of Coastal Highway in Kozhikode district-From Kodikkal to Kolavippalam	10299.35	8239.49

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3.9.3.3 Operation & Maintenance Cost

Maintenance costs are recurring costs, comprising routine and periodic maintenance components. The routine maintenance involves day-to-day repairs and maintenance of Bridge and road etc.

The routine maintenance cost would start incurring from the second year from the date of commencement of operation (in this case December 2019 is assumed as the starting year of the project and the construction is expected to complete and start its Economic Cost. The total project financial cost is estimated to Rs.11600.00 lakhs and this is faced during 19 months of land acquisition and construction period.

3.9.4 PROJECT BENEFITS

There are various benefits through provision of proposed coastal highway which include social benefits such as savings in time of travel, reduction in accidents due to congestion during peak hours, reduction in sound pollution through avoidance of horns, reduction in air pollution etc.

The benefits (which are converted in to monitory terms) considered from the construction of the proposed road are as under:

- Travel Time savings of passengers
- Savings in the cost of maintenance of old road (operating cost of warning signals and Police man engaged for traffic control etc).
- Savings in idle fuel consumption
- Less pollution from vehicles
- Helps in tourism development
- Provision of proper drainage system
- Bus shelter units helps people to take rest and do primary things
- Cycle riders can enjoy safe riding

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3.9.4.1 Travel Time savings of passengers

Generally car passengers and motor cycle riders enjoy a saving in travel time. Through The proposed road, a considerable amount of travel time can be saved due to seamless flow of vehicles by avoiding waiting time in traffic at old road. Time Value of Passenger (Work Trips and Non Work/leisure trip) is arrived based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP:30 -2009)".

The value of travel time of passengers for each category of travelers as specified in the IRC SP has been based on the March price and the reproduced below

Table 3.11 Value of Travel Time of Passengers (Rs/hour) – 2009 prices

Sl.No	Nature of Journey by Passenger	Value of Time
		Primary Route
1	Cars	62.5
2	Two Wheelers	32
3	Ordinary Bus Passenger	39.5

Note: Average 365 days a year is considered to arrive at the value of passenger time saved.

These values of 2009 are revised based on the wholesale price index to arrive at the current price. The monthly WPI index for all products from the website of "Office of the Economic Adviser Govt. of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIPP)" (http://www.eaindustry.nic.in/display_data.asp) is considered to arrive a "Value Indexation Factor" (VIF) to arrive at the current price levels of the time value provided in the IRC SP 30, 2009. The calculation of VIF is provided below;

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Wholesale Price Index			
As on Mar-2009	123.5		
As on Aug-2018	187.40	Index Multipier	1.5174

The current value arrived at through multiplying with VIF is provided below

Table 3.12 Value of Travel Time of Passengers (Rs/hour) March-17 prices

Sl.No	Nature of Journey by Passenger	Value of Time
		Primary Route
1	Cars	94.84
2	Two Wheelers	48.56
3	Auto*	48.56
4	Ordinary Bus Passenger	59.94

* Assumed same as Two Wheelers

Note: For the economic evaluation the value for 'value of time' for the primary route is considered. Out of the total travellers it is assumed that 85% of the total population travels is considered as work travel and the balance 15% as leisure travel. The time saved through proposed road for leisure travel is not considered as benefit under this head.

To arrive at the value of time saved, the average occupancy of vehicles passing □ro□□□ □□□ ra□□ro□□ □□ □on□d□r□d a□ o□o□□

Table 3.13 Average Passenger Occupancy

Sl.No	Nature of Journey by Passenger	Passenger Occupancy
1	Cars	4.80
2	Two Wheelers	1.50
3	Auto	3.00
4	Ordinary Bus Passenger	43.00

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3.9.4.2 Time Value of Cargo

With regard to time value of cargo, as the travel time reduces the inventory carrying cost of the cargo also reduces. Reduced travel time for cargo leads to;

- Use of lesser number of commercial vehicles and
- Leads to reduction in the fixed charges per km which every operator has to pay
- Results in time savings to the vehicle crew

The savings in travel time are an important component of the benefits from the construction of the proposed road. Theoretically, it is possible to visualize the savings in cost of holding inventories by working out the value of goods held during the transport and deriving the interest payment thereon.

The Average value of time for commodity is considered for the working based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP: 30 - 2009)". Equivalent cost of commodity in 2016-2017 is determined using multiplying the WPI as specified in IRC SP: 30 – 2009 with Value Indexation Factor" (VIF) (as detailed in the previous section). The value of time saving of commodity transport as specified under IRC SP: 30 – 2009 and its indexed value are provided in the following table.

Table 3.14 Commodity Holding cost

Vehicle type	Value of Commodity (Rs./t)	Average Load (t/Vehicle)	Commodity Holding Cost (Rs/day)	
			As on 2009 March	As on 2018 march
LCV	35300	3.2	58.10	88.16
HCV	38750	9	178.00	270.10
MAV	36300	18.3	333.00	505.29

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Note: For the calculation of time value saving for commodities, 365 days a year is considered.

Through the construction of the proposed road, the cost of idle fuel consumption can be saved. It is assumed that on an average 50% of total single lane stoppage time, the vehicles will be turned on. Hence through the construction of the proposed road, the fuel consumption otherwise occur during idling time can be saved. Savings in idle fuel consumption is worked out assuming that each type of vehicles consumes fuel in the following quantity.

Type of Vehicle	Idle Fuel consumption in ml. per hour	Fuel
2 Wheeler	200	Petrol
3 Wheeler	250	Diesel
Car / Jeep	667	Diesel
LCV	810	Diesel
BUS	920	Diesel
HCV	920	Diesel
Truck	942	Diesel

Average cost of fuel per litter considered for economic analysis is as per"IRC SP:30 -2009" is then converted to March 2017 WPI with corresponding index factors.

Fuel Type	March 2009 price without tax	March 2016 price without tax
Petrol	18.55	27.91
Diesel	18.2	27.62

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3.9.5 ECONOMIC RATE OF RETURN

The ERR through implementing road works out to 28.36% . The CBR (Project Benefits / Project Costs) of the project is 1.252. This indicates that the construction of The proposed road will yield an economic rate of return of 28.36% and this ERR is very attractive for an infrastructure investment. The CBR of more than 1 is acceptable for any infrastructure development and this project higher CBR. The CBR of 1.252 indicate that the total benefit derived from the project is 1.252 times than the total project related costs. The total Economic Cost and Benefits, component wise for the entire project period under consideration (ie. 20 years) is tabulated in the following table.

Particulars	**Rs. in lakhs**
Economic Cost of Project	
Capital Cost	-8239.48.00
Maintenance Cost	-3954.88.00
Total Cost	**-12194.36**
Economic Benefits	
Value of Travel time saving of passengers	71266.49
Value of Travel time saving for Cargo	55.12
Value of saving in idle fuel consumption	2145.59
Total Benefit	**73467.20**

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Table 3.15 Cost Benefit Analysis

Year	Project Costs		TOTAL PROJECT COSTS	Project Benefits			Total Project Benefits	Net Project Benefits
	Cost of Development	O&M cost of new bridge		Value of Travel Time Saving of Passengers (lakhs)	Value of Travel Time Saving of Commodities	Value of idling fuel cost Year		
2020	-5029.76		-5029.76	0	0	0	0	-5029.76
2021	-3209.72		-3209.72	0	0	0	0	-3209.72
2022		0	0	2333.62	1.81	70.26	2405.69	2405.69
2023		0	0	2450.31	1.89	73.77	2525.97	2525.97
2024		0	0	2572.82	1.99	77.46	2652.27	2652.27
2025		-247.18	-247.18	2701.46	2.09	81.33	2784.88	2537.70
2026		-247.18	-247.18	2836.53	2.19	85.40	2924.12	2676.94
2027		-247.18	-247.18	2978.36	2.30	89.67	3070.33	2823.15
2028		-247.18	-247.18	3127.28	2.42	94.15	3223.85	2976.67
2029		-247.18	-247.18	3283.64	2.54	98.86	3385.04	3137.86
2030		-247.18	-247.18	3447.82	2.67	103.80	3554.29	3307.11
2031		-247.18	-247.18	3620.21	2.80	108.99	3732.00	3484.82
2032		-247.18	-247.18	3801.22	2.94	114.44	3918.60	3671.42
2033		-247.18	-247.18	3991.28	3.09	120.17	4114.54	3867.36
2034		-247.18	-247.18	4190.85	3.24	126.17	4320.26	4073.08
2035		-247.18	-247.18	4400.39	3.41	132.48	4536.28	4289.10
2036		-247.18	-247.18	4620.41	3.57	139.11	4763.09	4515.91
2037		-247.18	-247.18	4851.43	3.75	146.06	5001.24	4754.06
2038		-247.18	-247.18	5094.01	3.94	153.36	5251.31	5004.13
2039		-247.18	-247.18	5348.71	4.14	161.03	5513.88	5266.70
2040		-247.18	-247.18	5616.14	4.34	169.08	5789.56	5542.38
TOTAL	-8239.48	-3954.88	-12194.36	71266.49	55.12	2145.59	73467.20	61272.84
TOTAL PROJECT COST			**-12194.36**	**TOTAL PROJECT BENEFITS**			**73467.20**	

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Table 3.16 Daily Traffic Projection

Year	Cycle	Bike	Auto	Car	LCV	Bus	Truck
2018	1	4151	570	3229	402	2	879
2019	1	4359	599	3390	422	2	923
2020	1	4577	629	3560	443	2	969
2021	1	4806	660	3738	465	2	1017
2022	1	5046	693	3925	488	2	1068
2023	1	5298	728	4121	512	2	1121
2024	1	5563	764	4327	538	2	1177
2025	1	5841	802	4543	565	2	1236
2026	1	6133	842	4770	593	2	1298
2027	1	6440	884	5009	623	2	1363
2028	1	6762	928	5259	654	2	1431
2029	1	7100	974	5522	687	2	1503
2030	1	7455	1023	5798	721	2	1578
2031	1	7828	1074	6088	757	2	1657
2032	1	8219	1128	6392	795	2	1740
2033	1	8630	1184	6712	835	2	1827
2034	1	9062	1243	7048	877	2	1918
2035	1	9515	1305	7400	921	2	2014
2036	1	9991	1370	7770	967	2	2115
2037	1	10491	1439	8159	1015	2	2221
2038	1	11016	1511	8567	1066	2	2332
2039	1	11567	1587	8995	1119	2	2449
2040	1	12145	1666	9445	1175	2	2571

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Table 3.17 Average passenger trip

Year	Bike	Auto	Car	Bus
Average Occupancy	1.5	3	4.8	43
Percentage of work passenger /Year	0.85	0.85	0.85	0.85
2018	5292.53	1453.50	13174.32	73.10
2019	5557.16	1526.18	13833.04	76.76
2020	5835.02	1602.49	14524.69	80.60
2021	6126.77	1682.61	15250.92	84.63
2022	6433.11	1766.74	16013.47	88.86
2023	6754.77	1855.08	16814.14	93.30
2024	7092.51	1947.83	17654.85	97.97
2025	7447.14	2045.22	18537.59	102.87
2026	7819.50	2147.48	19464.47	108.01
2027	8210.48	2254.85	20437.69	113.41
2028	8621.00	2367.59	21459.57	119.08
2029	9052.05	2485.97	22532.55	125.03
2030	9504.65	2610.27	23659.18	131.28
2031	9979.88	2740.78	24842.14	137.84
2032	10478.87	2877.82	26084.25	144.73
2033	11002.81	3021.71	27388.46	151.97
2034	11552.95	3172.80	28757.88	159.57
2035	12130.60	3331.44	30195.77	167.55
2036	12737.13	3498.01	31705.56	175.93
2037	13373.99	3672.91	33290.84	184.73
2038	14042.69	3856.56	34955.38	193.97
2039	14744.82	4049.39	36703.15	203.67
2040	15482.06	4251.86	38538.31	213.85

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Table 3.18 Passenger time saving

Type of Vehicle	2w	Auto	car/jeep	bus	Time value of passengers per day	Yearly passeneger time cost
Time savings in minute	20	20	20	20		
Average trips wise passenger time cost	16.1856	16.1856	31.61	4.99		
2018	85663	23526	416440	365	525994	191987810
2019	89946	24702	437262	383	552293	201586945
2020	94443	25937	459125	402	579907	211666055
2021	99165	27234	482082	422	608903	222249595
2022	104124	28596	506186	443	639349	233362385
2023	109330	30026	531495	466	671317	245030705
2024	114797	31527	558070	489	704883	257282295
2025	120536	33103	585973	513	740125	270145625
2026	126563	34758	615272	539	777132	283653180
2027	132892	36496	646035	566	815989	297835985
2028	139536	38321	678337	594	856788	312727620
2029	146513	40237	712254	624	899628	328364220
2030	153838	42249	747867	655	944609	344782285
2031	161530	44361	785260	688	991839	362021235
2032	169607	46579	824523	722	1041431	380122315
2033	178087	48908	865749	758	1093502	399128230
2034	186991	51354	909037	796	1148178	419084970
2035	196341	53921	954488	836	1205586	440038890
2036	206158	56617	1002213	878	1265866	462041090
2037	216466	59448	1052323	922	1329159	485143035
2038	227289	62421	1104940	968	1395618	509400570
2039	238654	65542	1160187	1016	1465399	534870635
2040	250586	68819	1218196	1067	153668	561613820

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Table 3.19 Savings in Commodity carrying cost

Year	LCV	Truck	TOTAL COMMODITY CARRYING COST PER DAY	YEARLY COMMODITY CARRYING COST PER YEAR
Commodity holding cost Rs/vehicle	0.05	0.43		
2018	20.10	386.76	407	148555
2019	21.11	406.10	427	155855
2020	22.17	426.41	449	163885
2021	23.28	447.73	471	171915
2022	24.44	470.12	495	180675
2023	25.66	493.63	519	189435
2024	26.94	518.31	545	198925
2025	28.29	544.23	573	209145
2026	29.70	571.44	601	219365
2027	31.19	600.01	631	230315
2028	32.75	630.01	663	241995
2029	34.39	661.51	696	254040
2030	36.11	694.59	731	266815
2031	37.92	729.32	767	279955
2032	39.82	765.79	806	294190
2033	41.81	804.08	846	308790
2034	43.90	844.28	888	324120
2035	46.10	886.49	933	340545
2036	48.41	930.81	979	357335
2037	50.83	977.35	1028	375220
2038	53.37	1026.22	1080	394200
2039	56.04	1077.53	1134	413910
2040	58.84	1131.41	1190	434350

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Table 3.20 Savings in Idle fuel cost

Average Idling Time		0.5	minutes					
	Mar-09		Mar-17					
WPI	123.5		187.4					
Petrol	18.55		28.15					
Diesel	18.2		27.62					
Type of Vehicle	**2w**	**Auto**	**car/ jeep**	**LCV**	**bus**	**truck**	**Total idling cost per day**	**Total idling fuel cost per year**
Average hourly idling fuel Consumption (ml)	200	250	667	810	920	942		
Average idling cost per trip	0.05	0.06	0.15	0.18	0.21	0.21		
2018	3113.25	524.40	7943.34	1197.96	6.78	3050.13	15836	5780140
2019	3268.91	550.62	8340.51	1257.86	7.12	3202.64	16628	6069220
2020	3432.36	578.15	8757.54	1320.75	7.48	3362.77	17459	6372535
2021	3603.98	607.06	9195.42	1386.79	7.85	3530.91	18332	6691180
2022	3784.18	637.41	9655.19	1456.13	8.24	3707.46	19249	7025885
2023	3973.39	669.28	10137.95	1528.94	8.65	3892.83	20211	7377015
2024	4172.06	702.74	10644.85	1605.39	9.08	4087.47	21222	7746030
2025	4380.66	737.88	11177.09	1685.66	9.53	4291.84	22283	8133295
2026	4599.69	774.77	11735.94	1769.94	10.01	4506.43	23397	8539905
2027	4829.67	813.51	12322.74	1858.44	10.51	4731.75	24567	8966955
2028	5071.15	854.19	12938.88	1951.36	11.04	4968.34	25795	9415175
2029	5324.71	896.90	13585.82	2048.93	11.59	5216.76	27085	9886025
2030	5590.95	941.75	14265.11	2151.38	12.17	5477.60	28439	10380235
2031	5870.50	988.84	14978.37	2258.95	12.78	5751.48	29861	10899265
2032	6164.03	1038.28	15727.29	2371.90	13.42	6039.05	31354	11444210
2033	6472.23	1090.19	16513.65	2490.50	14.09	6341.00	32922	12016530
2034	6795.84	1144.70	17339.33	2615.03	14.79	6658.05	34568	12617320
2035	7135.63	1201.94	18206.30	2745.78	15.53	6990.95	36296	13248040
2036	7492.41	1262.04	19116.62	2883.07	16.31	7340.50	38111	13910515
2037	7867.03	1325.14	20072.45	3027.22	17.13	7707.53	40017	14606205
2038	8260.38	1391.40	21076.07	3178.58	17.99	8092.91	42017	15336205
2039	8673.40	1460.97	22129.87	3337.51	18.89	8497.56	44118	16103070
2040	9107.07	1534.02	23236.36	3504.39	19.83	8922.44	46324	16908260

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3.10 ENVIRONMENTAL ASPECTS AND SUSTAINABILITY

Objective of the EIA study is to understand and analyse the Environmental and Social Impacts associated with the proposed road alignment in the coastal region of Kerala. However, the subject project – construction of Coastal highway from Kolavipalam to Kodikkal beach will not attract item 7 of schedule of EIA notification of 2006 as the maximum width of land required for the construction coastal highway and road will be 14.5 m. Hence this project does not require prior environmental clearance.

3.10.1 ENVIRONMENTAL SETTING PROJECT AREA

The district of Kozhikode is one of the coastal districts of Kerala. Kozhikode district is bounded on the north by Kannur district, on the east by Wayanad district, on the south by Malappuram district and the district is divided into 4 taluks and 12 developmental blocks and 70 panchayats for administrative purposes.

The district has one corporation (Kozhikode) and seven Municipalities. It has a total of 117 revenue villages. Out of the total area of 2344 Sq. Kms 336 Sq. Kms fall under urban area and the remaining 2008 Sq. Kms falls under rural area. The district has a total population of 30, 89,543 persons as per 2011 census. It lies between North latitudes 11º 08’ and 11º 50’ and East longitudes 75 º 30’ and 76 º 8’.

The road from Kolavipalam to Kodikkal beach passes along the coastal belt of Payyoli municipality and Thikkodi panchayath which connects Vadakara and Koyilandy taluks. Geographically, Vadakara is situated about 49 km to the north of Kozhikode City, approximately 44 km to the south of Kannur City and it is proximate to Mahi. The town lies by the side of a river known by different names including the Moorad river, Kuttiyadi river, and Kottakkal river.

The proposed Coastal highway from Kolavipalam to Kodikkal beach is an alternative route to National Highway 66 and can reduce the traffic problems. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in the district.

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The proposed road will fall under coastal area. Hence it should get coastal clearance from Coastal Regulations Zone authority (CRZ). No mandatory or other rare species of trees will not be destroyed during the construction of the project and no wild animals found in the localities of populated area of the proposed project locations.

3.10.2 RAINFALL AND CLIMATE

Kozhikode district experienced an average annual rainfall of 3698 mm. It has been noticed that rainfall displays an increasing trend towards north-eastern areas of the district. The District has more or less the same climate conditions prevalent elsewhere in the state viz. dry season from December to February and hot season from March to May, the southwest monsoon from June to September and North East monsoon from October to December. The SW and NE monsoons mainly contribute rainfall in the area with 82.77 % of the rainfall. The South West monsoon is usually very heavy and merely 72.15% of the rain fall is received during this season. North East monsoon contributes nearly 10.63%. During winter (January to March) it is 0.49% and during summer (April and May) it is16.74%.The month of June experiences maximum rainfall. The months of July, August and October also receive heavy rainfall. The agricultural activity of the district depends on the onset of SW tropical monsoon.

3.10.3 OTHER METEOROLOGICAL PARAMETERS

3.10.3.1 Temperature

The climate is generally hot and humid. March and April months are the hottest and January and February months are the coldest. The minimum temperature ranges between 22 and 25.8º C and the maximum between 28.2 and 32.9º C. The temperature starts rising from January and reaches its peak in the month of March and April and then decreases during the monsoon month and again rising from September onwards.

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3.10.3.2 Relative Humidity

The relative humidity ranges from 74 to 92 % during morning hours and from 64 to 89% in evening hours. The monsoon months (June to September) record high humidity.

3.10.3.3 Wind speed

The wind is predominant from east as well as west during morning and evening hours. The wind speed ranges from 8.1 to 12.6 km/h. The maximum wind speed is during April and minimum in November.

3.10.3.4 Potential Evapotranspiration

The annual Potential Evapotranspiration (PET) is 1505.7 mm. The monthly PET ranges from 92.9 to 170.2 mm. The PET is less than the rainfall during May to November and hence the possibility of recharge to ground water regime is more during these months.

3.10.3.5 Geology

The district can be divided into three geological belts viz., (i) a linear NW-SE trending gneissic belt, along the middle extending from north to south, (ii) a charnockite belt occupying areas in the northeast and south, extending to the adjacent districts and also occurring as pockets within the gneissic terrain and (iii) a narrow coastal belt.

3.10.3.6 Geomorphology

Geomorphology is the study of the features that make up the earth's surface and their relationship to the underlying geology. There is a well-developed beach all along the coast with sea cliffs and rocky beaches near Quilandy, Payyoli and Vadakara. Vadakara Sand banks beach is where locals and tourists throng to view the confluence of the Kottakkalkadavu and the Arabian Sea.

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3.10.3.7 Soil types

The soils of the district are alluvial soil, lateritic soil and forest loam. As the project area is very near to sea, the soil in the proposed locations is sandy in nature. Mainly the Arabian Sea deposits a large quantity of sandy soil.

3.10.3.8 Groundwater scenario

Groundwater occurs in the weathered, fractured, crystalline and alluvial formations in the district. Phreatic conditions exist in weathered formation and are mostly developed by dug wells for domestic and irrigation purposes. Semi-confined conditions exist in deep fractures and storage and movement of groundwater is mainly controlled by the fracture system. Deep high yielding bore wells are located along fractures / lineaments. The district is divisible into two hydrological provinces viz., (i) the eastern Wayanad Plateau where dug wells give moderate yield and bore wells are feasible along fracture planes and (ii) the western mountains, which are generally unsuitable for groundwater development but the valleys with thick alluvium sustain dug wells. All the four blocks in the district are having similar hydrogeological conditions. The major water bearing formations in the district are weathered/fractured crystalline, alluvium and valley fills.

3.10.3.9 Air and Noise Pollution

Air and Noise pollution are the adverse impacts mainly during construction phase. Dust depressing measure will be done aimed at prevention of air pollution through watering of access roads and construction site. During construction air pollution level will be increased mostly by machine operations for earthwork. The main pollutants caused by these operations include exhaust gases emitted by machines and dust caused by the earthwork. Regular sprinkling of water during construction works will depress the dust thus reducing impact on workers. Additional measures planned to maintain air quality include locating concrete mixing plant and

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stockpiles in isolated area as well as confining working vehicles to designated routes only following the established schedule. Trucks loaded with loose construction materials (such as gravel, sand, soil, etc) shall be covered to minimise dust emissions during transportation. Vehicles and machinery should be fitted with effective exhaust silencers and maintained in good and efficient working order. Machinery in intermittent use should be shut down or throttled down to a minimum when not in use.

3.10.4 ENVIRONMENTAL ASPECTS

3.10.4.1 Positive Impacts of the Project

The potential positive environmental impacts due to project apart from its economic importance include the following.

- **Reduced noise and air pollution**. With the proposed construction of road, noise and air pollution levels on National Highway is expected to go down, because the overall human exposure to noise and air pollution will be minimal due to less congestion.
- **Reduced risk of accidents**. The proposed road alignment shall provide adequate safety measures and proper sight distances thereby resulting in reduced accidents and traffic congestions. Moreover with expected decrease in overall traffic density on National Highway, the chances of accidents will reduce considerably.
- **Improved accessibility and connectivity**
- The proposed road is an alternative route to National Highway. Hence the traders can easily access the market without entering the national highway. The goods and other commodities for trade have to be brought through this road. People from the nearby Panchayat depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion.

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- **Savings in fuel consumption.** Savings in fuel consumption can be attributed to low traffic congestion and relatively less travel time due to proposed improvements.
- **Improved quality of life.** The proposed project is expected to improve the quality of life of the people residing in the project zone in terms of their economic, social and health status. Land value in the nearby areas of the proposed alignment will increase substantially.

3.10.4.2 Negative Impacts of the Project

The likely adverse environment impacts during the construction phase of the project will include the following.

- Degradation of soil, landscape and soil erosion due to improper disposal of excavated materials and construction waste;
- Spillage of oil and other substances during the construction;
- Pollution of water resources and soil by construction run-offs;
- Use of temporary construction sites (access roads, camps, machinery sites, storage facilities, etc ;)
- Use of borrow pits; extraction of aggregate material, such as gravel, sand, granite;
- Temporary air pollution related to increased truck traffic during the construction;
- Release of dust from digging-loading works and heavy machinery operation;
- Noise and vibration disturbances;
- Safety hazards during implementation of construction works.

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3.11 RISK ASSESSMENT AND MITIGATION MEASURES

3.11.1 GENERAL

Risk is an uncertainty that matters; it can affect project objectives negatively or positively. The uncert0ainty may be about a future event that may or may not happen and the unknown magnitude of the impact on project objectives if it does happen. Thus, a "risk" is characterized by its probability of occurrence and its uncertain impact on project objectives.

Risk of many types can occur prior to work and at the time of construction The occurrence of the unexpected events may adversely affect the timely completion of the project. For a smooth running of the project these should be assessed and should take measures to mitigate the same. The chances of such occurrences are verified and the mitigation measures are proposed.

Table 3.21 Risk Assessment and Risk Management Plan

Risks	Assessment without Mitigation	Management Plan or Measure	Assessment with Mitigation
Project road will not be built, maintained, and operated to the specified standards	High	To ensure high quality design and supervision, Kerala Public Works Department will be executing the work. Highly qualified technical persons of DRIQ board of KPWD have designed the bridge structure. Supervision at all stage of construction will be done by Technically highly qualified persons of National Highway wing of KPWD. Procurement for the highway and bridge contract included a prequalification to ensure only contractors with experience of successfully completing of similar scale and type would be permitted to bid for the contract.	Low
Major traffic accidents	Medium	There will exist both workers and traffic during the construction period. So for reducing the accidents safety jackets and temporary warning signals are providing.	Low

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Boundary arguments	High	Revenue authorities will be directed to fix the boundary of National highway land in advance in coordination with District administration	Low
Land acquisition	High	Land acquisition proposal should be given in advance to Revenue authorities in advance. compensation for the acquired land will be paid as per The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Low
Environmental risks	Medium	Environmental management plans are incorporated in bid and contract documents for civil works; annual independent monitoring of compliance is required	Low
Social and resettlement risks	Medium	Implementation of a social action plan addressing social and gender issues will be monitored. Implementation of resettlement plans and income restoration programs will be independently monitored semi-annually to address resettlement-related risks. Even though the project involves land acquisition no direct effect on residential, commercial and other establishments.	Low
Utility Shifting	High	Advance notice will be issued to service providers like KSEB, KWA, BSNL and other private firms. Utility shifting charge has been included in the estimate for shifting electric post.	Low
Unforeseen construction delays	Medium	Mitigated through force majeure provisions of the construction contracts.	Low

3.12 PROJECT MANAGEMENT ORGANISATION

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorized to implement the proposed coastal highway project in Kozhikode district.

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3.13 CONTRACT MANAGEMENT STRATEGY

3.13.1 GENERAL

All contracts in India are to be within the framework of the Indian Contract Act, 1872, which lays down the general principles relating to formation, performance and enforceability of contracts, PWD NH Kerala officers responsible for drawing up the contract documents should keep these principles in mind.

3.13.2 DEFINITION

When two or more persons have a common intention communicated to each other to create some obligation between them, there is said to be an "agreement". An agreement which is enforceable by law is a "Contract".

3.13.2.1 The following steps are involved in procurement.

1. Preparation of Bid (Tender) Documents
2. Approval of Bid Documents by the tender accepting authority
3. Public invitation for Pre-qualification (where so specified)
4. Issue of instructions to Bidders, and Pre-qualification Criteria
5. Receipt of Applications for Pre-qualification, and their Evaluation
6. Approval of Pre-qualification
7. Invitation for Bids
8. Issue of Bid Documents to prospective bidders
9. Pre-bid meeting (if specified), issue of minutes and clarifications, with the approval of the authority who originally approved the bid documents.
10. Receipt of Bids
11. Scrutiny of Bids and their Evaluation
12. Negotiation (where warranted)

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13. Acceptance of Bid (or Rejection of Bids)

3.14 IMPLEMENTATION SCHEDULE AND WORK BREAK DOWN STRUCTURE

3.14.1 GENERAL

A Work Break down Structure (WBS) , In Project management and systems Engineering , is a deliverable – oriented break down of a project into smaller components. WBS is a hierarchical and incremental decomposition of the project into phases deliverable and work packages. It shows a subdivision of effort required achieve an objective.

3.14.2 NEED FOR WBS

WBS (Work Breakdown Structure) is a critical phase in management. The time bound work schedule is an important part of every project because it helps in better handling of projects in planning, implementation etc. More over Work Breakdown Structure must be consistent in the way work gets performed.

WBS can considered as input to five key project management activities

- Cost Estimating
- Cost Budgeting
- Resource Planning
- Risk management Planning
- Activity Definition

3.14.2.1 WBS for Project Management

- Indicates the Project milestone and check point
- Helps to estimate project scope, time, risk, and other factors
- Gives a better understanding of the project
- Provides a frame work for managing and delegating work

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- Serves as a great decision – making tool

A detailed Work Program Schedule is enclosed with annexure IV having clear indication of completion of time and resources used. The start date indicated in the Work Breakdown Structure is first January2018. The end date can be shifted in accordance with the shift in date of start, keeping the period of construction constant. A detailed cash flow diagram is also appended in Annexure V.

3.15 STATUTORY CLEARANCE

A review of the project relevant legal policies, regulations and institutions at the International, National and State levels has been presented in this section. Applicable clearances required for the project under various regulations and role of various institutions in implementing various regulations and environmental management measures have been addressed below.

3.16 EIA NOTIFICATION 2006

The EIA notification dated 14 th September, 2006 imposes certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects on activities based on their potential environmental impacts as indicated in the schedule to the notification, being undertaken in any part of India unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy as approved by the Union Cabinet on 18th May,2006 and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Authority(SEIAA)

The notification has listed out the Projects or activities requiring prior environmental clearance under Category "A" and "B" based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade recourses. Category "A" projects require prior environmental clearance from MoEF & CC on the recommendations of an Expert Appraisal Committee (EAC) and Category "B" project require prior environmental clearance from State or Union territory Level Environment

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Impact Assessment Authority (SEIAA) on the recommendations of a State or Union territory Level Expert Appraisal Committee (SEAC). In the absence of a duly constituted SEIAA or SEAC, a category "B"project shall be treated as a Category "A" project.

New National Highways and expansion of National Highways greater than 100 Km, involving additional right of way greater than 40 m on existing alignment and 60m on realignment involving land acquisition is categorized as "A" New State Highways and expansion of State Highways project in hilly terrain (above 1000 on AMSL) and or ecologically sensitive areas is categorized as "B" . Any project specified in category "B" will be treated as category A, If located in whole or in part within 10Km from the boundary of (i) Protected Areas notified under the Wild life (Protection) Act, 1972, (ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time , (iii) Notified Eco-sensitive areas and (iv) inter-State boundaries and international boundaries.

As the new road will not come under hilly terrain or ecologically sensitive areas, the project will not attract EIA notification 2006.

3.16.1 COASTAL REGULATION ZONE (CRZ) CLEARANCE

As populations in coastal areas increase and the economic activity diversifies, all the impacts on coastal environment are bound to worsen threatening survival of several species, productivity of the biota, and render fishing an unsustainable proposition. It is, therefore, clear that unless governments and resource users take appropriate action, the degradation of the coastal and marine environment will become uncontrollable and there will be no possibilities for sustainable use of resources from these waters. The Coastal Regulation Zone (CRZ) Act notified by the Ministry of Environment and Forests in 1991 needs to be seen against this background. It declares coastal stretches as CRZ and regulates certain activities within the zone. The provisions of the act are to be implemented by the coastal states and Union Territories. It also envisages the creation of an appropriate authority at the state/UT level to be responsible for enforcement and enactment of these

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provisions. The request for CRZ clearance is applied through the corresponding local bodies. Provision for 5% of the estimated cost of work as lumpsum is included in the estimate as fee for CRZ clearance.

3.17 QUALITY MANAGEMENT PLAN

3.17.1 BACKGROUND

The Quality Management Plan is an integral part of any project management plan. The purpose of the Quality Management Plan is to describe how quality will be managed throughout the lifecycle of the project. It also includes the processes and procedures for ensuring quality planning, assurance, and control are all conducted. All stakeholders should be familiar with how quality will be planned, assured, and controlled.

Quality Assurance is defined as all the planned and systematic activities implemented within the Quality System and demonstrated as needed, to provide adequate confidence that an object will fulfil the requirements. The **PWD Quality Management Manual** provides a base document outlining policy, procedures, responsibilities, compliance, acceptance criteria and documentation.

3.17.2 ADOPTED STRATEGY

This section of the Quality Management Plan describes the approach the organization will use for managing quality throughout the project's life cycle. Quality must always be planned into a project in order to prevent unnecessary rework, waste, cost, and time. Quality should also be considered from both a product and process perspective.

3.17.3 STRUCTURE OF QUALITY MANAGEMENT WING

Quality control tests have been made mandatory for projects undertaken by state PWD from 1.9.2014. Clause 2401 and 2406 of Revised PWD Manual - 2012 stipulates that PWD shall follow a three-tier quality control system for ensuring quality of projects executed as per PWD Quality

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Control Manual. This includes technical audit after completion of construction. The system envisaged is as below:

3.17.3.1 First-tier QC testing

In first-tier QC testing, the Contractor has to carry out the required tests at his own cost during the course of a work. First tier quality control tests are mandatory for all projects

As per Govt. circular No. 23631/G2/2013/PWD dated 1.11.2013, Contractors shall establish field laboratories at the site. If any test cannot be carried out with the facilities available in the Contractor's laboratory, it shall be got done in an approved laboratory by the Contractor at his own cost.

If the QC test is done in the field laboratory established at site, the test results shall be signed by the Overseer/Assistant Engineer, whoever is supervising the work. It shall also be signed by the Contractor. Copy of test results shall be forwarded by the Assistant Engineer to the Assistant Executive Engineer/Executive Engineer for review. The same procedure shall be followed, in case of tests done in an approved laboratory also.

3.17.3.2 Second-tier QC testing

Second-tier QC checks/tests are to be done by the QC wing of PWD on a random basis. However, it is desirable that the QC wing does quality control tests for all major and important items of construction. The frequency of tests shall be as per PWD Quality Control Manual or as specified in the Contract. The QC wing is authorized to inspect all projects undertaken by PWD, and conduct quality tests.

3.17.3.3 Third-tier QC checking (Technical audit)

As per clause 2406 of the revised PWD Manual 2012, Technical audit shall be done by an external agency/expert empanelled for the purpose after the construction of a project is completed. This will form the third tier of QC system. Technical audit shall be done for projects, estimated cost of which is above Rs 5 crores. All tests carried out in the first-tier and second-tier QC

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testing shall be reviewed during technical audit. Technical Audit shall be completed within six months from the date of completion of construction. Non-destructive testing techniques shall be adopted if conventional testing techniques cannot be applied.

3.18 OPERATION AND MAINTENANCE PLAN

3.18.1 GENERAL

After the construction is completed, it is essential that the road structure is kept under observation and its condition monitored regularly so as to ascertain its performance and the efficiency of the measures adopted. The monitoring may involve inspections at frequent intervals, carrying out of certain laboratory and field-tests as well as condition surveys and measurements to detect even small strains, movements, changes in deformation etc.

3.18.2 INSPECTION OF WORK

Periodical inspection shall be conducted for all roads as per IRC guidelines. Detailed guidelines for highway road inspection and maintenance are contained in the following and the same should be invariably followed.

- IRC SP 57 - 2000 "Guidelines on Quality Systems for Roads"
- IRC:82 2015 "Code of Practice for Maintenance of Bituminous Road Surfaces".

3.18.3 MAINTENANCE

The purpose of detailed inspection as outlined above is to find out whether damage or deterioration has occurred in any part of the structure and if so immediate steps have to be taken for appropriate Remedial measures

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3.18.4 REMEDIAL MEASURES

- Wherever cracks, spalling of concrete, disintegration etc. are noted in wearing coat, drainage spouts, hand rails, footpaths and construction joints shall be rectified.
- Periodical maintenance of roads
- Corrosion of reinforcement shall be attended.
- Missing and broken footpath slab shall be replaced immediately

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4 LAND ACQUISITION

There is no development to the country without land. Land required for construction of Highways, Roads, Bridges, Railways, and Airports etc are acquired from public by implementing prevailing land acquisition rules. The Proposed road from Kolavipalam to Kodikkal beach which is a part of coastal highway also require minimum land for construction. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in this stretch. The process of land acquisition for the construction of proposed road is carried out as per the 'The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2015'. The amount of compensation to be awarded for land owners as per the provisions of this act.

4.1 LAND ACQUISITION ACT, 2015

An Act to ensure, in consultation with institutions of local self-government and Gram Sabha's established under the Constitution, a humane, participative, informed and transparent process for land acquisition for industrialization, development of essential infrastructural facilities and urbanization with the least disturbance to the owners of the land and other affected families and provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition and make adequate provisions for such affected persons for their rehabilitation and resettlement and for ensuring that the cumulative outcome of compulsory acquisition should be that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto.

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4.1.1 APPLICATION OF ACT

The provisions of this Act relating to land acquisition, compensation, rehabilitation and resettlement, shall apply, when the appropriate Government acquires land for its own use, hold and control, including for Public Sector Undertakings and for public purpose, and shall include the following purposes, namely:

a) for strategic purposes relating to naval, military, air force, and armed forces of the Union, including central paramilitary forces or any work vital to national security or defense of India or State police, safety of the people; or

b) for infrastructure projects,

The provisions of this Act relating to land acquisition, consent, compensation, rehabilitation and resettlement, shall also apply, when the appropriate Government acquires land for the following purposes, namely:

a) for public private partnership projects, where the ownership of the land continues to vest with the Government, for public purpose as defined in sub-section (1)

b) For private companies for public purpose, as defined in sub - section (1)

4.1.1 LAND ACQUISITION COASTAL HIGHWAY FROM KOLAVIPALAM TO KODIKKAL BEACH

The total land area to be acquired for the construction of proposed Coastal highway from Kolavipalam to Kodikkal beach is 1271 acres. In this nearly 40% of land exists as public road and the remaining 60% to be acquired from private parties. The amount of compensation to be awarded for land owners as per the market value of the land at the premises.

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The details such as the extent of land to be acquired, survey number, type of land, taluk, village, Name of land owner is already submitted to Revenue Department. The Revenue Department is the acquiring authority and hence 5% of charge should be paid to them. Provison for the same is included in the estimate as lumpsum amount.

4.1.2 LOCATION OF LAND ACQUISITION

A total area of 12.71 hectors has to be acquired for the construction of coastal highway in this stretch. The land to be acquired lies in three villages namely Payyoli village, Iringal village and Thikodi village in Koyilandy Thaluk, Kozhikode District, Kerala State.

4.2 CONCEPT NOTE

The proposed coastal highway from Kolavipalam to Kodikkal beach which passes along the coastal belt of Payyoli municipality and Thikkodi panchayath connecting Koyilandy and Vadakara taluks in Kozhikode district. It is an alternative route to National Highway 66. This will surely help in saving time and fuel and reducing traffic congestion on the towns and in the national highway.

The proposed road from Kolavipalam to Kodikkal beach has two lanes having total length of 7.527 km. The recommended width of the proposed coastal highway is 15.60 metres. While the carriage way will be 7m wide, two pavements each having 1.55 m width will be constructed on both sides of the road. And a pedestrian guard rails shall be provided on both sides of the carriage way along the edge of the footpath. More over a 2m Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

The proposed coastal highway is planned almost parallel to the National Highway 66 is expected to divert a major share of the traffic from the NH and cities. Besides reducing the congestion in the NH corridors and in the cities, the Coastal Highway is expected to boost the tourism sector and help better integration with various other modes of transport.

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The road is designed after detailed investigation and to be constructed according to requirement standards of traffic, nature of soil etc. The success of the project depends on a time-bound and early implementation of the entire package of the development proposals. The implementation shall be supplemented with timely maintenance activities to sustain the quality of road infrastructure and furniture.

Baiju. P. B
Assistant Executive Engineer
PWD NH Bypass Sub Division
Kozhikode

Thushara. K
Assistant Engineer
NH Bypass Section
Nellikkode

KERALA PWD
NH DIVISION KOZHIKODE

LIST OF ANNEXURES

ANNEXURE I - DRAWINGS

ANNEXURE II - ESTIMATE

ANNEXURE III - INVESTIGATION DETAILS

ANNEXURE IV - WORK BREAK DOWN SCHEDULE & CASH FLOW

ANNEXURE V - COST BENEFIT ANALYSIS

ANNEXURE VI - QUARRY CHART AND MATERIAL TEST RESULTS

ANNEXURE VII - LAND ACQUISITION DETAILS

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NH DIVISION KOZHIKODE

ANNEXURE I

DRAWINGS

ALIGNMENT DRAWING

KODIKKAL BEACH TO KOLAVIPALAM

SURVEY DETAILS AT □ODI□□AL TO □OLAVI □EAC□

LAND AC□UISITION PROPOSAL □OR PROPOSED COASTAL □IG□□ AY

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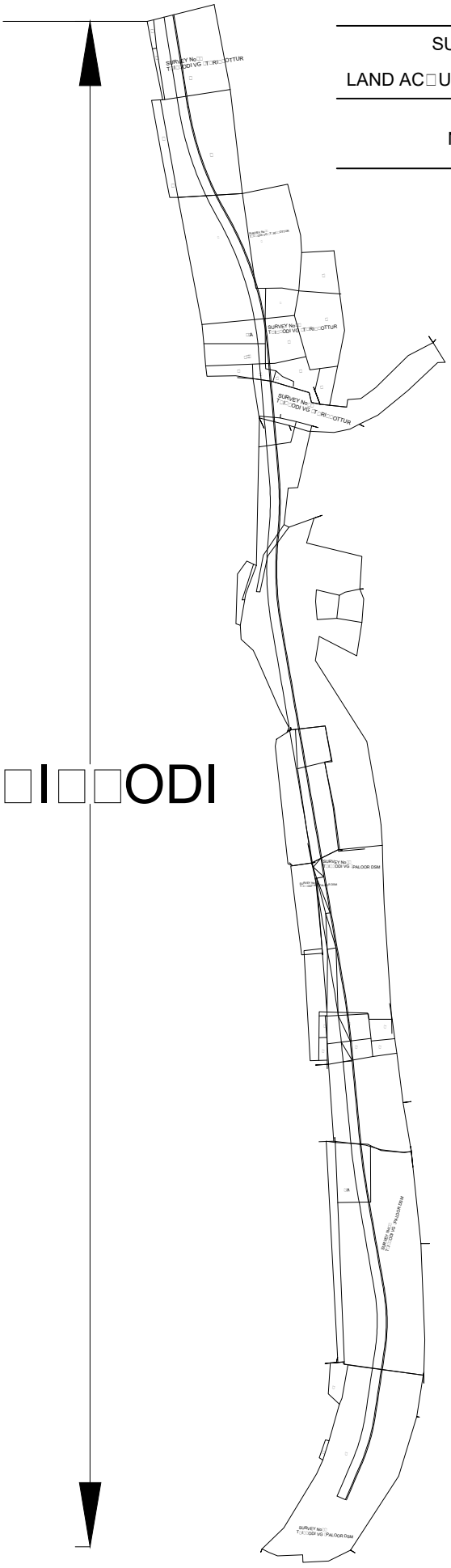

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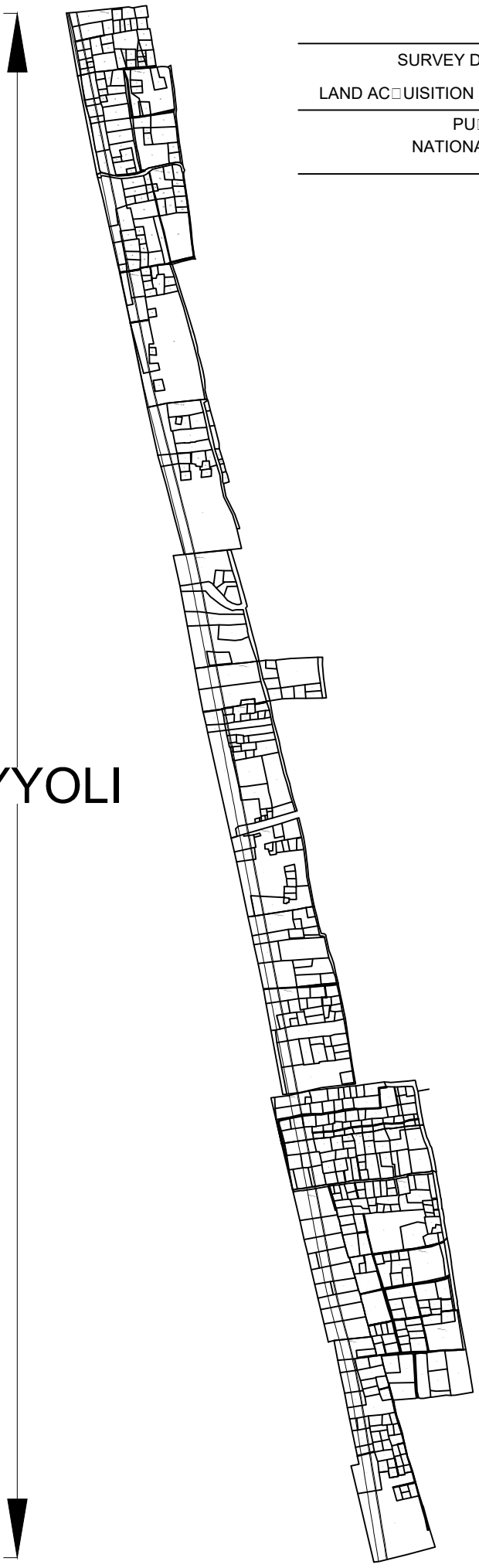

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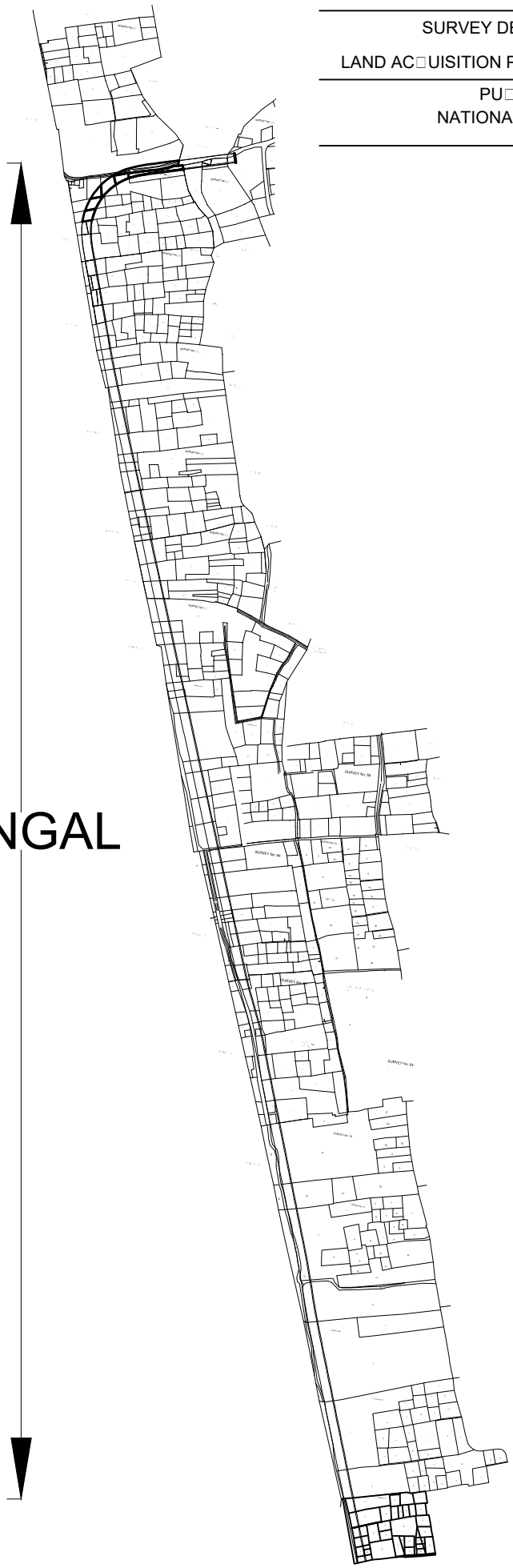

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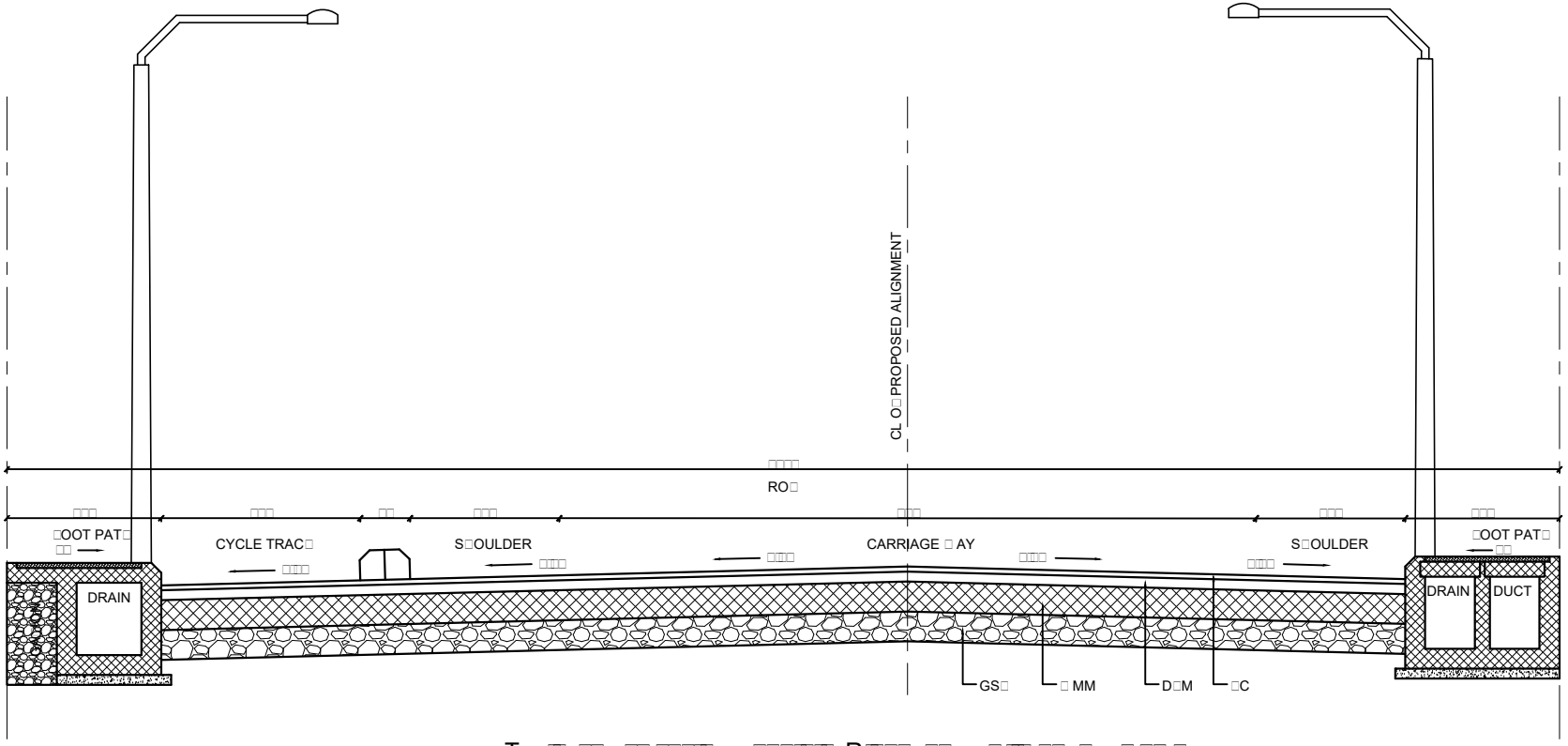
CROSS SECTION

KODIKKAL BEACH TO KOLAVIPALAM



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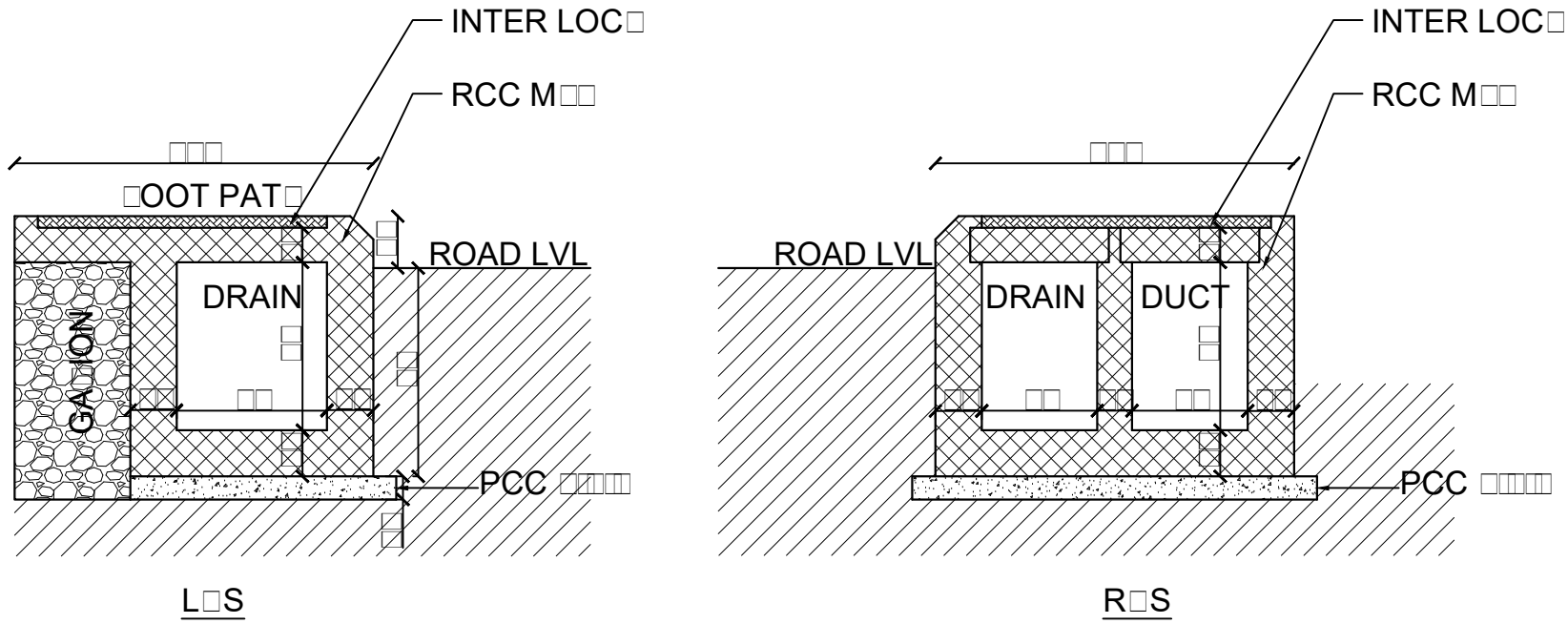
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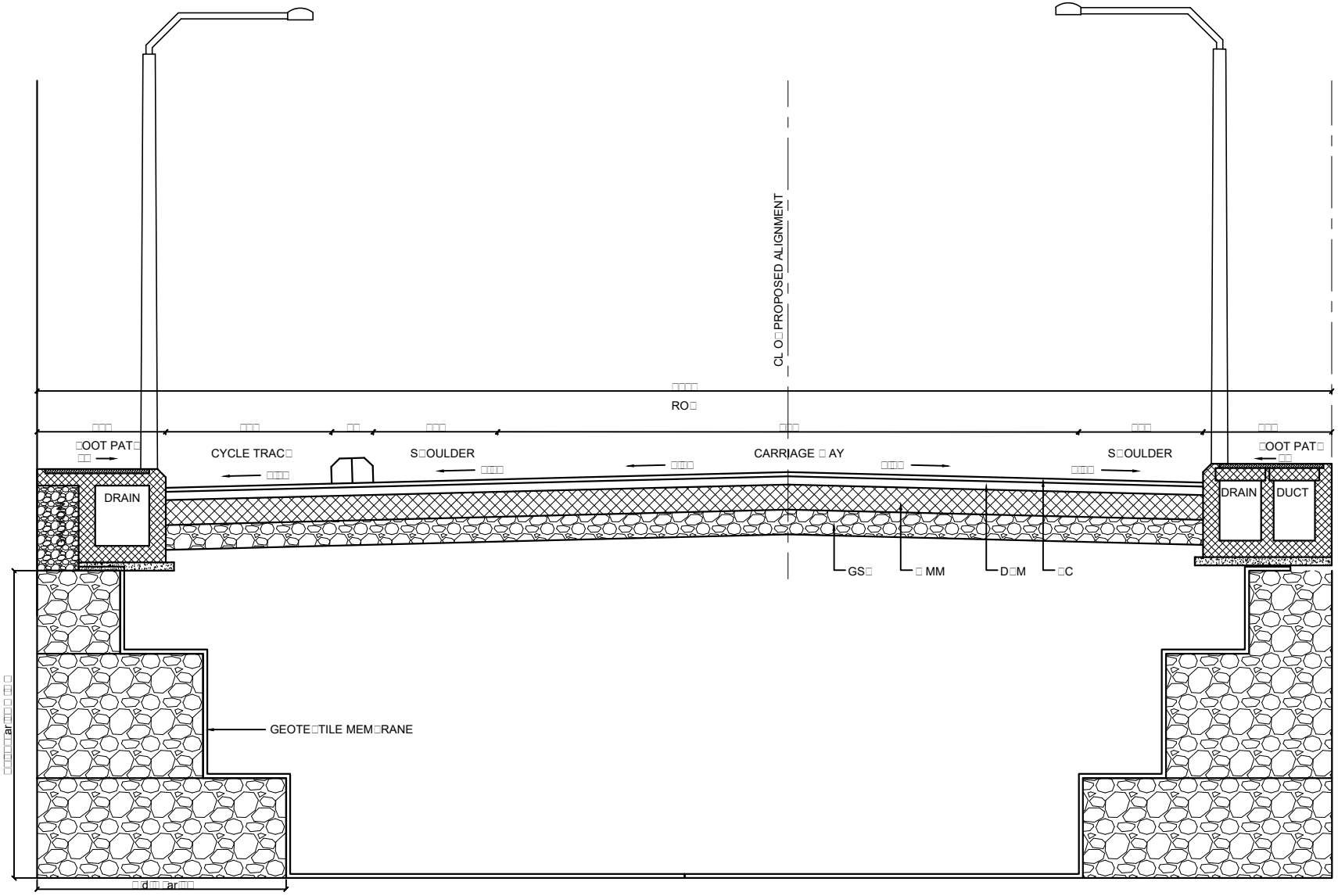

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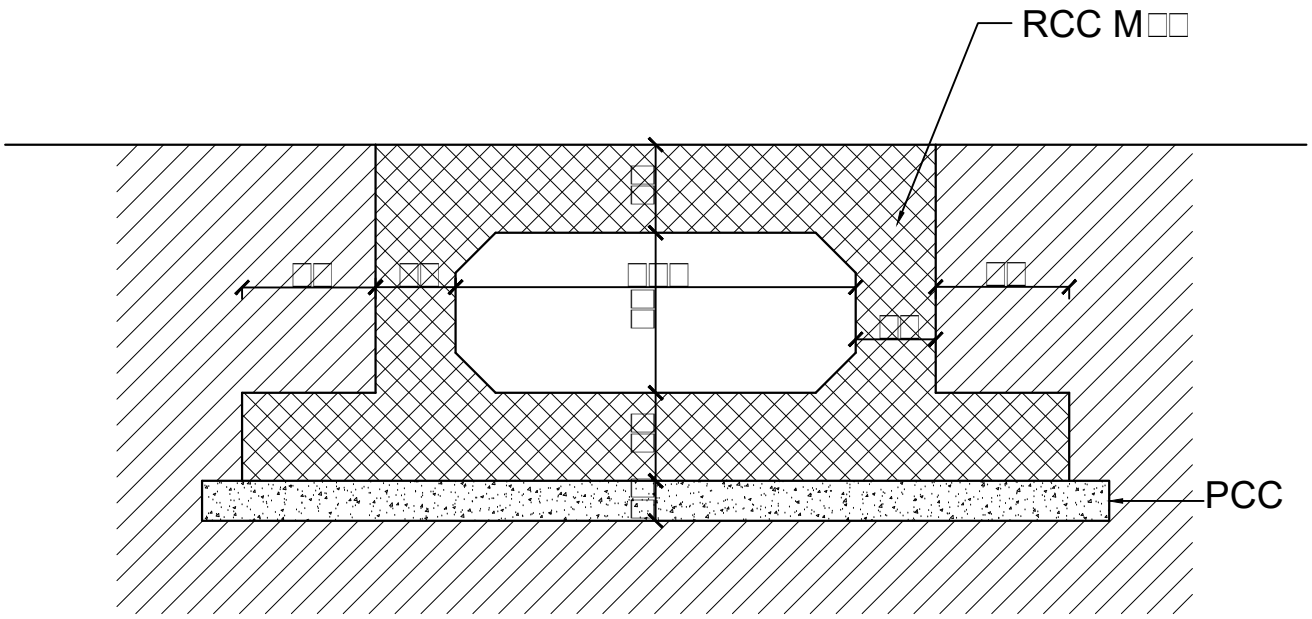

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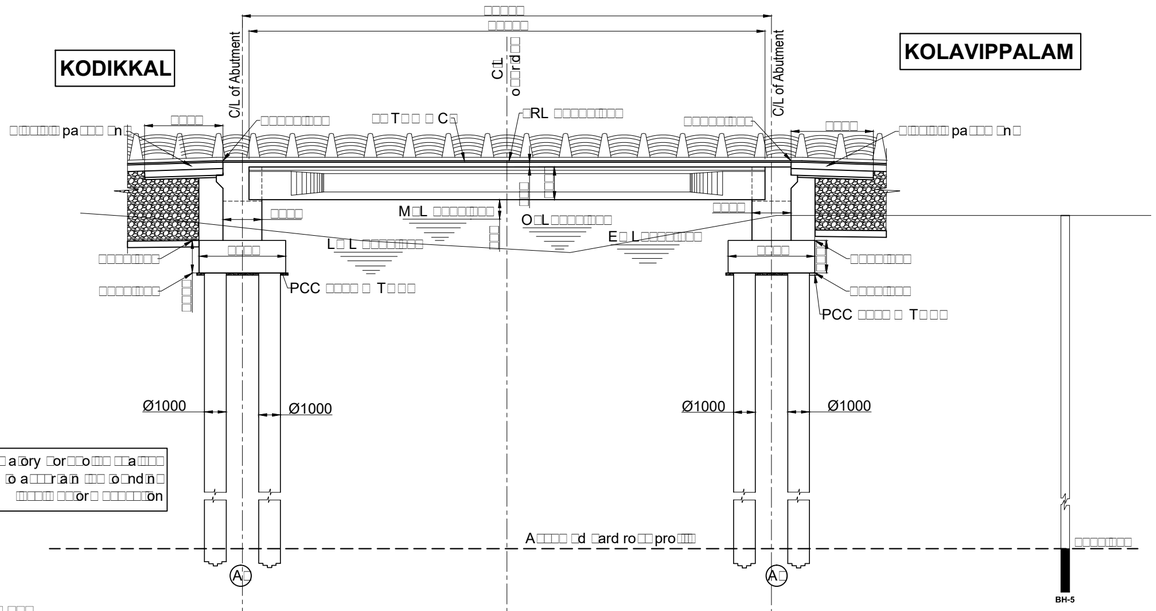

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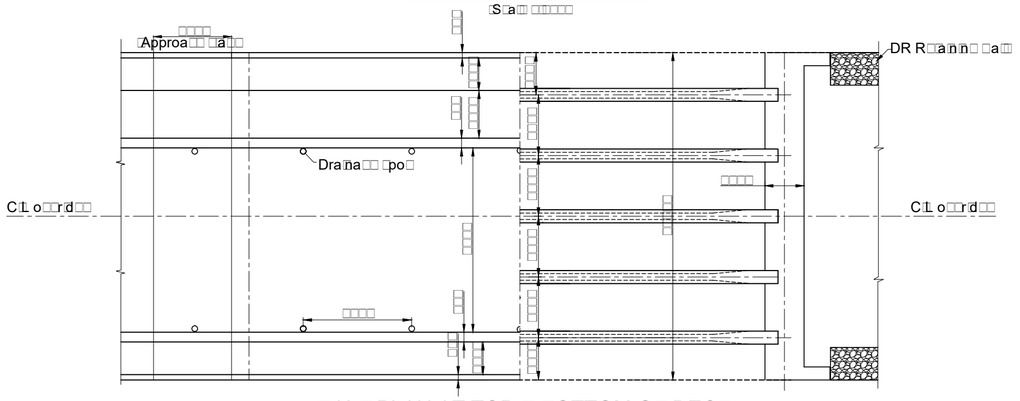
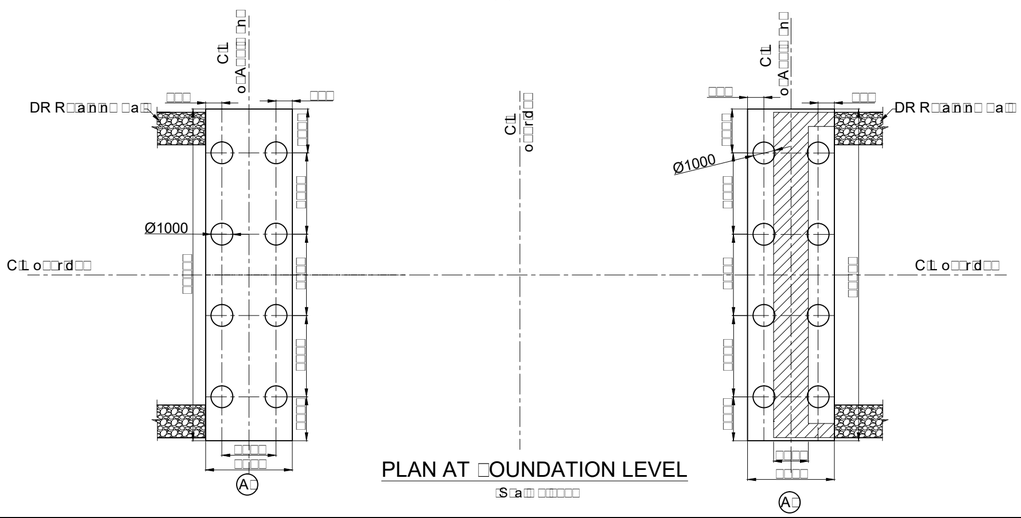
REDUCED LEVEL	
CHAINAGE (m)	

SECTIONAL ELEVATION



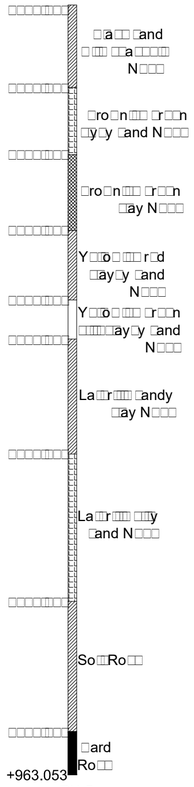
PLAN AT TOP & BOTTOM OF DECK

Scale



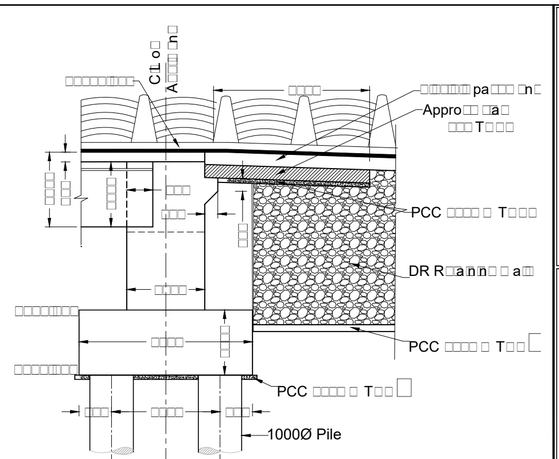
PLAN AT FOUNDATION LEVEL

Scale



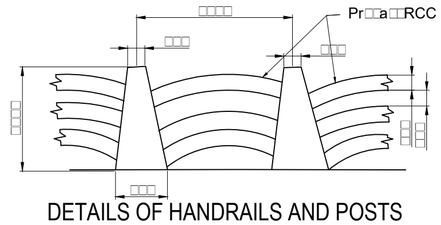
BORE HOLE DETAILS

(SCALE 1:200)



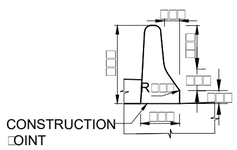
LONGITUDINAL ELEVATION OF ABUTMENT

(SCALE 1:100)



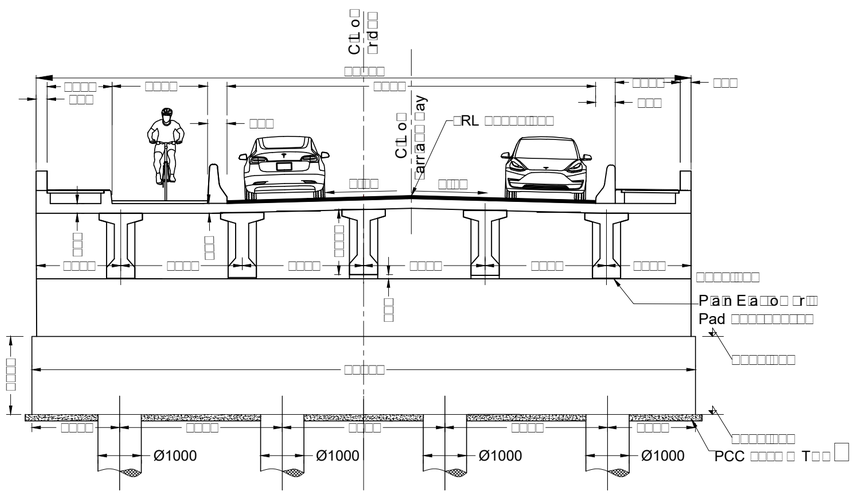
DETAILS OF HANDRAILS AND POSTS

Scale (1:50)



DETAILS OF CRASHBARRIER

(SCALE 1:50)



TRANSVERSE ELEVATION OF ABUTMENT

(SCALE 1:100)

KEY PLAN

NOTES

I. **GENERAL**

1. All dimensions are in millimeters and all levels are in meters unless otherwise mentioned.
2. Only written dimensions are to be followed. No drawing shall be scaled.

No	Layer No	Date	Description
3			
2			
1	-	-	Investigation Details

REFERENCE LETTERS

No	Drawing No	Date	Description
4			
3			
2	2/6	/05/2019	TENDATIVE GENERAL DESIGN DRAWING
1	1(b)/6	/05/2019	NOTES ON BRIDGE ELEMENTS

REFERENCE DRAWINGS

No	Description	Drawn	Checked	Approved	Date
R4					
R3					
R2					
R1					

REVISIONS

NAME OF ROAD	-
ROAD No.	-
NAME OF CROSSING	-
ROAD CHAINAGE AT C\L OF CROSSING	CH: 21.690
NAME OF BRIDGE	-
BRIDGE No.	

DRAWING ISSUED FOR:
- [x] DPR PREPARATION
- [ ] ADMIN./FINANCIAL SANCTION
- [ ] TECHNICAL SANCTION
- [ ] CONSTRUCTION

EXECUTION WING: BRIDGES

NAME OF DIVISION: KOZHIKODE

ROAD CATEGORY:
- [ ] NATIONAL HIGHWAY
- [ ] STATE HIGHWAY
- [ ] MAJOR DISTRICT ROAD
- [ ] OTHER DISTRICT ROAD
- [x] VILLAGE ROAD

DRAWN BY: NEETU MARIAM JOHN, 1ST GRADE DRAUGHTSMAN

DESIGNED BY: REMIL K, ASSISTANT EXECUTIVE ENGINEER

BRIDGE CATEGORY:
- [ ] CULVERT
- [x] MINOR BRIDGE
- [ ] MAJOR BRIDGE
- [ ] FLYOVER BRIDGE
- [ ] UNDER PASS
- [ ] ROAD OVER BRIDGE
- [ ] ROAD UNDER BRIDGE
- [ ] CAUSEWAY

CHECKED BY: ARUN K.S, EXECUTIVE ENGINEER

REVIEWED BY: SAJU S., SENIOR EXECUTIVE ENGINEER

CONSTRUCTION NATURE:
- [ ] NEW
- [x] RECONSTRUCTION
- [ ] REHABILITATION

RECOMMENDED BY: ANIL KUMAR .J, DIRECTOR (TECH)

DATE: /11/2019

APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 04712322029 Website: keralapwd.gov.in
Fax: 04712325856 Email: bducdo@gmail.com

DRAWING TITLE: TENDATIVE GENERAL DESIGN DRAWING

DRAWING SCALE: 1:200,1:100 & 1:50

SHEET SIZE: A2

REVISION No.: R0

DRAWING No.: CDO/BDU/ /19

FILE No.: CDO/BDU/-/2019/-

SHEET No.: 2/5

NOTES ON BRIDGE ELEMENTS

1. SUPERSTRUCTURE

a) The superstructure shall be PSC I girder and slab type construction.

b) The superstructure shall be constructed as per the approved drawings.

c) The superstructure shall be designed and constructed as per the relevant clauses in the Standard Specifications.

d) The superstructure shall be designed for the loadings and combinations as per the Standard Specifications.

e) No construction joint shall be provided in the bottom slab and web. Construction joint in the deck slab shall be provided as per the approved drawings.

f) Provision of construction joints shall be avoided as far as possible. However, if unavoidable, the construction joints shall be provided at locations where the shear force is minimum and shall be perpendicular to the direction of the member.

g) The superstructure shall be constructed using the following tolerances:

i) Variation in the cross sectional dimensions of the superstructure	: ±5mm
ii) Variation in overall depth of the superstructure	: ±5mm
iii) Variation in overall length of the superstructure	: ±10mm OR 1/1000 of the span, whichever is less
iv) Straightness in horizontal plane	: 1/1000 of the span

2. SUBSTRUCTURE

a) The substructure shall be constructed in the locations and dimensions as shown in the drawings or as directed by the Engineer.

b) The Standard specifications for concrete shall be followed for the construction of the substructure.

c) Vibrators shall be used for compaction of concrete in the substructure.

d) In case of piers and abutments, the construction joints shall be provided at least 1.2m above the highest flood level. The Contractor shall submit the proposal for the construction joints to the Engineer for approval.

e) Adequate measures shall be taken to prevent any damage to the substructure during the construction of superstructure.

f) The superstructure shall be constructed using the following tolerances:

i) Variation in cross sectional dimensions	: ±5mm
ii) Misplacement from specified position in plan	: ±10mm
iii) Variation in top level	: ±10mm
iv) Variation in vertical alignment	: ±5mm
v) Variation in plumb	: ±10mm
vi) Straightness in horizontal plane	: 1/1000 of the span

3. FOUNDATIONS

The foundation shall be constructed on the location as shown in the drawings. Any variation in foundation due to the site conditions shall be informed to the Engineer and approval shall be obtained before proceeding with the construction.

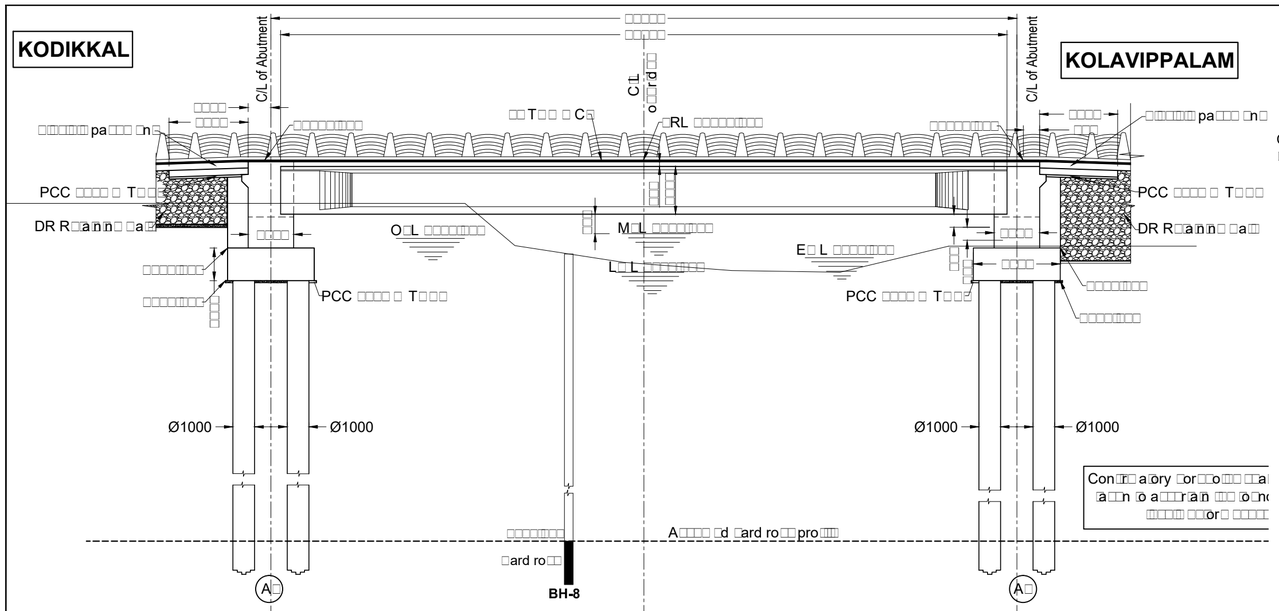
Pile foundation:

a) Pile shall be constructed as per the standard specifications in IS 2911 (Part 1/Sec 2) and relevant clauses in IRC 78.

b) Bored cast in situ piles shall be designed as friction piles and shall be constructed as per the approved drawings and bored cast in situ piling shall be carried out by rotary percussion method.

c) Driving shall be carried out in accordance with the provisions in the Standard Specifications. The hammer shall be of adequate capacity to drive the piles to the required depth or to the required set. The Contractor shall submit the proposal for the pile driving equipment to the Engineer for approval.

d) Pile load test shall be carried out as per the approved drawings or as directed by the Engineer. The load test shall be carried out as per the Standard Specifications for Road and Bridge Works, Kerala (DSL) and as directed by the Engineer. The load test shall be carried out in the presence of the Engineer or his authorized representative. The Contractor shall provide adequate facilities for the load test. The load test shall be carried out on working piles as directed by the Engineer. The load test shall be carried out as per IRC 78



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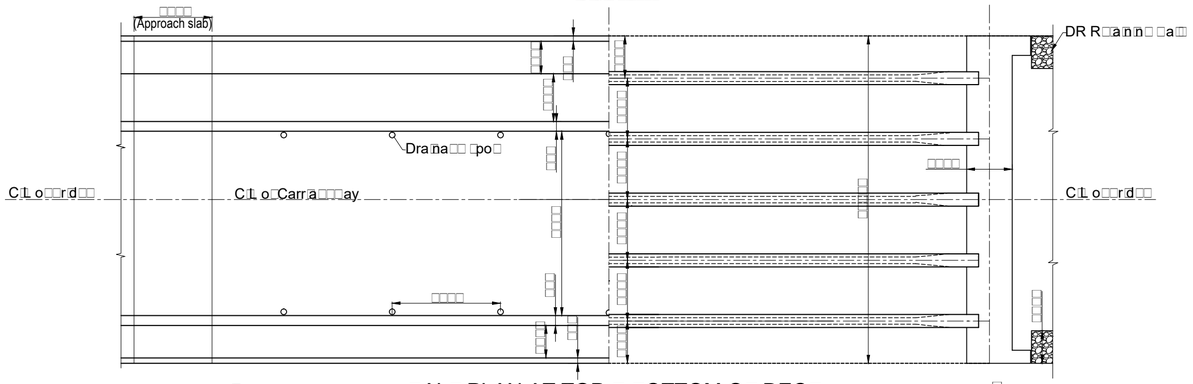
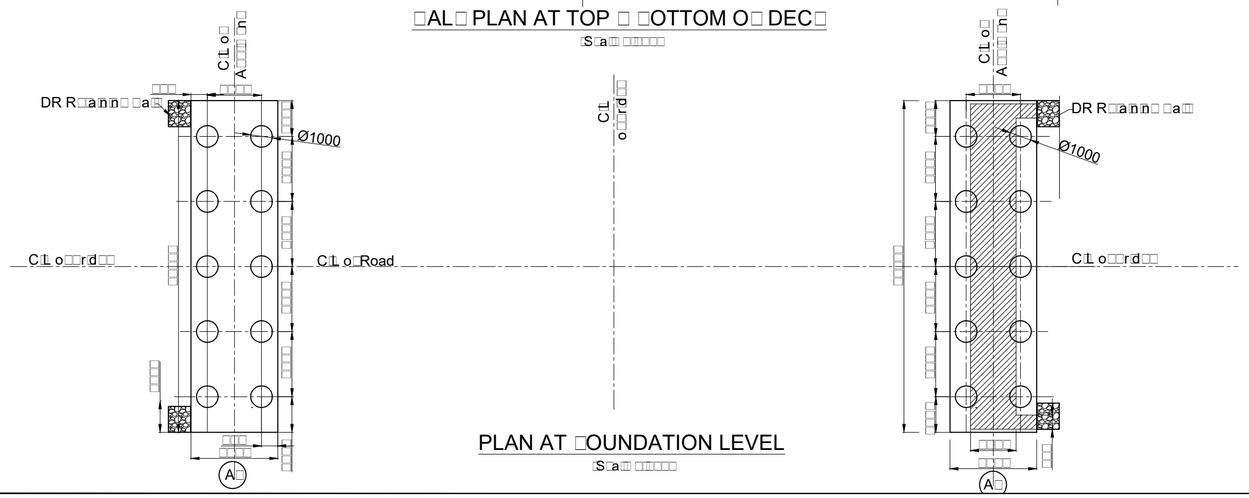
REDUCED LEVEL (m)		+999.462	+997.518	+996.744	+996.365	+996.286	+997.469
CHAINAGE (m)	0.000	11.894	14.053	19.053	24.053	29.053	32.053

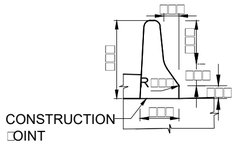
SECTIONAL ELEVATION



PLAN AT TOP & BOTTOM OF DECK

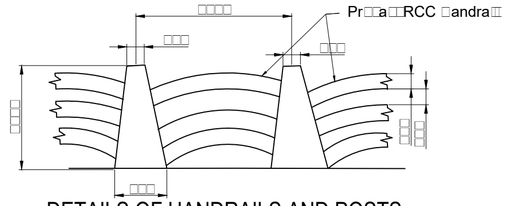


PLAN AT FOUNDATION LEVEL

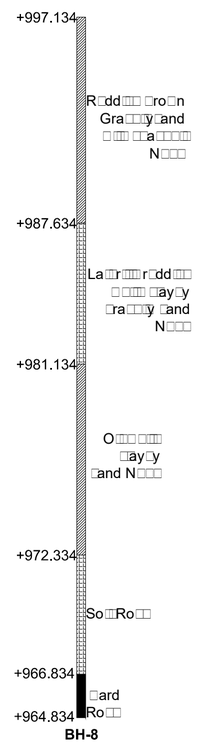


DETAILS OF CRASHBARRIER

(SCALE 1:50)

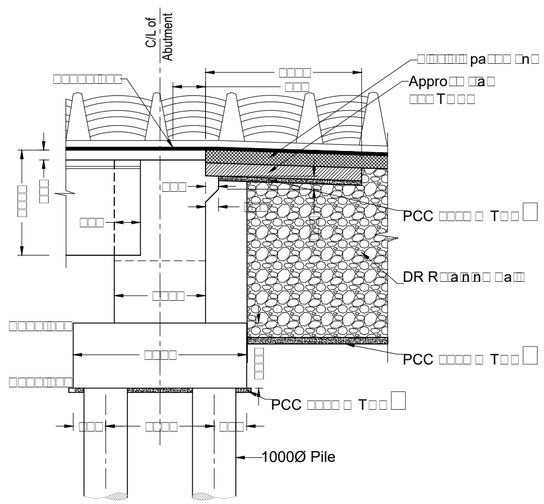


Scale (1:50)



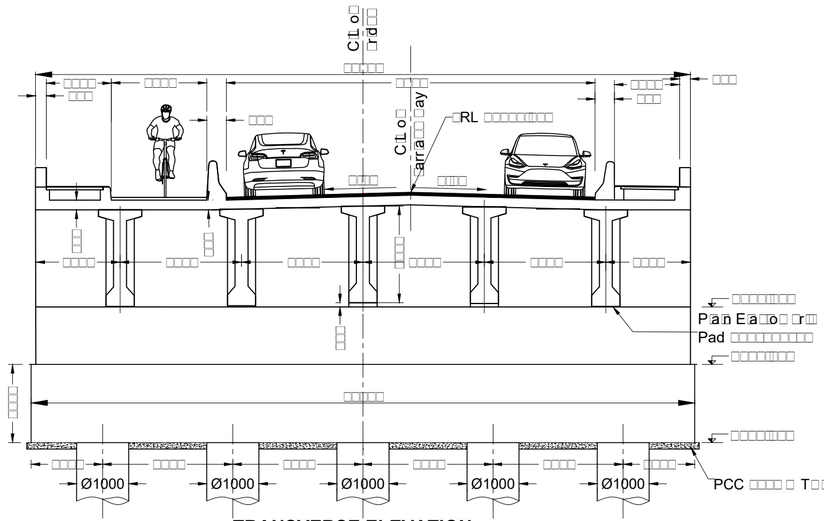
BORE HOLE DETAILS

(SCALE 1:200)



LONGITUDINAL ELEVATION OF ABUTMENT

(SCALE 1:100)



TRANSVERSE ELEVATION OF ABUTMENT

(SCALE 1:100)

KEY PLAN

NOTES

I. **GENERAL**
1. All dimensions are in millimeters and all levels are in meters unless otherwise mentioned.
2. Only written dimensions are to be followed. No drawing shall be scaled.

No.	Letter No.	Date	Description
3			
2			
1	-	-	-

REFERENCE LETTERS

No.	Drawing No.	Date	Description
4			
3			
2	2/6	/05/2019	TENDATIVE GENERAL DESIGN DRAWING
1	1(b)/6	/05/2019	NOTES ON BRIDGE ELEMENTS

REFERENCE DRAWINGS

No.	Description	Date	Drawing No.
R4			
R3			
R2			
R1			

REVISIONS

NAME OF ROAD: COASTAL HIGHWAY — ROAD No:

NAME OF CROSSING: - — ROAD CHAINAGE AT C/L OF CROSSING: -

NAME OF BRIDGE: BRIDGE 2 — BRIDGE No:

DRAWING ISSUED FOR:
- [x] DPR PREPARATION
- [ ] ADMIN./FINANCIAL SANCTION
- [ ] TECHNICAL SANCTION
- [ ] CONSTRUCTION

EXECUTION WING: NH

NAME OF DIVISION: KOZHIKODE

ROAD CATEGORY:
- [ ] NATIONAL HIGHWAY
- [ ] STATE HIGHWAY
- [ ] MAJOR DISTRICT ROAD
- [ ] OTHER DISTRICT ROAD
- [x] VILLAGE ROAD

DRAWN BY: NEETU MARIAM JOHN, 1ST GRADE DRAUGHTSMAN

DESIGNED BY: REMIL K, ASSISTANT BRIDGE ENGINEER

BRIDGE CATEGORY:
- [ ] CULVERT
- [x] MINOR BRIDGE
- [ ] MAJOR BRIDGE
- [ ] FLYOVER BRIDGE
- [ ] UNDER PASS
- [ ] ROAD OVER BRIDGE
- [ ] ROAD UNDER BRIDGE
- [ ] CAUSEWAY

CHECKED BY: ARUN K.S, BRIDGE ENGINEER

REVIEWED BY: SAJU S, SENIOR BRIDGE ENGINEER

CONSTRUCTION NATURE:
- [ ] NEW
- [x] RECONSTRUCTION
- [ ] REHABILITATION

RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I/C)

DATE: /11/2019

APPROVED BY: HUGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 04712322029 Website: keralapwd.gov.in
Fax: 04712325856 Email: bducdo@gmail.com
BDU|CDO|PWD

DRAWING TITLE: TENTATIVE GENERAL DESIGN DRAWING

DRAWING SCALE: 1:200,1:100 & 1:50

SHEET SIZE: A2

REVISION No: R0

DRAWING No: CDO/BDU/ /19

FILE No: CDO/BDU/KKD/-/19

SHEET No: 2/5

NOTES ON BRIDGE ELEMENTS

1. SUPERSTRUCTURE

a) The superstructure consists of PSC I girder and slab in composite action.

b) The bearings are provided in the abutments and piers.

c) The superstructure consists of continuous slab and girder arrangement.

d) The superstructure consists of simply supported and continuous RCC slab and PSC girder arrangement.

e) No construction joint is allowed in the middle third of the span and construction joint shall be provided at the end of the span only.

f) Provision of construction joint in the span shall be approved by Engineer.

g) The superstructure consists of PSC girder and slab in composite action.

i) Variation in overall length of span	: ±5mm
ii) Variation in overall width of span	: ±10mm OR 0.2% of span whichever is less
iii) Straightness of girder	: ±10mm

2. SUBSTRUCTURE

a) The substructure consists of RCC pier and abutment with open foundation.

b) Vertical construction joint shall be provided at the location of contraction joint in the substructure.

c) Drilling and blasting shall be carried out in accordance with the provisions in IS 4081 and IRC 9.

d) In case of adjacent spans, the superstructure shall be constructed in such a way that the differential settlement between the adjacent spans shall be within the permissible limit.

e) Additional measures shall be taken to protect the substructure from the effect of scour and the design shall be in accordance with IRC 78.

f) Provision of construction joint in the substructure shall be approved by Engineer.

i) Variation in cross sectional dimension	: ±10mm
ii) Misplacement of pier cap from the position in plan	: ±10mm
iii) Variation of thickness of cap	: ±10mm
iv) Variation of vertical alignment of pier	: ±5mm
v) Variation in cross slope	: ±10mm
vi) Straightness of pier	: ±10mm

3. FOUNDATIONS

The foundation is designed and cast on the competent rock as confirmed in the construction stage. During construction any variation in foundation strata shall be informed to the Engineer for necessary action and report to the concerned authority.

Pile foundation:

a) Pile foundation is designed in accordance with IS 2911 and IRC 78.

b) Bored cast in situ piles are designed and constructed as per the provisions in IS 2911 and IRC 78.

c) During the construction of adjacent piles, the vibration shall be monitored in accordance with IS 4081 and the construction shall be carried out in such a way that the vibration shall be within the permissible limit.

d) Pile cap is designed and constructed in such a way that the pile cap is at least 300mm above the ground level. Pile cap is designed in accordance with IRC 78.

e) Pile foundation is designed and constructed in accordance with IRC 78 and IS 2911.

f) Pile foundation is designed and constructed in accordance with IRC 78 and IS 2911.

4. HAND RAILS OR CRASH BARRIERS

a) The hand rail or crash barrier is designed as RCC type or precast type RCC crash barrier is designed and constructed as per MORTH and MOST or crash barrier and shall be approved by Engineer.

b) Appropriate measures shall be taken to protect the bridge from the effect of corrosion and the design shall be approved by Engineer.

5. WEARING COAT

a) The wearing coat shall be provided as per the specification of MORTH section 900 and as per the approved drawing.

b) Water proofing coat shall be provided in the wearing coat as per the approved drawing and as per MORTH specification.

Table-1: GEOMETRICAL FEATURES

Span arrangement	1 No.
Overall length	30.00m
Overall width	12.00m
Carriageway width	10.00m Kerb to kerb distance
Footpath	1.00m on both sides
Superstructure type	PSC Girder and slab composite

Table-2: HYDRAULIC PARAMETERS

Design HFL	0.00m
Design LWL	0.00m
Design OWL	0.00m
Design Scour Level at Pier	0
Design Scour Level at Abutment	0
Design min. clearance	0
Design velocity	0

Table-3: DESIGN PARAMETERS FOR CONCRETE

Sl. No.	Component	Grade of concrete	Max. W/C ratio	Min. Cement content kg/m³	Clear cover mm	Exposure condition
1	Superstructure	M40	0.40	360	As per drawing	Severe
2	Abutment & wing wall	M30	0.45	320	50	Severe
3	Pier	M30	0.45	320	50	Severe
4	Pier cap	M30	0.45	320	50	Severe
5	Pile	M30	0.45	320	50	Severe
6	Approach Slab	M30	0.45	320	50	Moderate

Table-4: DESIGN PARAMETERS FOR FOUNDATION

Abutment/ Pier No.	Foundation type	Size of Foundation OR Dia. of Pile mm	Max. Base pressure (kN/m²) OR Working Pile Load kN	Horizontal load on Pile kN	Embedment/ Socket depth into hard rock/strata mm	Estimated length of MS liner/Casing pipe for pile mm
A1&A2	Pile	1200	0	0	1000	1000

Table-4: ESTIMATED QUANTITY OF MATERIALS FOR PSC SUPERSTRUCTURE PER SPAN

Sl. No.	Type	Item	Structural concrete (m³)	Reinforcing Steel kg	Prestressing Steel kg
1	Interior	PSC I girder	000	00000	00000
2	Interior	Deck slab & Diaphragm	000	00000	00

The above quantity does not include any quantity of end railing and earthwork etc.

KEY PLAN:

NOTES:

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No.	Letter No.	Date	Description
3			
2			
1	-	-	Investigation Details

REFERENCE LETTERS

No.	Drawing/Sheet No.	Date	Drawing Title
4			
3			
2	2/5	/09/2019	TENDATIV GENERAL DESIGN DRAWING
1	1(a)/5	/09/2019	GENERAL NOTES

REFERENCE DRAWINGS

Rev. No.	Designed	Checked	Reviewed	Recommended	Approved	Date	Description
R4							
R3							
R2							
R1							

REVISIONS

NAME OF ROAD: COASTAL HIGHWAY — ROAD No.:

NAME OF CROSSING: — ROAD CHAINAGE AT C/L OF CROSSING: -

NAME OF BRIDGE: BRIDGE 2 — BRIDGE No.:

DRAWING ISSUED FOR:
- ☑ DPR PREPARATION
- ☐ ADMIN./FINANCIAL SANCTION
- ☐ TECHNICAL SANCTION
- ☐ CONSTRUCTION

EXECUTION WING: NATIONAL HIGHWAY

NAME OF DIVISION: KOZHIKODE

ROAD CATEGORY:
- ☐ NATIONAL HIGHWAY
- ☐ STATE HIGHWAY
- ☐ MAJOR DISTRICT ROAD
- ☑ OTHER DISTRICT ROAD
- ☐ VILLAGE ROAD

DRAWN BY: NEETU MARIAM JOHN, 1ST GRADE DRAFTSMAN

DESIGNED BY: REMIL K, ASSISTANT BRIDGE ENGINEER

BRIDGE CATEGORY:
- ☐ CULVERT
- ☑ MINOR BRIDGE
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- ☐ ROAD UNDER BRIDGE
- ☐ CAUSEWAY

CHECKED BY: ARUN K.S, BRIDGE ENGINEER

REVIEWED BY: SAJU S, SENIOR BRIDGE ENGINEER

CONSTRUCTION NATURE:
- ☐ NEW
- ☑ RECONSTRUCTION
- ☐ REHABILITATION

RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I&QC)

DATE: /11/2019

APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 04712322029 Website: keralapwd.gov.in
Fax: 04712325856 Email: bducdo@gmail.com
BDU CDO PWD

DRAWING TITLE: NOTES ON BRIDGE ELEMNTS

DRAWING SCALE: NOT TO SCALE

SHEET SIZE: A2

REVISION No.: R0

DRAWING No.: CDO/BDU/ /19

FILE No.: CDO/BDU/-/2019/-

SHEET No.: 1(d)/5

ANNEXURE II

ESTIMATE

DETAILED APPRAISAL REPORT

DETAILED PROJECT REPORT FOR THE CONSTRUCTION OF COASTAL HIGHWAY IN KOZHIKODE DISTRICT-FROM KOLAVIPPALAM TO KOTTAKKALKADAVU IN KOZHIKODE DIST.

1. SALIENT FEATURES

1.1 Project details in brief

Name of Project	Construction of Coastal highway from Kolavipalam to Kottakkal Kadavu in Kozhikode District
District	Kozhikode
Constituency	Koyilandy
Project Outlay	Rs 32.82 Cr against the original DPR cost of Rs36.80Cr
Report Prepared by	PWD NH Division Kozhikode
SPV/Implementing Agency	KRFB
Administrative Sanction	GO(Rt) No 942/2017/PWD Dtd 10/07/2017
Budget Speech Reference	2016-17
Budget provision	Funded by KIIFB
Total length of road	**2.861 Km**
Overall width & Carriageway	15.60m, 7.00 m plus 1.50 m paved shoulder on either side plus 1.50 m foot path on either side plus 2.25 m Cycle track on beach side
Foot Path	1.50 m wide on both sides at essential locations
Other Details on Proposed Road	2.25 m wide Cycle Track with kerb on coastal side of road (in line with carriage way), Street lights, Road furniture, Handrails, Drain and Duct at essential locations
Land to be acquired &	4.0469 H

structures affected	
CVPD	450
MSA	33 msa
Design MSA	33 msa
Design Life	15 years
CBR of existing soil	10 % (assumed)
Design CBR	10%
Soil Improvement if any	Sand Piling proposed
Pavement Thickness Total	**580 mm as per IRC 37:2012 Plate 4**
GSB	200 mm
WMM	250 mm
DBM	90 mm
BC	40 mm
Statutory clearances	CRZ clearance under E(P) act 1986

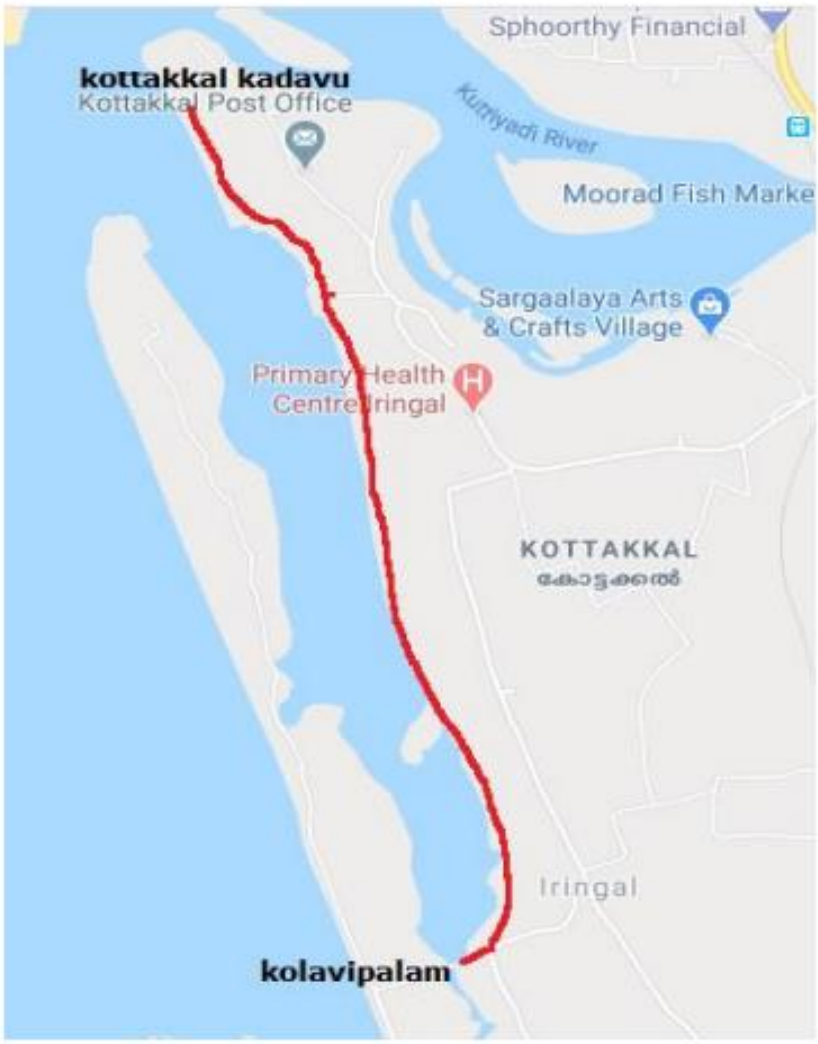
1.2 The road is proposed as part of Coastal Highway- from Kolavipalam to Kottakkal -Kadavu in Kozhikode District. This stretch is in between sanctioned reaches of Kodikkal to Kolavipalam and Kunhalimarakkar Bridge

1.3 Admn. sanction was accorded for the work as per GO(Rt) No 942/2017/PWD Dated 10/07/2017 for the construction of coastal Highway in the state.

1.4 The Detailed Project Report is prepared by PWD NH Wing Kozhikode which comprises project description, engineering surveys and investigation details, Geometric design and General Arrangement Drawing (GAD), Project cost estimation and Cost benefit Analysis. The report acknowledge that all activities related to field studies, design and documentation were done as per the prevailing IRC/KIIFB guidelines. The report also states that the on completion of the project, it would improve the connectivity of the area, reduce the traffic congestion along NH 66.

1.6 Total length of road stretch is 2.861 km, with 15.60m RoW, 7.00 m carriageway, plus 1.50 m paved shoulder on either side, footpath of 1.50 m wide on both sides at necessary locations, and 2.25 m Cycle track. The DPR comprises all necessary Traffic study data, GAD, Geotechnical data, Cost estimate, Socio-economic analysis etc. in support of the arguments favoring the project.

1.7 The map of the study stretch is as given below.



Project Influence corridor

2. REQUIREMENT / DEMAND ANALYSIS

2.1 The stretch is a part of the proposed Coastal Highway in the state having a length of 655 Kms connecting Poovar (Trivandrum) & Kunjathoor (Kasargode) covering 9 coastal districts.

2.2 Promoting Tourism, Spots, Fisheries Development, Easy Cargo Movement & Reducing congestion in NH are the objectives of this highway in addition to providing transport facilities to the coastal areas/ports. The proposed project is implemented through KIIFB funding.

2.3 In addition to the above objectives, on completion of the entire reaches of coastal highway in this district, it would decongest the NH 66 between Kozhikode and Kannur. The average daily traffic (ADT) for the base year worked out is 1283. The design traffic with a vehicle damage factor of 3.9 & lane distribution factor of 0.50 comes to 33 msa.

2.4 . This stretch comes in between the already approved reaches of Kodikkal to Kolavipalam and Kunhalimarakkar bridge.

3. FUNCTIONAL DESIGN

3.1 The functional design is carried out based on the requirement analysis through field studies and documentation as per IRC & KIIFB guidelines. Designs are strictly as per geometric standards. The alignment drawing has been finalized based on the topographic and geotechnical studies carried out by NH division & in consultation with NATPAC.

3.2 The alignment is selected in such a way that the land acquisition and rehabilitation is minimum.

3.3 It is reported in the DPR that this alignment is verified and vetted by the NATPAC team also.

3.4 The DPR contains traffic volume study data, BBD & CBR test results.

3.5 The proposed road pavement is with DBM&BC

3.6 ROW of the proposed road is 15.6 meters, and the boundary of RoW is to be demarcated with boundary stones.

3.7 The proposed road has a carriageway width of 7m, 1.5m paved shoulders on both sides, 2.25 m wide cycle track and 1.5 m wide drain on both sides of the road (as

applicable) with average RoW of 15.6 meters, which satisfies the minimum requirement for Coastal Highway as per KIIFB Planning and Design Manual.

3.8 Drains, Foot path and ducts are also proposed at essential locations.

3.9 Footpaths and road safety features including necessary warning signs, chevron signs, OHM, direction boards, road marking etc. are provided to avoid accidents. Provision of road furniture shall be evaluated by the TS committee prior to technical sanction.

3.10 Detailed drawings of the proposed bus bay and bus shelters along with chainage shall be prepared prior to TS.

4.ENGINEERING DESIGN

4.3 The pavement design has been carried out using the data from traffic study &CBR.

4.4 Detailed soil investigation report with CBR test results is furnished along with the DPR.

4.5 Pavement condition survey report is furnished along with the DPR.

4.6 Detailed design report of horizontal curve and vertical curve shall be prepared and the same shall be evaluated by TS committee prior to sanction.

4.7 The Proposed thickness of subbase GSB is 200 mm and thickness of wet mix (WMM) is 250 mm. The thickness of bituminous layers of DBM is 90 mm and BC is 40 mm. Design CBR value is 10 % and design traffic in msa comes to 33. Pavement has been designed as per provisions in IRC 37:2012 (Plate :4) with a total thickness of 580 mm. Now this design need revision in the context of 6 lane work of NH 66 in the district.

4.8 Longitudinal and cross-sectional drawings of the proposed road to assess the quantity of cutting and filling shall be prepared prior to TS.

4.9 Full-fledged alignment plan in the required scale with all levels and chainages marked to assess the topographical features for quantity estimation of cutting and filling shall be prepared prior to TS.

5. O&M STRATEGY

Sl No	Item	Cost as per Revised DPR (lakhs)	Recommended Cost	Remarks
1	Road work	1241,38,590	1241,38,590	
2	Retaining wall	619,23,789	619,23,789	TS committee shall review the provisions
3	Traffic safety works	277,74,351	277,74,351	TS committee shall review the provisions
4	Cross drainage and VCB	103,75,902	103,75,902	TS committee shall review the provisions
6	Compound wall and security cabin	7,27,401	7,27,401	
7	Soil Stabilization	271,41,392	271,41,392	As the trial pit taken is not falling in the chainage where soil stabilization is proposed, fresh investigation shall be conducted in the presence of KIIFB and PMU team before TS.
	Total	2520,81,425	2520,81,425	
8	Utility shifting	10,00000	10,00000	
9	Land acquisition & rehabilitation	448,86,528	448,86,528	
	Total	297967953	2979,67,953	
	GST	**30249771**	**30249771**	
	L S round off	82276	-	
	Grand Total	**32,83,00000**	**32,82,17,724**	

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5.1 Construction and maintenance of the coastal Highways in Kerala is under the control of PMU KRFB. The defects if any during the defect liability period will be done by the original project contractor with the supervision of KRFB.KRFB will stipulate necessary conditions in the agreement for the same.

5.2 The DLP of the project will be **5** years.

5.3 All the activities in connection with the O&M strategy are explained in the DPR.

6. FINANCIAL ESTIMATES & COST PROJECTIONS

6.1 The estimated cost is based on MoRTH specifications and DSR 2018 arrived at as per PRICE with cost index of 136.44 of Kozhikode Dist.

6.2 The summary of cost sought for funding and the recommended cost is provided below:

Total Recommended Cost – Rs.32.82 Cr

TS Committee shall evaluate the revised estimate prior to sanction.

7. COST BENEFIT ANALYSIS

7.1Cost Benefit analysis (CBA) are well detailed and documented in the report.

7.2 This route will decongest the traffic snarled in NH 66 between Kozhikode & Kannur. Also, reduction in air pollution, noise pollution, travel time savings of passengers, savings in fuel consumption etc. are the benefits documented in the report.

7.3 Development of tourism will be a major benefit of the proposed project.

7.4 Cost benefit ratio worked out comes to 1.16 and EIRR 31.83%.

8.VALUE ENGINEERING OPTIONS

8.1 The alignment is selected in such a way that the land acquisition and rehabilitation

will be minimum.

8.2 It is reported in the DPR that this alignment is verified by the NATPAC team.

9.IMPLEMENTATION SCHEDULE & WBS

9.1 A detailed Work Program Schedule is furnished in Annexure.

9.2 The schedule is to be re-worked as the preparatory work itself has delayed considerably.

10.PROJECT MANAGEMENT ORGANIZATION STRATEGY

10.1 KRFB has been appointed as the Special Purpose vehicle (SPV) for the

implementation of the project.

10.2 Newly formed Engineering wing of the KRFB will implement the project

11.CONTRACT MANAGEMENT STRATEGY

11.1 The strategy has been explained in the DPR.

11.2 Tenders will be invited by KRFB as per prevailing practice under two cover

System and normally the price of the lowest bidder will be accepted.

11.3 The work will be implemented through KRFB Engineering wing.

12.STATUTORY CLEARANCES

12.1 Administrative sanction has already been accorded for the construction coastal

road as per GO(Rt) No 942/2017/PWD dated 10.07.2017

12.2 As the project is close to coastal belt, CRZ clearance is also inevitable.

12.3 It is reported that PWD have already moved for CRZ clearance.

13.ENVIRONMENTAL ASPECTS & SUSTAINABILITY

13.1 It is reported that the project is not coming under protected areas such as Forest/Sanctuary/National Park etc, prior clearance is not applicable under Forest

Conservation Act. This shall be confirmed by the SPV as the road stretch is passing close to Arabian sea

13.2 But the project falls under coastal area and as such CRZ clearance is inevitable for the implementation of the project.

14.QUALITY MANAGEMENT PLAN

14.1Quality management plan and strategies are also covered in the DPR contemplated in the PWD manual.

14.21st tier quality management will be the responsibility of the contractor and will be done in consultation with the supervising agencies.

14.3The 2nd tier quality management will be done by the PWD through reputed lab.

14.4The 3rd tier QC checking shall be arranged by the external agency empaneled for the purpose.

15.RISK ASSESSMENT AND MITIGATION MEASURES

15.1The DPR has covered and assessed the possible risk associated with this work and

suggested measures for the mitigation.

15.2 Detailed work program schedule, statement towards cash flow for mitigating

financial risk, construction management strategy, strategy for utility shifting etc.

are covered in this report.

16.REMARKS AND INFERENCES

16.1 The project report has satisfied all the basic requirements for consideration for the financial assistance from KIIFB. The revised alignment proposal for the coastal highways in Kozhikode District have been approved by the government vide G1/196/2020-PWD dated 11/10/2020.

16.2The parameters studied as per the demand are regarding this project itself and the functional design is matching with the actual requirements and are as per standards.

16.3 The estimate prepared and submitted is as per the alignment proposal and meets all the basic requirements.

16.4 ***The traffic considered for the stretch at present is same as that of the National Highway 66. Now, 6 lane work of NH 66 has been commenced and the entire work is expected to be completed by 3 years period. As such after commissioning the 6 lane NH, traffic through the Coastal Highway stretch would be comparatively less. As the scenario of traffic in the district is changing considerably, pavement design is to be revised. TS authority should see this aspect and get the design revised before according TS.***

16.5The quantity of embankment material shall be verified at the time of the submission of the Detailed drawing prior to issuing TS.

16.6Rectification of defects and maintenance requirements are to be handled in a unified manner within the DLP and after expiry of DLP and a foolproof strategy to be framed before tendering.

16.7The period of completion targeted not realistic and the WBS is to be revised. The same shall be submitted to KIIFB as early as possible.

16.8The contract management plans are acceptable provided the procedures and the documentations shall strictly be as per the prevailing norms.

16.9 The risk factors in obtaining statutory clearances from other department shall strictly be monitored by KRFB and delay avoided.

16.10 Need for environmental clearances shall also be verified and confirmed at the time of commencement of work.

16.11 The risk management plan shall be one which eliminates and mitigates all the risk factors associated with the work. It is the responsibility of KRFB to make available majority of ROW at the beginning of the execution and the timely shifting of utilities, to avoid possible chances of time extension.

16.12 As the design, execution and quality control of different items are to ensure by contractor also, all the personnel deployed by the contractor should be well qualified and experienced to achieve desired output.

17. RECOMMENDATIONS AND SUGGESTIONS

17.1 The project may be considered for funding by KIIFB provided the tripartite agreement shall be entered after ensuring adequate clarity in the observations 16.4 to 16.12.

17.2 In view of the replies to TAR, furnished by KRFB the amounts to be considered for sanction comes to **Rs 32.82 Cr**.

17.3 The detailed estimate shall strictly be reviewed and scrutinized by the TS authority. To avoid any ambiguity during execution, the TS authority should confirm that the estimate is not an inflated one, satisfies all the design standards & specifications and yardstick for various provisions are not exceeded.

17.4 Technical sanction is mandatory before tendering and executing agreement

17.5 The cost provisions earmarked against work alone shall be utilized for execution of work. The savings or anticipated savings from LA, QC, shifting utilities etc. shall not be re- appropriated for meeting expenditure of work proper.

17.6 The identified revenue streams if any shall be communicated while signing tripartite agreement.

……

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1 SALIENT FEATURES 4
2 EXECUTIVE SUMMARY 7
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2.6 QUALITY ASSURANCE PLAN 12
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1 SALIENT FEATURES

1	Title of the project	Construction of Coastal highway from Kolavipalam to Kottakkal kadavu in Kozhikode District
2	Department	Public works Department
3	Details of project location	
	i. District	Kozhikode
	ii.Taluk	Kozhikode
	iii. Corporation/Municipality/Panchayath	Payyoli Municipality
	iv. Assembly Constituency	Koyilandy
4	Implementing agency/SPV	KIIFB & KRFB
5	DPR prepared by	PWD National Highway Division, Kozhikode
6	Project outlay	Construction of BM&BC road as per the design with all road furniture Drain, Duct, Cycle Track and footpath works Traffic Safety Works: Provision of sign boards, Kerbs, delineator posts, Object Hazard Marker etc. Construction Cross Drainage works comes in the alignment Shifting utilities- Electricity, Telephone, Water Supply lines
7	Budget provision	
8	Budget speech reference	budget speech for financial year 2015-16
9	Administrative sanction	GO (Rt)No.942/2017/PWD dt.10.07.2017
10	Nature of the project (New Road/Improvement of existing road Strengthening of existing road/widening and Strengthening of existing road))	Construction of Coastal Highway from Kolavipalam to Kottakkal kadavu in Koyilandy LA constituency in Kozhikode District
11	Present status of existing roads	For a length of 0.2 km there exists a village road of 3.5 m width without footpath. The land to be acquired for the Construction of this Coastal Highway

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12	Need of the project	The Proposed coastal highway will be a parallel road to overcrowded NH66 and It will also boost the tourism
13	Type of road	Flexible Pavement of two lane divide carriage way
	Total length of road	2.861Km
	Overall and carriage way widths	15.60m, 7.00 m
	Provision of footpath	1.55 m wide on both sides with 0.25m Kerb at selected place
	IRC loading class	70R
	Other details of proposed road	2.5m wide Cycle Track on coastal side of road (in line with carriage way),Street lights, Road furniture, Hand rails, Drain and Duct.
14	Details of investigations/surveys conducted	
	i. Topographical	Yes
	ii. Hydraulic	Yes
	iii. Geotechnical	Yes
	iv. Traffic	Yes
	v. Others	
15	Whether Land Acquisition involved? If yes, furnish details	Yes,
16	Total estimated cost and item wise cost break up and details of Schedule of Rates	36.80 Crores SOR 2016
17	Whether detailed estimate attached?	Yes
18	Details of revenue streams	KIIFB
19	Details of Cost Benefit Analysis (CBA value)	Attached
20	Details of project risks	Land acquisition Timely shifting of utilities Public involvement Availability of construction materials Mandatory approval and clearance from authorities like CRZ
21	Details of project management organization strategy	Work to be implemented through KRFB and Work to be executed by National Highway wing of Kerala PWD
22	Details of contract management strategy	Work to be executed by competent and approved

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		contracting firms through open competitive tender
23	Details of Project Implementation Schedule (PIS) & Work Breakdown Schedule (WBS) - Proposed duration to complete the project	Expecting the work to start during the financial year 2019-2020 and complete by 2021-22 Duration of project- 10 months
24	Details of statutory clearances	Will be obtained from concerned departments before execution of work
25	Quality control infrastructure and mechanism	Quality Control mechanism will be as per the PWD Quality Control Manual. Contractor has to set up Quality Control lab and responsible for 1st tier QC, 2nd and 3rd tier QC to be done/monitored by QC wing of PWD as
26	Operations & Maintenance (O&M) arrangements of the project after completion	Defect liability period is 36 months after completion of project
27	Details of attached drawings	General Alignment Drawing Design drawings
28	Other attachments	LA Plan and Proposal.

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2 EXECUTIVE SUMMARY

2.1 GENERAL

Government of Kerala has accorded administrative sanction for the construction of coastal highway vide GO (Rt)No.942/2017/PWDdt.10.07.2017. The construction of Coastal highway from Kolavipalam to Kottakkal kadavu in Payyoli municipality in Kozhikode district comes in the alignment of above proposal.

Kozhikode formerly known as Calicut is a coastal and metropolitan city in the south Indian state of Kerala. Kozhikode is the third-most-populous town and the largest urban area in the state and 192nd largest urban area in the world. The city lies about 374 kilometres north of 'Thiruvananthapuram' the state capital.

The proposed coastal highway from Kolavipalam to Kottakkal kadavu is a part of road which connects the Vadakara and Koyilandy taluks. Vadakara and Koyilandy are coastal towns in Kozhikode district. Vadakara has great historical importance. Historically Vadakara has been known as Kadathanadu. There are many tourist places such as Sargalaya, Sandbanks, Kunhali Marakkar Museum and Velliyamkallu.

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorized to implement the proposed coastal highway project in Kozhikode district.

Kerala has a network of 11 National Highways, 72 state highways, many district roads and is having a long stretch of coastal line. Kerala has narrower national highways compared to other parts of India; hence the present road network is not in a position to accommodate the increasing traffic. So the government has been planning to revive the coastal highway project that runs parallel to the National Highway 66 to reduce the traffic

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conjunctions. The alignment of the proposed Coastal Highway which will traverse through nine districts from Thiruvananthapuram in the south to Kasaragod in the north of Kerala state. The project is conceived not just to meet the transportation need of the state, but also to develop the coastal economy and living standards of the community living there.

The Kerala coast is 590 km long, laying in the direction of North-Northwest to South-Southeast, with many special features like sea cliff formed by the action of waves on the coast. Distributed on the coast, there are long patches of sandy beaches. The coast acts as major resource for coastal tourism development in the state. Nine out of fourteen districts of Kerala have coastline. Construction of coastal highway in Kerala is taken as a Government Policy. The coastal highways since it passes through the coastal area will provide better connectivity between fishing harbours and fish landing centres which will be giving a major savings in fuel costs and will promote tourism. It is seen that the traffic is increasing at a rate of 7% per year and the major corridors of the district are presently suffering from traffic congestion through most hours of the day.

As per the feasibility study report submitted by NATPAC the proposed length of the coastal highway is 657Km in which a length of 80.12 Km falls in Kozhikode District. The coastal highway project has been divided into three phases. And the construction of coastal highway from Kolavipalam to Kottakkal kadavu is comes under first phase of project. It is having a total length of 2.861 km which is planned along the coastal belt of Payyoli municipality. The proposed coastal highway is almost parallel to the National Highway 66. It is expected to divert a major share of the traffic from the National Highway on completion and is also aimed at improving the road connectivity of the coastal belt of the State for the tourism development, transshipment of goods and sea foods. Besides reducing the congestion in the National Highway corridors and in the cities, the Coastal Highway is expected to boost the tourism sector and help better integration with various other modes of transport, especially water transport.

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Since the proposed road is to be constructed in the coastal line it is necessary to obtain permission from **C**oastal **R**egulation **Z**one. The land to be acquired and the number of families to be relocated for the construction of coastal highway are minimum in this stretch.

2.2 PROJECT DESCRIPTION

The newly proposed Coastal highway from Kolavipalam to Kottakkal kadavu has two lanes having total length of 2.861km. The recommended width of the proposed coastal highway is 15.6 meters. While the carriage way will be 7m wide with two footpaths each having 1.5m width will be constructed on both sides of the road wherever necessary. And pedestrian guard rails shall be provided on both sides of the carriage way along the edge of the footpath. More over a 2.50 m wide Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors. As the road passes through an entirely new alignment, geometry of the road has been designed as per the IRC standards. The proposed alignment is a green field alignment. The alignment in this stretch is fixed in a way that the land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum.

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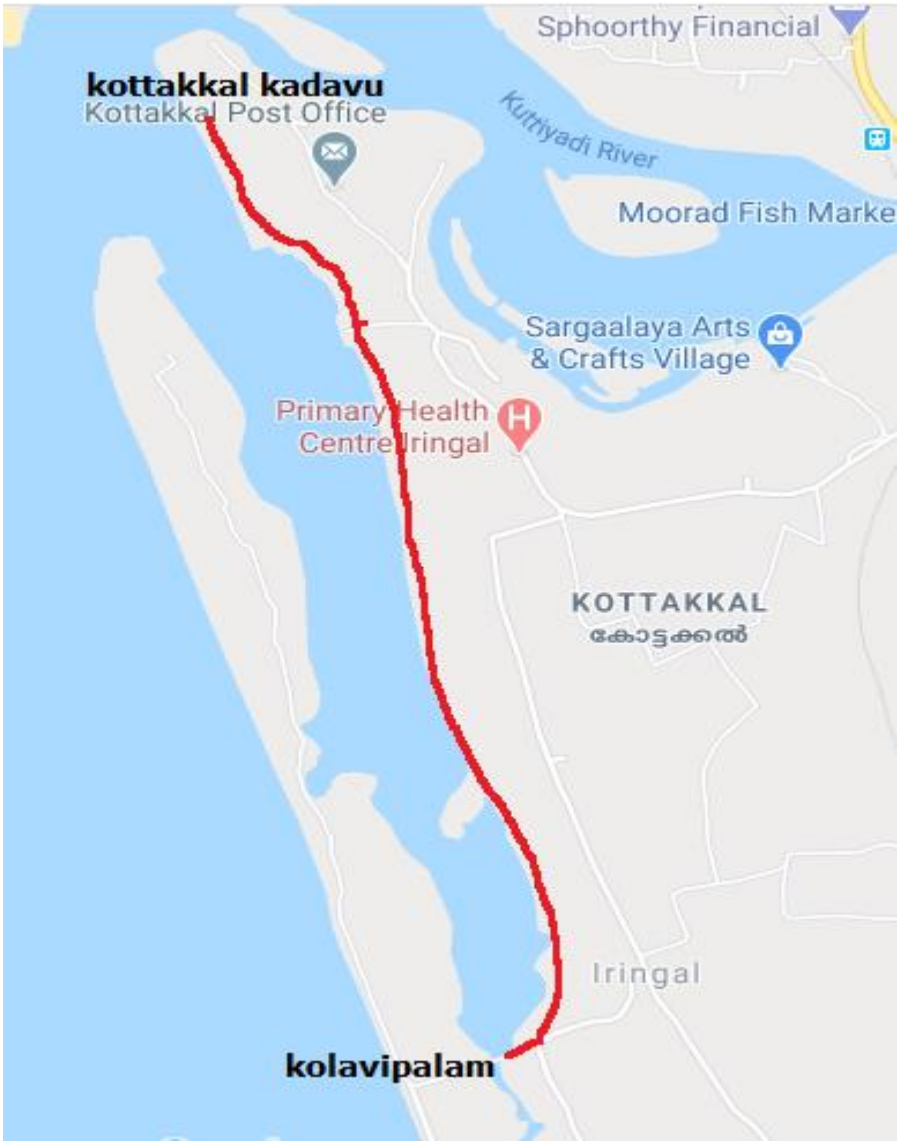

Figure 2.1 Location of the proposed road

2.3 APPROACH AND METHODOLOGY

Our Approach towards the project is in accordance with the project objectives and MoRT&H guide lines. All activities related to field studies, design and documentation are done as per the latest revisions and amendments of relevant guidelines of MoRT&H, referring to the publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS) and 'Guidelines for Planning and Design for Roads & Highway Projects Funded by KIIFB'

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2.4 NEED FOR THE PROJECT

Kerala's coastal belt is relatively flat, teeming with paddy fields, groves of coconut trees and heavily crisscrossed by a network of interconnected canals and rivers. The Kerala coastal area is the center for many economic activities like agriculture, aquaculture, fishing, fish processing industry, chemical industry, mining and tourism. Beaches and backwaters are the major attraction of the tourists in this area.

The motor transport sector is an important and integral part of the State economy. The growth of vehicle population in Kerala is eight per cent over the previous year. The growth of motor vehicles creates traffic congestion and pollution. The proposed road is an alternative route to National Highway 66 from Kozhikode to Vadakara. There will be savings in time and fuel, if vehicles can ply over the new road without stopping and waiting.

The coastal highway project was designed not only as a mere road project but as means to transform the coastal economy of the state. It will serve as a second transportation route for container and goods movement from major and other minor ports of the state. And it will also provide a boost to the tourism sector relying on its beautiful beaches and coasts.

The road from Kolavipalam to Kottakkal kadavu passes along the coastal belt of Payyoli municipality. The proposed road is planned almost parallel to the National Highway 66 to divert a major share of the traffic from the National Highway. Development of the road into a coastal highway standard can help the passengers to travel without traffic congestion in addition to the tourism development. There will be savings in time and fuel, if vehicles can move without stopping and waiting. More over a 2.5m Cycle track with kerb have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

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The proposed road is a link which connects the two taluks Vadakara and Koyilandy. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali marakkar memorial museum is located at kottakkal which is very near to the kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

2.5 SURVEY AND INVESTIGATION FOR DESIGN

All activities related to field studies design and documentation are done by National Highway By pass Sub-Division Kozhikode as per the latest revisions and amendments of relevant guidelines of MoRTH, referring the publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). International standard practices have been followed for aspects not covered under IRC / BIS All notations, abbreviations and symbols used in the reports, documents and drawings are as per IRC: 71-1977 the latest edition with amendments.

2.6 QUALITY ASSURANCE PLAN

The provisions of the IRC SP-19-2001, "Manual for survey, investigation and preparation of road projects" have been adhered for the rectification of the Design Engineering and report preparation of this project. For the quality control during execution of the project latest version of "PWD Quality Control Manual" and relevant IRC codes and BIS standards will be followed.

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2.7 REVIEW OF DATA AND DOCUMENTS

All the available data and information relevant for the study, like climate, road inventory, geotechnical data etc. have been collected and analysed.

2.8 TRAFFIC SURVEYS

Traffic data is collected as per IRC: SP 19-2001. The traffic survey location for conducting the traffic volume count was identified at Puthiyappa as the location resemblance to the proposed Alignment and Puthiyappa is also a part of coastal highway. A volume counts for 3 days within 10th April 2018 to 12th April 2018 was taken for 24hrs duration each. The method adopted was manual Classified Traffic Volume Count. Traffic surveys have been carried out on the project corridor in order to identify present and likely future scenarios so as to device suitable remedial measures and to evolve appropriate design method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement over the road.

2.9 RECONNAISSANCE AND ALIGNMENT

An in-depth study of the available land width (ROW), topographic maps, satellite imageries etc. have been done for the project area. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in this stretch. The detailed ground reconnaissance was taken up immediately after the study of maps and other data collected.

The proposed coastal highway from Kolavipalam to Kottakkal kadavu passes along the coastal line of Payyoli municipality in Kozhikode district. Kolavi beach at Payyoli

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is a beautiful stretch that border Velliyamkallu, the rocky island which can be reached by 1-hour boat drive. The rare species of olive ridely turtles are found in Kolavipalam beach side. The proposed coastal highway may enhance the possibility of Thikkodi drive-in-beach.

The proposed road is a link between the two taluks Vadakara and Koyilandy. Vadakara Sand banks beach is where locals and tourists throng to view the confluence of the Kuttiyadi River and Arabian Sea.

Kunhali marakkar memorial museum is located at kottakkal which is very near to the kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages

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that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district.

Lokanarkavu temple is an ancient Hindu temple situated in Vadakara

and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

Some portions of the beach in the proposed locations are protected by

sea wall. The houses in the beach side are mostly made of brick and lime/cement walls and clay-tile roofs. Traditionally there occupies a fishing community. Like any other typical coastal village, this community too draws its major source of income from fishing in the sea. And the seashell mining is

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also added to the small incomes of some of the families. Mainly coconut plantations are occupied in the spaces between the houses and the beach stretches.

Figure 2.2 Proposed Project Location

2.10 TOPOGRAPHIC SURVEYS

The basic objective of the topographic survey was to capture the essential ground features along the alignment identified during the reconnaissance survey, for finalizing the alignment. The cost of improvements, rehabilitation and upgrading also can be worked out based on details from topographic survey. A length of 2.861Km along the road was surveyed using total station, a precision instrument required for finalizing alignment along the proposed route. Longitudinal sections and cross sections have been prepared on the basis of the detailed topographic surveys conducted.

2.11 GEOTECHNICAL INVESTIGATIONS AND SUB SOIL EXPLORATIONS

CBR test and all other relevant laboratory and field tests on soil samples obtained were conducted. The CBR test is performed by measuring

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the pressure required to penetrate a soil sample with a plunger of standard area. For determining the CBR ratio, the measured pressure is then divided by pressure required to achieve an equal penetration on a standard crushed rock material. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

As the alignment passes through the coastal belt, Sub soil boring has been taken at every 1km in the entire stretch of the proposed road to a depth of 15m for obtaining a good idea about the sub soil. This has been considered for making decision regarding the soil improvement methods and protection works.

2.12 DESIGN STANDARDS OF ROAD AND PAVEMENTS

Design Standards and material specifications have been evolved, primarily from IRC publications and MoRT&H specifications. The Design Standards evolved for the project have covered all aspects of detailed design including the design of geometric elements, design of road, pavement design, traffic safety, drainage system and materials.

Pavement Design of the proposed road has been done according to IRC 37 (code for Tentative Guidelines for the Design of Flexible Pavements), IRC 067 (Code of Practice for Road Signs) and

IRC: 35-1997 Code of Practice for Road Markings. For pavement design CBR for the filled earth has been assumed as 10%.

2.13 ESTIMATION OF QUANTITIES AND PROJECT COSTS

Detailed estimates for quantities (considering designs and conveyance of materials) and the project cost (civil packages wise), including the cost of environmental and social safeguards, have been taken based on MoRT&H's Standard Data Book, latest Kerala PWD schedule of rates and PWD Project Information and Cost Estimation (PRICE) software. The estimation of quantities is based on detailed design of various components of the projects.

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The estimation of quantities and costs are worked out separately for each civil work Package. The total project cost comes to Rs 116.00 crores

Table 2.1 Abstract of Total Project Cost

Sl No	Heading Description	Amount
1	Road Work	110021933.88
2	Retaining wall	56958865.02
3	Traffic Safety	24856516.9
4	Cross Drainage and VCB	9422533.55
5	Compound wall and security cabin	567604.44
6	Soil stabilization	19803224.40
7	Utility Shifting	1000000.00
8	Land Acquisition -cost of land and Procedure charges	105316903.00
Estimate Total		**327947581.20**
GST @12%		39353709.75
Lumpsum Roundoff		698709.96
Rounded Total		**36,80,00,000**
Rupees Thirty Six Crores Eighty Lakhs Only		

2.14 COST BENEFIT ANALYSIS

Though the construction of coastal highway brings about a variety of benefits enjoyed practically by all sectors of the society, the prevailing condition of resource scarcity necessitates an economic evaluation of projects so that only the projects which are worth be taken up for implementation. The Indian Roads Congress special Publication No.30, Manual on Economic Evaluation of Highway Projects, contains the detailed procedures for economic evaluation and that is referred as guidance. The Economic Cost of the road works out to Rs 2623.58 lakhs against the Financial Cost of Rs. 3279.48 lakhs. The coastal highway project has various benefits and costs, which can be expressed in monetary terms, and which are difficult to be expressed in monitory terms. The period of analysis is taken as 20 years. All social benefits and costs possible to be expressed in monitory terms in accordance to IRC: SP: 30-2009 are tabulated and analysed. From the analysis, the road yields a Cost Benefit Ratio of 1.16 and Economic Rate of Return of 31.83 %.

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3 CHAPTERS

3.1 INTRODUCTION

3.1.1.1 General

Kerala is fairly well networked in the matter of transport. With a well-connected road network a rail the connecting all but two districts of the State, four international airports (at Thiruvananthapuram, Cochin,Kozhikode and Kannur), National Waterway III consisting of the vast stretches of backwaters and canals, 17 seaports, international Transshipment Container Terminal at Vallarpadam, Cochin, Vizhinjam deep sea Transshipment Container etc., Kerala is poised to become the commercial and travel hub not only to the country but to the world all over. Kerala can be proud of having developed a good road network compared to other states in India. At present Transportation Infrastructure of Kerala consists of 3.72 Lakh km of road, 1257 km of railways, 1687 km. of inland waterways, 111 statute miles of airways and 18 ports. Even though it is comparatively better placed than most of the other states as regards to the road length, the quality and service level of many of these roads are poor.

During classical antiquity and the Middle Ages, Kozhikode was dubbed the "City of Spices" for its role as the major trading point of eastern spices. It was the capital of an independent kingdom ruled by the Samoothiris (Zamorins) in the Middle Ages and later of the erstwhile Malabar District under British rule. Arab merchants traded with the region as early as 7th century, and Portuguese explorer Vasco da Gama landed at Kozhikode on 20 May 1498, thus opening a trade route between Europe and Malabar. A Portuguese factory and fort was intact in Kozhikode for short period. the English landed in 1615 (constructing a trading post in 1665), followed by the French (1698) and the Dutch (1752). In 1765, Mysore captured Kozhikode as part of its occupation of the Malabar Coast. Kozhikode, once a famous cotton-weaving centre, gave its name to the 'Calico cloth'.

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The proposed road is a link between the two taluks Vadakara and Koyilandy. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali Marakkar memorial museum is located at kottakkal which is very near to the Kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

Figure 3.1 View of Sargalaya

The construction of Coastal highway from Kolavipalam to Kottakkal kadavu passes along the coastal belt of Payyoli municipality. Kolavipalam also known as Kotta Kadapuram, is located in Iringal village of Payyoli municipality in Quilandy taluk of Kozhikode District. Kolavipalam beach is situated 46 km north of Kozhikode. The nearest town is Payyoli, presently which can be reached by private buses plying from Kozhikode.

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A good infrastructure facility is an essential pre-requisite for the growth and development of a region. Government of Kerala has decided to construct coastal highway along the coastal belt of Kerala. For the above work the fund will be allotted by KIIFB. For implementing the project KRFB is entrusted as SPV. National highway wing of Public Works Department will be executing the Project. At road junctions, considerable time is lost due to traffic congestions during signals. The traffic congestion resulting from the stop signal increases the loss towards fuel and precious time of lots of people.

Based on the Economic Review Report 2015, the total road length in Kerala increased from 3,31,372.261 Km in 2014-15 to 3,72,472.216 Km in 2015-16 Road density in the state is 8534 Km./100 sq.km. and the far ahead of the national average of 387 Km./100 sq.km. Road transport acts as the feeder service to rail, air and inland water transport. The vehicle density of the State is very high compared to many other States in India. The road freight services in the state are wholly owned and operated by the private sector. The transport system in Kerala is consumer oriented and passenger movements account for major portion of transportation. Goods transport in the State is mostly carried out through road transport. The tremendous increase in volume of road traffic in recent years caused increase in road accidents. The high vehicle population along with the under developed road network has resulted in high vehicle operating cost (VOC) and high level of environment pollution and road accidents.

Even though Kerala is graced with a good network of transportation the lack of a reliable and efficient road transport which is the feeder service to all other system, has adversely affected the growth prospects of the State. The inability to develop good quality transport infrastructure has stagnated both industrial and service sector and the GDP growth. Kerala State has got nearly 3% of the country's population, but it has recorded nearly 12% of country's road traffic accidents. The increasing trend of road accidents is a matter of great concern. The accident rate of Kerala is the highest in the country with 15 accidents per 1000 vehicles, twice that of all India average.

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Even bigger States the Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan and Andhra Pradesh have reported far less number of accidents compared to Kerala. Having got an average, better than the national and still lagging behind in the quality of the roads is a very serious concern of the public.

3.1.1.2 Transport and Industrial

Generally, two transportation objectives are usually taken into consideration when firms make their choices of location namely: 1) low transportation cost and 2) satisfactory transportation service. Firms that consider transportation cost to be of major significance usually locate at places where the cost of supplying raw materials is minimized. Availability of an effective and efficient (satisfactory) transport system is also important to firms as it helps facilitate production by increasing accessibility and mobility.

When these two transportation objectives (low transportation cost and satisfactory transportation service) are available in regions, there is high attractiveness to investors because they are assured of lower distribution cost and improved access for both employees and customers. Thus, investing in transport yields growth in a number of firms and expansion of the already existing ones and firm growth implies more job opportunities.

Expansion of existing firms will lead to greater profitability and or increased market share, and as a result, employment and income will increase as the firms grow. Furthermore, expansion of existing businesses together with the just-created ones will demand more raw material and components from their suppliers. Retail and wholesale businesses can expand as employees will spend more as a result of their additional income.

3.1.1.3 Socio-Economic-Significance of Transports:

Transport system is catalyst of the Socio-economic development.

1. Promotes industrialization.
2. Provides access to rural area.

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3. Provides the vital linkage between production and consumption.
4. Is the key factor to link dispersed areas.
5. Increase the economic efficiency of resources.
6. Provides mobility of labour and boost Tourism Industry.
7. Creates competitive environment.
8. Promotes social welfare.
9. Helps to stabilize prices.
10. Curbs monopoly of the trader.
11. Discovery of new market.
12. Provides large employment opportunities.
13. Adequate transport facilities in a country help to combat the natural calamities.
14. Is helpful in funding revenue to the Govt.

Traffic congestion, longer travel time and high level of air pollution are just some of the growing problems faced by the people today. The intensity of traffic in the State High ways, National Highways as well as in the Major District Road is very high; it not only delays the traffic but also invites fatal accidents.

3.1.1.4 Aim and Significance

The coastal highways since it passes through the coastal area will provide better connectivity between fishing harbors and fish landing centers which will be giving a major savings in fuel costs and will promote tourism. It is seen that the traffic is increasing at a rate of 5% per year and the major corridors of the district are presently suffering from traffic congestion through most hours of the day.

The road from Kolavipalam to Kottakkal kadavu passes along the coastal belt of Payyoli municipality. The proposed road is planned almost parallel to the National Highway 66 to divert a major share of the traffic from

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the National Highway. Development of the road into a coastal highway standard can help the passengers to travel without traffic congestion in addition to the tourism development. There will be savings in time and fuel, if vehicles can move without stopping and waiting. Also, road accidents can be considerably reduced once the vehicle starts plying through the new road. More over a 2.50m (with kerb) Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

The above factors necessitate the formation of the coastal highway as per MoRTH standards.

3.1.2 PROJECT DEFINITION, CONCEPT AND SCOPE

An in-depth study of the available land width (ROW) using topographic maps, satellite imageries etc. have been done at the proposed road location. Other available relevant information is collected for the proposed Green field alignment. Having received the information needed efforts is made for minimizing land acquisition and number of families to be rehabilitated as far as possible. The detailed ground reconnaissance was taken up immediately after the study of maps and other data collected from various sources.

3.1.3 PROJECT BACKGROUND

3.1.3.1 General

Government of Kerala has accorded administrative sanction for the construction of coastal highway vide GO (Rt)No.942/2017/PWD dt.10.07.2017. The proposed coastal highway from Kolavipalam to Kottakkal kadavu is a link between the Vadakara and Koyilandy taluks in Kozhikode district comes in the alignment of above proposal.

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorized to

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implement the proposed coastal highway project in Kozhikode district. On behalf of KRFB National Highway Bypass Sub Division Kozhikode has done detailed investigation and prepared Detailed Project Report for the construction of coastal highway from Kolavipalam to Kottakkal kadavu for onward submission to KIIFB for approval.

3.1.3.2 Road construction Background Information

The coastal highway project first began with a study conducted by National Transportation Planning and Research Centre (NATPAC). The newly proposed coastal highway from Kolavipalam to Kottakkal kadavu passes along the coastal belt of Payyoli municipality in Kozhikode district, which holds vast potential in the tourism.

The proposed coastal highway stretch has two lanes and a total length of 2.861Km. The recommended width of the proposed coastal highway is 15.6 meters. While the carriage way will be 7m wide with two footpaths each having 1.55m width will be constructed on both sides of the road. More over a 2.5m Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

3.1.3.3 Materials for Construction

On the sea side gabion retaining walls is proposed for the construction of embankment. The soils on both the sides are of sandy nature and unequal settlements are expected at this region. In order to overcome the damages due to this gabion retaining walls are proposed.

Dense Bituminous macadam and bituminous concrete provided as per IRC 35, codes for guidelines on design of flexible pavement. For the construction of duct, drain and footpath RCC grade M20 is proposed.

Samples of 20mm broken stone, M sand WMM and GSB has been collected from different quarries and put under testing. Most suited and relevant to corresponding codes has been identified. Test results have been kept as appendix VI.

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As the locality is very near to sea and is of saline nature, the water for all construction activity and curing purpose has to be collected from Payyoli cheerp.

For ensuring the quality of concrete, contractor can arrange a ready-mix plant in the vicinity of project area.

All the concrete works has to be carried out in an extreme exposure condition it is also recommended to use PSC grade cements for underground structures.

3.1.3.4 Additional works

- The carriage way parameters are designed based on field data and projected 20-year traffic.
- Required road furniture like mandatory/cautionary and informatory signage is proposed in the estimate. Road marking with retro reflective point at center, edge line and reflective studs are proposed in the estimate based on Road Safety Audit. 2.5m wide cycle track with kerb is provided along the carriage way
- The minimum land acquisition for the construction of proposed road
- Reconstruction of VCB is included
- Provision for construction of security cabin and reconctruction of compound wall near boat jetty is included

3.1.4 PROJECT DETAILS

The road from Kolavipalam to Kottakkal kadavu passes along the coastal belt of Payyoli municipality in Kozhikode District. The road can be a connecting link in the proposed Coastal highway. The tourism and fisheries sectors in the district are likely to get a boost with the construction of Kolavipalam to Kottakkal kadavu road.

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The coastal highway which is planned almost parallel to the national highway 66 is also expected to divert a major share of the traffic from the NH on completion. The land to be acquired and the number of families to be relocated for the construction of proposed road is minimum. The newly proposed coastal highway has two lanes and a total length 2.861Km along with 1.55 m footpath on both sides and a cycle track of 2.50m wide (with kerb) on costal side.

The proposed road is a link between the two taluks Vadakara and Koyilandy. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali marakkar memorial museum is located at kottakkal which is very near to the Kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

This project helps a major growth to the tourism industry in the area with the development of coastal highway. Some portions of the Kolavipalam beach in the proposed locations are protected by sea wall. The houses in the beach side are mostly made of brick and lime walls and clay-tile roofs. Traditionally there occupies a fishing community. Like any other typical coastal village, this community too draws its major source of income from fishing in the sea. And the seashell mining is also added to the small incomes of some of the families. Mainly coconut plantations are occupied in the spaces between the houses and the beach stretches.

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3.1.5 OBJECTIVE AND SCOPE OF THE WORK

3.1.5.1 Objective

The main objective of the work is to establish the technical and environmental viability of the project with a view to construct a coastal highway from Kolavipalam to Kottakkal kadavu and to prepare the detailed project reports with designs estimates and drawings. The major objectives covered under the proposal are

- Engineering and economic studies of the proposed road
- Engineering design of proposed road
- Estimate the cost of the project
- Cost benefit analysis
- Detailed Project Report for construction of Kolavipalam to Kottakkal kadavu road
- Land acquisition proposal

3.1.5.2 Scope of the Work

- To carry out reconnaissance survey to assess all the engineering characteristics of the existing project including but not limited to carriageway details, geometrics, terrain, soil and drainage condition and cross drainage details.
- To assess and forecast traffic using data from traffic studies and Reports
- To carry out surveys to identify sources of materials having adequate quantity and quality required for the works
- To carry out preliminary design for the project.
- To prepare cost estimates with prevailing schedule of rates

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- To identify utility services and their likely cost of shifting based on the rates of the respective utility agencies.
- To prepare GAD for road and other structures
- To prepare alignment plan and profile.
- To carry out all engineering surveys in detail viz. topographical, geo-technical, traffic etc. along the accepted alignment and requisite tests of the materials at identified sources to ensure quality & quantity of materials.
- To carryout economic evaluation of the project improvements based on road user cost analysis.
- To acquire the land for the construction of road and its components from private land owners.

3.2 STATUS FEASILBILTY STUDIES

During the initial stage of Discussion of Coastal Highway, the alignment was proposed along the existing village road by NATPAC. During the preliminary investigation it is found that the proposed alignment was having large number of 90degee curves as all these roads has been developed from footpaths. More over this alignment is passing through thickly populated area which invites large scale of rehabilitation process.

Considering all these alternate green field alignments along the costal belt was identified and discussed with MLA and other public representatives. This alignment is widely accepted.

3.3 REQUIREMENT/ DEMAND ANALYSIS

Kozhikode or Calicut is a city in the state of Kerala in southern India on the Malabar Coast. It is the third most populous city in the Kerala state. The proposed road from Kolavipalam to Kottakkal kadavu lies in coastal belt of

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Vadakara in Kozhikode district. It also connects the two taluks namely Vadakara and Koyilandy.

Historically Vadakara has been known as Kadathanadu. This place has a great cultural heritage. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. Kunhali marakkar memorial museum is located at kottakkal which is very near to the Kolavipalam. Sargalaya arts and craft village is an initiative of Department of tourism and it has many stalls housed in beautiful cottages that are environment friendly and ethnic in design. It is a well-known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. Moreover, the Payyoli beach is famous in the name of Olympian P.T. Usha, where she started her athletic career. The rocky island "Velliyamkallu" is reachable through 1 hour boat drive from Payyoli beach. The rare species of olive ridely turtles are found in Kolavipalam beach side. All these places are easily reached by this route.

Vadakara is also an important trade center other than Kozhikode. The traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this road. People from the nearby Panchayath depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion.

Area near by the project location, especially Kolavipalam beach portions in the proposed locations are occupied by fishing community. Like any other typical coastal village, this community too draws its major source of income from fishing in the sea. And the seashell mining is also added to the small incomes of some of the families. Beneficiaries of this project includes all the above including the daily commuters. The project will have much positive impact for the beneficiaries in terms of saving in travel time, safety, tourism developments and finally it will lead to overall development of the area.

Overhead and underground power cables, water line, telecommunication line, etc. which come in the way of the road alignment

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have to be relocated or re-routed before the commencement of the project. Prior information to be given to concerned departments and the people of the affected area before the start of work. The information to public regarding the work will be given though paper notification.

3.4 ENGINEERING SURVEYS AND INVESTIGATIONS

3.4.1 TOPOGRAPHIC SURVEY

3.4.1.1 GENERAL

The basic objective of the topographic survey is to capture the essential ground features along the alignment in order to consider improvements and for working out improvements, rehabilitation and upgrading costs. The detailed topographic survey was taken up after the completion of reconnaissance surveys.

The work of topographic survey has been entrusted to M/S Synergy Architects and Engineers, Ernakulam. Sufficient area near the Road was surveyed for a length of 2.861 Km along road using total station, a precision instrument required for finalizing alignment along the proposed route. Longitudinal sections and cross sections have been prepared on the basis of the detailed topographic surveys conducted.

3.4.1.2 Standards and Codes of Practises

All activities related to field studies, design and documentation are done as per the latest revisions and amendments of relevant guidelines of MoRTH and publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). For aspects not covered by IRC and BIS, international standard practices are followed. All notations, abbreviations and symbols used in the reports, documents and drawings shall be as per IRC: SP 19-2001

3.4.1.3 Quality Assurance Plan

The provisions of the IRC: SP 19-2001 (Manual for survey, investigation and Report preparation of Road Projects) have been adhered to.

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3.4.1.4 Survey

The topographic survey is one of the most important and crucial field tasks under the project. The detailed field survey is carried out using high precision instruments i.e. Total stations. The data from the topographic surveys is made available in (x, y, z) format for use in a sophisticated digital terrain model (DTM). The survey plan is attached. The detailed field surveys essentially included the following activities.

- Topographic Survey along the alignment options identified in the reconnaissance survey for sufficient width of 50m (at least two times the width of proposed Right of Way as required for finalizing alignment) by running a continuous open traverse along the proposed alignment, and fixation of all cardinal points such as horizontal intersection points (HIP's), center points and transit points etc. and properly referencing the same with a pair of reference pillars fixed on either side of the center line at safe places within the Right of Way.
- Collection of details for all features such as structures (bridges, culverts etc.) utilities, existing roads, demarcation stones, electric and telephone installations, buildings, fencing and trees (with girth greater than 0.3 meter) etc. falling within the extent of survey.

3.4.1.5 Longitudinal and Cross Sections

- The topographic surveys for longitudinal and cross-sections cover the following:
- Longitudinal section levels along final centre line at suitable locations of curve points, small streams, and intersections and at the locations of change in elevation.
- Cross sections at required interval in full extent of survey covering sufficient number of spot levels on the proposed bridge location and adjacent ground for profile correction course and

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earth work calculations. Cross sections shall be taken at closer interval at curves.

- Longitudinal section for cross roads for length adequate for design and quantity estimation purposes.
- Longitudinal and cross sections for river

Recommendations contained in IRC Special Publication No. 13 (Guidelines for the Design of Small Bridges and Culverts), IRC 35 (code for Road Markings), IRC 67 (Code of Practice for Road Signs) and IRC 37(guidelines on design of flexible pavement). Detailed topographic survey was conducted along the alignment of the proposed road from Kolavipalam to Kottakkal kadavu.

3.4.2 SOIL INVESTIGATION

Soil investigation surveys were carried out on all the selected corridors. The trial pit investigation surveys will show the composition of the existing layers and the sub grade soil collected was used to estimate the CBR vale of under laying soil. The CBR test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. For determining the CBR ratio, the measured pressure is then divided by pressure required to achieve an equal penetration on a standard crushed rock material. The test is simple and has been extensively investigated for field correlations of flexible pavement thickness requirement.

As the alignment passes through the coastal belt, Sub soil boring has been taken at every 1km in the entire stretch of the proposed road to a depth of 15m for obtaining a good idea about the sub soil. This has been considered for making decision regarding the soil improvement methods and protection works.

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3.4.3 TRAFFIC SURVEYS AND ANALYSIS

3.4.3.1 Introduction

Traffic studies are the initial step of any Road project. These studies play important role in fixing components such as carriage way width, lane width etc. Since the project is through a new alignment the traffic census taken at Puthiyappa which is a point in the existing coastal highway stretch in Kozhikode District is used for analysis and design purpose. Survey is conducted for three days and 24 hours in April 2018. The procedure for conducting survey and the data collection are briefly dealt in following sections

3.4.3.2 Project Background

The proposed coastal highway from Kolavipalam to Kottakkal kadavu connects Vadakara and Koyilandy taluk in Kozhikode district which can be a connecting link in the proposed Coastal highway.

Vadakara is also an important trade center other than Kozhikode. The traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this road.

People from the nearby Panchayath depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion. Area near by the road is a developing fish landing center and tourism sector. Beneficiaries of this project includes all the above including the daily commuters.

The tourism and fisheries sectors in the district are likely to get a boost with the construction of Kolavipalam to Kottakkal kadavu along coastal highway in Koyilandy taluk in Kozhikode district.

The coastal highway which is planned almost parallel to the national highway 66 is also expected to divert a major share of the traffic from the NH on completion. Hence, the road accidents can be considerably reduced once the vehicle starts plying through the new road. The land acquisition for the

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construction of road is minimum and there is no direct effect on residential, commercial buildings and other establishments.

This project helps a major growth to the tourism industry in the area with the development of coastal highway. Vadakara sandbanks, kunhali marakkar museum, Sargalaya arts and crafts village and boating facilities at Kottakkal are major destinations along this coastal line.

Traffic census data reveals that PCU is 8377 at the location. Cycle tracks are recommended along the proposed road to offer a high degree of safety and to promote tourism. This track separates the cyclist from motorized traffic. In proposed road a modern bus shelter unit with toilets, police aid post, cafeteria etc are provided which increases passenger comfort and revenue

3.4.3.3 Purpose of Traffic Study

Traffic surveys have been carried out on the project area in order to identify suitable remedial measures and to evolve appropriate design method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement along the road. All the traffic surveys and further analysis is carried out as per the guidelines given in IRC: SP 19-2001, IRC: 108-1996, IRC SP: 41-1994, IRC: 102-1988 and IRC: 09-1972. For making the proper assessment of traffic volume, base year traffic and its projection necessary traffic surveys and investigations are carried out in the location. The base year traffic data is the primary input for determination of future traffic demand. With a view to estimate the base year traffic volume in respect of goods and passenger carrying vehicles, the Classified Traffic Volume Count (CTVC) Survey was conducted. For the purpose of traffic estimation and projections, the year 2018 is taken as the base year.

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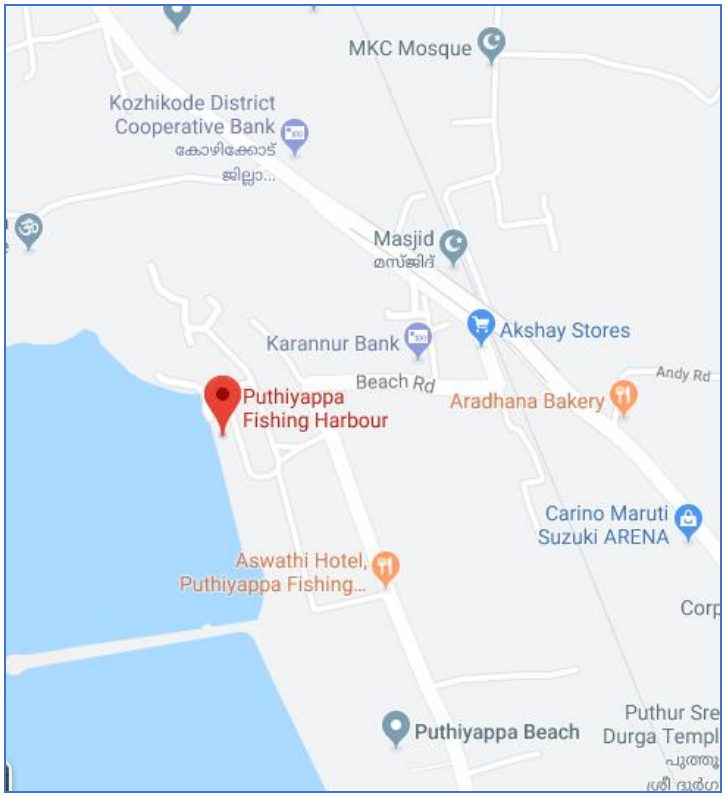

Figure 3.2 Traffic Survey Location

3.4.3.4 Traffic Survey Schedule

The survey schedule was prepared as per the requirements of the study. The schedule of Traffic Surveys and locations are given in Table 3.1

Table 3.1 Schedule of Traffic Surveys

Item No.	Type of Survey	Survey Location	Direction	Duration	Date of Survey
1	Classified Traffic Volume Count Survey (CTVC)	Near Puthiyappa Harbour	Kozhikode to Kannur & Kannur to Kozhikode	3 Days, 24 hours	10-04-2018, 11-04-2018, 12-04-2018

The traffic survey is carried out in accordance with the guidelines specified by IRC: 9-1972 and IRC: 102-□□□□□T□□ □ □□□odo□o□y adop□□d □or □□□ □ra□□□ □□□dy □□d□□a□□d □□□o□

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3.4.3.5 Methodology Adopted For Traffic Surveys

3.4.3.5.1 Classified Traffic Volume Count (CTVC) Survey

The Classified Traffic Volume Count survey was conducted at proposed road. The count was conducted for 3 days and 24 hours as per IRC: SP: 19 – 2001, 'Manual for Survey, Investigation and Preparation of Road Projects'. Fig 3-2 shows the traffic survey location for carrying out the traffic count survey. The vehicles were grouped under following categories as given in Table 3-2. For the purpose of smooth counting, a day was divided into three shifts of 8 hours each and groups of enumerators with a supervisor were assigned for each shift in both directions.

Table 3.2 Vehicle Classification System (Fast & Slow)

Fast moving vehicles	
Two wheelers: Motor Cycle, Scooter etc.	
Car/ Jeeps/ Taxies/Van/Three Wheelers (Autorickshaw)	
Passenger Car	Car, jeep, taxi & van (Old & new technology vehicles)
Bus	Mini Bus
	Govt. Bus
	Private Bus
	Two axle truck and Tanker
	Multi axle trucks, tanker trailors etc.
Other Vehicles	Agriculture Tractor, Tractor & Trailer
Slow moving vehicles	
	Bicycle
	Cycle Rickshaw
	Animal drawn (Bullock cart/Horse cart/)

3.4.3.6 Data Analysis

The classified traffic volume survey data of coastal highway from Francis road junction to Puthiyappa in Kozhikode District, Proposed Road location is analysed in order to obtain the following traffic characteristics:

- Average Daily Traffic (ADT) Volume
- Average Hourly Variation of Traffic Volume
- Daily Variation of Traffic volume

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- ➢ Peak Hour Factor
- ➢ Average Composition of Traffic

Daily and hourly variation of classified traffic flow is recorded by conducting 3-day continuous traffic count at Puthiyappa which is a location in the existing beach road in Kozhikode District and □□ra□□d □ro□ IRC□□□ – 1990, 'Guidelines for Capacity of Roads in Rural Areas'.

Table 3.3 Vehicle Classification along with their PCU factor

Vehicle Type	PCU Factor
Motorized Vehicle	
Car, Jeep, Van	1.0
Two-Wheeler (Motor Cycle)	0.5
Three Wheeler (Auto-Rickshaw)/ Mini LCV	1.0
Mini Bus	1.5
Govt. Bus	3.0
Private Bus	3.0
School Bus	3.0
Light Commercial Vehicle (LCV)	1.5
2-Axle Truck	3.0
3-Axle Truck	3.0
Multi Axle Vehicle (MAV)	4.5
Agricultural Tractor	1.5
Agricultural Tractor with Trailer	4.5
Non-Motorized Vehicle	
Cycle	0.5
Cycle Rickshaw	2.0
Animal Drawn Cart	6.0

(*Source: IRC: 64-1990)*

3.4.3.6.1 **Average Daily Traffic (ADT)**

The traffic volume data collected during the survey was averaged to arrive at the Average Daily Traffic (ADT) on the project location. The summary of ADT in terms of vehicles and PCU is presented in table 3.4. After the completion of the coastal highway full connectivity will be attained and traffic from Puthiyappa which is location in existing beach road is expected to ply through the bridge. Hence the traffic count observed at Puthiyappa is 9235 (8377 PCU).

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Table 3.4 Average Daily Traffic Volume (ADT)

Type of Vehicles		ADT in Nos	PCU factor	ADT in PCUs
Fast Moving Vehicles	Two-wheeler (Motor Cycle, Scooter etc.)	4151	0.5	2076
	Car/ Jeeps/ Taxies/Van/Three Wheelers (Auto)	3799	1	3799
	LCV (Light commercial vehicle eg.Mini truck)	402	1.5	603
	Bus	2	3	6
	Two axle truck and Tanker	674	3	2022
	Multi axle trucks, tanker trailors etc.	205	4.5	923
	Agriculture tractor with trailor	0	4.5	0
Slow Moving Vehicles	Cycle	1	0.5	1
	Bullock cart/Horse cart/Other animal powered	0	6	0

3.4.3.6.2 **Average Hourly Variation of Traffic Volume**

The analysis has been carried out to study the hourly variation and peak hour traffic characteristics. The morning peak hour is observed between 9 am to 10 am and the evening peak hour is observed between 3 pm to 4 pm at the count location. The Peak Hour share is defined as the ratio of the number of vehicles counted during the peak hour to the total vehicles counted in a day. The peak hour share on the survey location is 7.70 % for morning and 8.12 % for evening. The hourly variation of traffic at the location is illustrated in Figure 3.3

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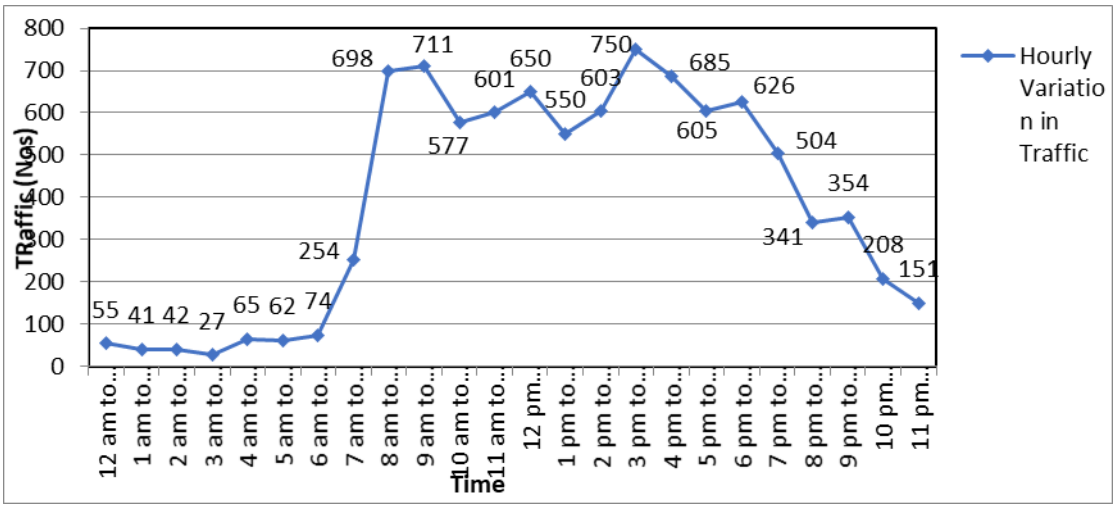
Figure 3.3 Hourly Variation of Traffic



3.4.3.6.3 **Daily Variation of Traffic Volume**

Daily variation of traffic at the count location is presented in Table 3.5. At the location, daily variation of traffic with respect to ADT is generally not noticeable as most of the daily volume being near to ADT volumes. The maximum traffic is observed on Thursday with 9494 Vehicles (8655 PCU).

The daily traffic varies with total traffic being lowest on Tuesday with 8971 Vehicles (8102 PCU) and highest on Thursday with 9494 Vehicles (8655 PCU) and is illustrated in Figure 3.5

Table 3.5 Daily Variation of Traffic for 3 days

Day	Date	Total Vehicles in Numbers	Total Vehicles in PCU
Day 1 (Tuesday)	10-04-2018	8971	8102
Day 2 (Wednesday)	11-04-2018	9239	8373
Day 3 (Thursday)	12-04-2018	9494	8655

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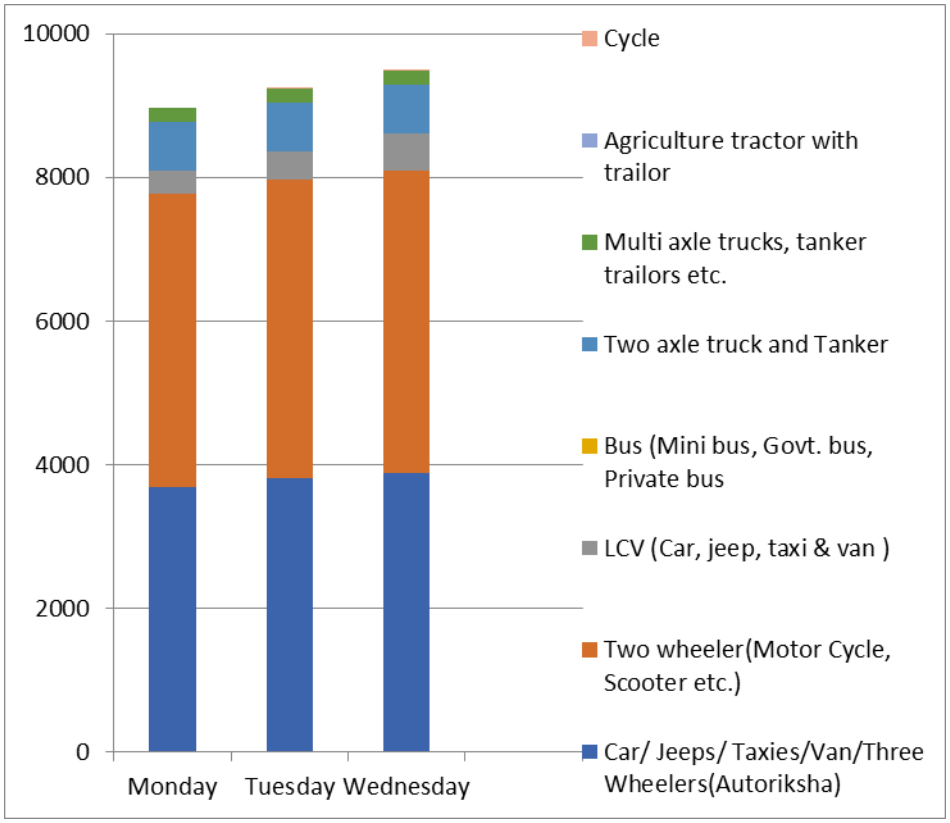

Figure 3.4 Daily Variation of Traffic for 3 days

3.4.3.6.4 **Composition of Traffic**

The traffic composition observed shows that major portion of the vehicles passing proposed road are fast moving passenger vehicles which includes Car, Bus and two wheelers. 46% of the traffic comprises of Car, Jeeps, Taxies, Van, Three Wheelers (Auto) and 41% is of Two-wheeler traffic. Two axle truck and Tanker contribute major share of commercial vehicle traffic. Figure 3.5 shows the traffic composition observed.

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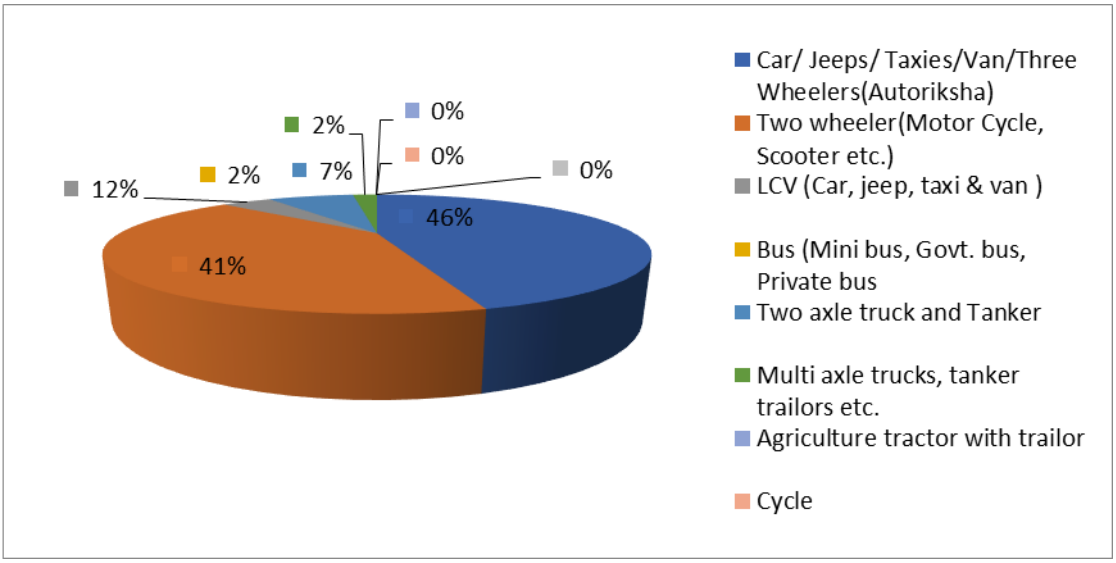

Figure 3.5 Traffic Composition Observed

3.4.3.7 TRAFFIC FORECAST

The traffic growth rate is normally established by studying the past trends in traffic growth and socio- economic parameters. In the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic. Annual growth rate of 5% is considered for the projection of traffic.

3.4.3.8 CONCLUSION

Construction of coastal highway in this reach is useful for diverting the long route traffic from the already congested National Highway. More than this it is providing transport facility to the coastal areas without any present transport facility.

3.4.4 PAVEMENT DESIGN

Deign of the pavement is an important part of detailed engineering study. Flexible pavement has been designed incompliance with IRC: 37-2018 "Guidelines for the design of flexible pavement". Flexible pavement has been proposed for the coastal highway.

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3.4.4.1 Design of Flexible Pavement

3.4.4.1.1 **Introduction**

New Pavement composition has been estimated on the basis of various factors such as traffic loading, Subgrade strength and environmental characteristic. Proposed new □o□ po□□□on □ □□□□arry □□□ ra□□□ oad□n□ □or □□□ d□□□□n p□r□od and □□o□d pro□d□ □□oo□□ and □a□□ r□d□n□ □□r a□□□ S□r□n□□□□n□n□ o□□□□□□□n□ pa□□□ □n□□ o □□□ □□□□□o□n□□ □on□r□□□□on □a□ □□□n d□□□□n□d □□□p□n□ □n □□□□ o□ □□□□ □□□□□□n□ pa□□□ □n□□o□ po□□□on□ □□□□ □rad□ □□r□n□□□ and □□□□□□n□ pa□□□ □n□ □ond□□on□ T□o□an□ □□o□□ay □arr□a□□□ay □on□□□□ra□□on□□a□□ p□ann□d □or □□□□ □□□□□on□□

The following three main steps have been followed in designing the new flexible pavement.

- Estimating the volume of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life of 20 years.
- Assessing the strength of the sub grade soil over which the road is to be built.
- Selecting the most economical combination of pavement materials and layer thickness that will provide satisfactory service for the design life of the pavement.

3.4.5 DESIGN PARAMETERS

3.4.5.1.1 **Initial Traffic**

As per IRC 37-2018, one of the important design parameters for pavement design is the project traffic which is indicated in terms of million standard axles (MSA). For the design of flexible pavement, only commercial vehicles with gross weight above 3000 Kg are considered out of the spectrum of vehicles counted in the traffic volume count. Accordingly, from the 3 day 24 hours classified traffic volume count data average daily traffic plying on the

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project location is estimated. The estimated Average Daily Traffic (ADT) is presented in Table 3.6 for the base year 2018.

Table 3.6 Base Year Traffic (ADT)

Sl No	Vehicle Type	ADT
1	Bus	2
2	LCV	402
3	Two axle	674
4	Multi axle	205
Total		1283

3.4.5.1.2 **Design Period**

The design period to be adopted for pavement design is the time span considered appropriate for the road pavement to function without major rehabilitation. It is recommended that a design period of 20 years may be adopted for the structural design of pavements for National Highways, State Highways and Urban Roads. Hence a design life of 20 years has been considered here for the design of pavement

3.4.5.1.3 **Traffic Growth Rate**

For estimating the cumulative traffic expected to use the pavement over the design period, it is necessary to estimate the rate(s) at which the commercial traffic will grow over the design period. The traffic growth rate is normally established by studying the past trends in traffic growth and socio-economic parameters. The present-day traffic has to be projected for the end of design life at growth rates (r) estimated by studying and analysing the following data:

- Past trends of traffic growth
- Demand elasticity of traffic with respect to macro-economic parameters (like GDP or SDP) and expected demand due to

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specific developments and land use changes likely to take place during design life period.

As per IRC 37-2018 cl 4.2.2, in the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic. Hence an annual growth rate of 5% has been assumed.

3.4.5.1.4 **Vehicle Damage Factor (VDF)**

The Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration into the number of repetitions of Standard axle load of magnitude 80 kN. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration and axle loading.

As per IRC:37-2018 Cl 4.4.6, For small projects, in the absence of weigh pad, the axle loads of typical commercial vehicles plying on the road may be estimated approximately from the type of goods carried. Where information on the axle loads is not available and the proportion of heavy vehicles using the road is small, the indicative values of vehicle damage factor given in Table 4.2 can be used. These indicative VDF values have been worked out based on typical axle load spectrums and taking into consideration the legal axle load limits notified in the Gazette of India dated 16th July 2018. Assumed values of VDF values are appended below in Table 3.7.

Table 3.7Indicative VDF Values

Initial Traffic Volume in Terms of Commercial Vehicles Per Day	Terrain	
	Rolling/Plain	Hilly
0-150	1.7	0.6
150-1500	3.9	1.7
More than 1500	5.0	2.8

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Since total commercial vehicle per day comes in between 150-1500 Category and project location falls in plain terrain, a VDF value of 3.9 has been assumed for the design of flexible pavement.

Lateral distribution

Lateral distribution of commercial traffic on the carriageway is required for estimating the design traffic (equivalent standard axle load applications) to be considered for the structural design of pavement. As per IRC:37-2018 Cl 4.5.1.3, for Two-lane two-way roads the design should be based on 50 per cent of the total number of commercial vehicles in both directions.

3.4.5.1.6 **Subgrade Strength**

The strength of sub grade is assessed by California Bearing Ratio (CBR) tests. The select soil forming the subgrade should have a minimum CBR of 8 per cent for roads having traffic of 450 commercial vehicles per day or higher. Minimum CBR of 10% is considered for the design of flexible pavement. Hence, borrow material used for filling the approaches of the bridge should have a minimum CBR of 10%.

3.4.5.2 Design Traffic

The design traffic is calculated in terms of the cumulative number of standard axles to be carried during the design life of the proposed road. It requires the estimation of initial commercial vehicles per day, lateral distribution of traffic, traffic growth rate, the design life and the vehicle damage factor (number of equivalent standard axle for commercial vehicle) to convert commercial vehicles to standard axles.

The following equation has been used to calculate the design traffic

$$N = \frac{365\{(1+r)^n - 1\}}{r} \times A \times D \times F$$

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Where,

N = the Cumulative number of standard axles to be catered in the design

A = Initial traffic, in the year of completion of construction, in term of the number of commercial vehicles per day duly modified to account for lane distribution.

$A = P(1 + r)^x$

Where P number of commercial vehicles per day as per last count, In this case P = 1283 as per traffic census conducted during April 2018

x is the number of years between the last count and the year of completion of construction taken as 3 in this case.

r = Annual growth rate of commercial vehicles taken as 5%

n = Design life in years taken as 20 years

D= Lane distribution factor taken as 0.50

F = Vehicle damage factor i.e. number of equivalent standard axles per Commercial vehicle. Here 3.9

The design traffic calculated using the above formula is 35 msa.

3.4.5.3 Proposed Pavement Thickness – Approach Road

Based on the traffic (35 msa) and the assumed CBR value (10%), the thickness of flexible pavement has been obtained by interpolation from IRC: 37-2018, Cl.10.1, Plate 6 and proposed layer thickness is given in Table 3.8 and illustrated in Figure 3.6. Plate 8 of IRC 37-2018 is given as Figure 3.7.

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Table 3.8 Estimated and Proposed Pavement Compositions

Crust Details	Thickness (mm)		Remarks
	Estimated	Proposed	
BC	40	40	
DBM	90	90	
WMM	250	250	
GSB	200	200	
Subgrade	500	500	

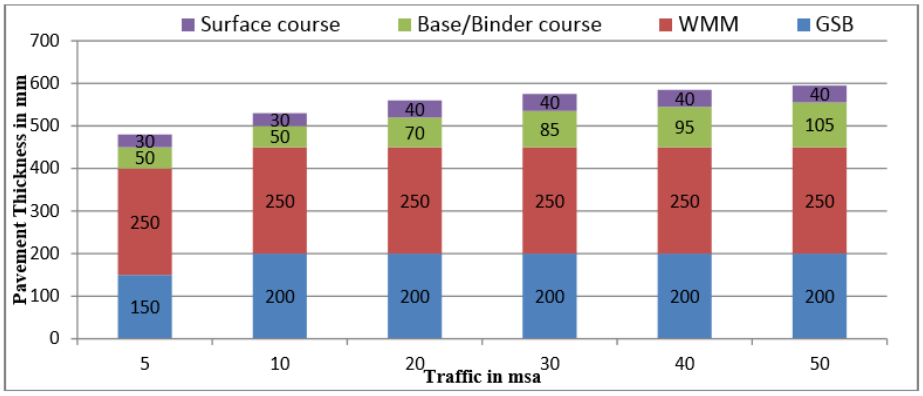

Figure 12.6 Catalogue for pavement with bituminous surface course with granular base and sub-base - Effective CBR 10% (Plate-6)

Figure 3.6 Catalogue for pavement as per IRC:37-2018

3.5 FUNCTIONAL DESIGN

The functional design of the project is mainly achieved through field study and documentation using existing information and specification from various standards. The field study includes all engineering studies viz. reconnaissance survey, topographic survey, geotechnical investigation, traffic survey etc. Documentation is done as per the latest revisions and amendments of the relevant guidelines of the MoRTH/IRC/BIS standards.

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The new alignment of the coastal alignment is passing through the coastal belt of Calicut district. The alignment is proposed in such a way that to minimise the land acquisition and rehabilitation.

3.6 ENGINEERING DESIGN

The proposed alignment of coastal highway stretch is verified by the expert team of NATPAC team at KIIFB. This alignment passes over small streams called "AVI". Two Bridges is proposed over these streams. The structural design for the above bridge is done by DRIQ board of Kerala Public Works Department.

3.6.1 STANDARDS AND CODES OF PRACTISES

All activities related to field studies, design and documentation is done as per the latest revisions and amendments of relevant guidelines of MoRTH/ Indian Railways and publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). All notations, abbreviations and symbols used in the reports, documents and drawings are as per IRC: 71-1977 latest edition with amendments.

3.6.2 GEOMETRIC DESIGN

The geometric design conforms to the relevant IRC codes. The design for geometric elements has covered the major aspects including Typical Cross Section and Plan and profile drawings. Geometric improvements are kept to a minimum land acquisition is proposed for the corridors. The horizontal alignment is kept as same for the existing road at the location. Camber for carriage way is 2.5%.

3.6.3 ALIGNMENT SELECTION

The proposed road is located in Payyoli municipality in Kozhikode district can be a connecting link in the proposed Coastal highway. General Arrangement Drawing (GAD) and Alignment Plan showing the salient features of the road and structures proposed to be constructed are covered under the study. These salient features such as alignment, overall length, cross section,

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are finalized based on the detailed topographic and geotechnical studies. The alignment of the newly proposed road includes minimum land acquisition and rehabilitation cost.

The total length of the two lanes road is 2.561 km. A footpath of 1.55 m is provided along with drainage facilities. A width of 2.50m(including kerb) is allocated for cycle track. The estimated cost of the Project is 3680.00 lakhs.

3.6.4 DESIGN OF FLEXIBLE PAVEMENT

Pavement design follows IRC 37-2012(guidelines on design of flexible pavement) for new pavement or pavement at widening section. The proposed coastal highway has two lanes and a total length of 2.861 Km. The recommended width of the proposed coastal highway is 15.6 meters. While the carriage way will be 7.0m wide, two footpaths each having 1.55 m width will be constructed on both sides of the road. A 2.5 m wide (including kerb) cycle track is provided along the carriage way.

3.7 FINANCIAL ESIMATES AND COST PROJECTIONS

3.7.1 GENERAL

The project cost estimates have been prepared considering various items of works associated with the identified improvements. Detailed estimates for quantities (considering preliminary designs and conveyance of materials) and cost for the entire project (civil packages wise), is worked out based on Standard Data Book of MoRT&H and latest Kerala PWD schedule of rates as per PWD Project Information and Cost Estimation (PRICE) software.

The estimate is based on PWD PRICE and cost index of 31.06% of Kozhikode district as on 06/05/2020. Where the data is not available, rates are worked out based on market rates.

Project Information and Cost Estimation (PRICE) software is a total solution for estimate preparation and online approval. It is developed for the Public Works Department Kerala. PRICE is based on CPWD Schedule of Rates, Specification, Rate Analysis and cost index.

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The project cost estimates have been prepared considering the various items of works associated with Identified improvements so as to assess financial and economic costs for evaluating viability of the Project.

3.7.2 APPROACH AND METHODOLOGY

3.7.2.1.1.1The cost estimate is grouped as follows.

- Part 1: Road work -safe dismantling of the various components like culverts, retaining walls, guard rails, road pavement layers, Traffic signs, etc and construction of DBM-BC road as per the design come under this.
- Part 2: Retaining wall – DR retaining walls at necessary locations comes under this.
- Part 3: Traffic Safety work: Construction of cement concrete kerb, Installation of signboards, Object Hazard Marker, delineator post, median marker, hand rails, streetlight, road studs and thermoplastic etc comes under this
- Part 4: Cross Drainage Work: Construction of box culverts and reconstruction of vented cross bar comes under this
- PART 5: Compound wall and security cabin - Construction of security cabin near boat jetty and reconstruction of compound wll of boat jetty are provided under this.
- PART 6: Soil stabilization – Provision of sand piles included under this hread
- PART 7: Utility Shifting is approximated as Rs 10000000.00
- PART 8: Cost of land acquisition and Procedure charges comes under this head

3.7.3 ESTIMATION OF QUANTITIES

The quantities of major items of work for the Project Road have been estimated on the basis of geometric designs, pavement designs and preliminary structural designs. The quantities of the following major items of works have been estimated separately.

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- Site Clearance and Earth Work
- Granular Pavement Courses
- Bituminous Courses
- VCB construction
- Culverts
- DR Retaining wall
- Kerbs, Drainage and Protective works
- Road Furniture and Safety Works
- Relocation of Utilities
- The total length of the New road will be 2.861Km
- Footpath of width 1.55m is considered on both the sides
- Carriage way width is 7m
- Cycle track of width 2.5 m (including kerb)

Detailed estimate is given as Annexure I

Table 3.9 Abstract of Estimate

Sl. No.	Description	Amount
1	Road Work	110021933.88
2	Retaining wall	56958865.02
3	Traffic Safety	24856516.99
4	Cross Drainage and VCB	9422533.55
5	Compound wall and security cabin	567604.44
6	Soil stabilisation	19803224.40
7	Utility Shifting	1000000.00
8	Land Acquisition -cost of land and procedure charges	105316903.00
	Total	**327947581.28**
	GST @ 12%	39353709.75
	Total with GST	367301291.04
	Lumpsum Round off	698708.96
	TOTAL	**368000000**
		36.80 Crores

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3.7.4 COST OF THE PROJECT

Administrative Sanction has been issued by the govt. of Kerala vide order no: GO(Rt) No.942/2017/PWD dated 12-10-2017. By funding from KIIFB.

3.7.5 COST OF CONSTRUCTION OF COASTAL HIGHWAY

The cost of coastal highway includes the cost of Road work, Retaining wall, Traffic Safety, Cross Drainage and VCB, Compound wall and security cabin, Soil stabilisation and Horticulture. This works out to Rs.221.63 lakhs for the project as detailed below.

Table 3.10 Cost of Construction

Sl No	Heading Description	Amount
1	Road Work	110021933.88
2	Retaining wall	56958865.02
3	Traffic Safety	24856516.90
4	Cross Drainage and VCB	9422533.55
5	Compound wall and security cabin	567604.44
6	Soil stabilisation	19803224.40
Total Construction Cost		**221630678.19**

3.7.6 COST OF SHIFTING OF UTILITIES

Overhead and underground power cables, water line, telecommunication line, etc. which come in the road way have to be relocated or re-routed. The detailed estimate for shifting utility is required to KSEB. The total amount for shifting of electric posts, cables, transformers ec comes to be Rs. 1000000.00/-..

3.8 REVENUE STREAMS

Levee may be imposed from service providers for using the utility duct proposed.

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3.9 COST-BENEFIT ANALYSIS (CBA)

3.9.1 GENERAL

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the project is worthy of investment keeping in view the benefits to the society. Economic analysis is not concerned about past events and investments.

The Economic Analysis Proposal for the reconstruction of the proposed road is to assess the benefits accrued to the society. The very basis of economic analysis being the selection of the most attractive option and it is necessary that evaluates a number of possible alternatives. The basic alternative is the 'do-nothing', or the continuation of the present situation. All other alternatives are evaluated against this basic condition.

Economic analysis estimates future traffic, costs and benefits. The Cost Benefit Analysis (CBA) is the implicit or explicit assessment of the benefits and costs (i.e., advantages and disadvantages) associated with an investment project. Benefits and costs may be nonmonetary and monetary.

Some of the non-monitory benefits, which are difficult to be expressed in monitory terms through construction of the proposed road, are reduction in air pollution and noise pollution as described below;

3.9.2 COST-BENEFIT ANALYSIS (CBA)

3.9.2.1 Reduction in Air Pollution

An Air Quality Index (AQI) up to 50 is regarded as good while the 51-100 range is considered moderate. A reading exceeding 100 is considered unhealthy for □n□□□□□ □ro□p□□□□□ a□ □□o□□ □a□n□ □□n□ d□□□a□□□□

The air is unhealthy for the people if the AQI is in the range of 151-200. AQI in the 201-300 range indicates very unhealthy air. A reading above 300 is hazardous. Aggregation of vehicles at stoppage at the existing National

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Highway while traffic block leads to high quantum of air pollution and thereby causes various health issues for the people in the nearby areas. The proposed construction will divert the traffic from existing NH thus reducing the air pollution due to seamless flow of vehicles.

3.9.2.2 Reduction in Noise Pollution

The noise pollution in the road during traffic block at the existing road is at an alarming rate. If a bus horn honks, it creates 92-94 decibels (dB) of sound, and hearing it repeatedly can cause hearing loss. Noises, which are below 75 dB, are harmless. But constant exposure to noise levels of 80-85 dB can increase the risk of hearing loss. The magnitude of sound of a two-wheeler horn is between 81 and 85 dB, and that of a car horn is between 83 and 88 dB. During congestion honking of horns by the vehicles is high and there by the noise Pollution in the area is also high. Through the construction of the proposed road, there will have seamless flow of vehicles and hence can avoid the noise pollution in the area.

Economic Rate of Return (ERR) and Cost Benefit Ratio (Benefit / Cost) are some of the measure to arrive at the social benefits from any infrastructure project. The financial analysis appraises the project in terms of return on investment while the economic analysis appraises the project contribution to the social and economic welfare of the city, region or country.

Though all the cost and benefits from an infrastructure project is not possible to be expressed in monitory terms, all possible costs and benefits are being measured in monitory terms and evaluated to arrive at a conclusion whether an infrastructure project is worth to the society. There are various methods to evaluate the economic benefits from any infrastructure projects. The economic evaluation of the proposed road project is carried out based on the IRC SP 30, 2009, which describes about "Economic Evaluation of Highway Projects in India". The Economic Evaluation carried out based on IRC SP 30, 2009 for the reconstruction of the proposed road is detailed in the following section.

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3.9.3 BASIS FOR ARRIVING AT COST AND BENEFITS

All the cost and benefits are taken at constant price without factoring the inflation so as to have better overview. The basis for arriving at each component of costs and benefits from the construction of the proposed road based on IRC SP 30, 2009 is detailed below

3.9.3.1 Project Cost

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices, as these are not real costs to the economy, but are only transfer payments.

All financial costs have been converted into economic costs by applying a Standard Conversion Factor (SCF) of 0.80, as suggested in IRC: SP: 30-2009. The cost for the project consists of two main components:

- Capital cost
- Operation and Maintenance cost

3.9.3.2 Capital Cost

The capital cost includes the cost of improvement of road, construction of drain footpath, amenities, street lighting, cost of traffic diversion and supervision charges during construction etc. These are estimated in financial terms i.e. at market prices. The total project cost worked out is amounting to Rs.11600.00 lakhs with cost for land acquisition and construction amounting Rs 10299.35 lakhs. The capital cost of all the project in financial and economic terms are summarized below.

Total Cost	Finance Cost (Lakhs)	Economic Cost (Lakhs)
Construction of Coastal Highway in Kozhikode district-From Kolavippalam to Kottakkal Kadavu	3279.48	2623.58

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3.9.3.3 Operation & Maintenance Cost

Maintenance costs are recurring costs, comprising routine and periodic maintenance components. The routine maintenance involves day-to-day repairs and maintenance of Bridge and road etc.

The routine maintenance cost would start incurring from the second year from the date of commencement of operation (in this case December 2021 is assumed as the starting year of the project and the construction is expected to complete and start its Economic Cost. The total project financial cost is estimated to Rs.3680.00 lakhs and this is faced during 18 months of land acquisition and construction period.

3.9.4 PROJECT BENEFITS

There are various benefits through provision of proposed coastal highway which include social benefits such as savings in time of travel, reduction in accidents due to congestion during peak hours, reduction in sound pollution through avoidance of horns, reduction in air pollution etc.

The benefits (which are converted in to monitory terms) considered from the construction of the proposed road are as under:

- Travel Time savings of passengers
- Savings in the cost of maintenance of old road (operating cost of warning signals and Police man engaged for traffic control etc).
- Savings in idle fuel consumption
- Less pollution from vehicles
- Helps in tourism development
- Provision of proper drainage system
- Bus shelter units helps people to take rest and do primary things
- Cycle riders can enjoy safe riding

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3.9.4.1 Travel Time savings of passengers

Generally car passengers and motor cycle riders enjoy a saving in travel time. Through The proposed road, a considerable amount of travel time can be saved due to seamless flow of vehicles by avoiding waiting time in traffic at old road. Time Value of Passenger (Work Trips and Non Work/leisure trip) is arrived based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP:30 -2009)".

The value of travel time of passengers for each category of travelers as specified in the IRC SP has been based on the March price and the reproduced below

Table 3.11 Value of Travel Time of Passengers (Rs/hour) – 2009 prices

Sl.No	Nature of Journey by Passenger	Value of Time
		Primary Route
1	Cars	62.5
2	Two Wheelers	32
3	Ordinary Bus Passenger	39.5

Note: Average 365 days a year is considered to arrive at the value of passenger time saved.

These values of 2009 are revised based on the wholesale price index to arrive at the current price. The monthly WPI index for all products from the website of "Office of the Economic Adviser Govt. of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIPP)" (http://www.eaindustry.nic.in/display_data.asp) is considered to arrive a "Value Indexation Factor" (VIF) to arrive at the current price levels of the time value provided in the IRC SP 30, 2009. The calculation of VIF is provided below;

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Wholesale Price Index			
As on Mar-2009	123.5		
As on Aug-2018	187.40	Index Multipier	1.5174

The current value arrived at through multiplying with VIF is provided below

Table 3.12 Value of Travel Time of Passengers (Rs/hour) March-17 prices

Sl.No	Nature of Journey by Passenger	Value of Time
		Primary Route
1	Cars	94.84
2	Two Wheelers	48.56
3	Auto*	48.56
4	Ordinary Bus Passenger	59.94

* Assumed same as Two Wheelers

Note: For the economic evaluation the value for 'value of time' for the primary route is considered. Out of the total travellers it is assumed that 85% of the total population travels is considered as work travel and the balance 15% as leisure travel. The time saved through proposed road for leisure travel is not considered as benefit under this head.

To arrive at the value of time saved, the average occupancy of vehicles passing □ro□□□ □□□ ra□□ro□□ □□ □on□d□r□d a□ o□o□□

Table 3.13 Average Passenger Occupancy

Sl.No	Nature of Journey by Passenger	Passenger Occupancy
1	Cars	4.80
2	Two Wheelers	1.50
3	Auto	3.00
4	Ordinary Bus Passenger	43.00

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3.9.4.2 Time Value of Cargo

With regard to time value of cargo, as the travel time reduces the inventory carrying cost of the cargo also reduces. Reduced travel time for cargo leads to;

- Use of lesser number of commercial vehicles and
- Leads to reduction in the fixed charges per km which every operator has to pay
- Results in time savings to the vehicle crew

The savings in travel time are an important component of the benefits from the construction of the proposed road. Theoretically, it is possible to visualize the savings in cost of holding inventories by working out the value of goods held during the transport and deriving the interest payment thereon.

The Average value of time for commodity is considered for the working based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP: 30 - 2009)". Equivalent cost of commodity in 2016-2017 is determined using multiplying the WPI as specified in IRC SP: 30 – 2009 with Value Indexation Factor" (VIF) (as detailed in the previous section). The value of time saving of commodity transport as specified under IRC SP: 30 – 2009 and its indexed value are provided in the following table.

Table 3.14 Commodity Holding cost

Vehicle type	Value of Commodity (Rs./t)	Average Load (t/Vehicle)	Commodity Holding Cost (Rs/day)	
			As on 2009 March	As on 2018 march
LCV	35300	3.2	58.10	88.16
HCV	38750	9	178.00	270.10
MAV	36300	18.3	333.00	505.29

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Note: For the calculation of time value saving for commodities, 365 days a year is considered.

Through the construction of the proposed road, the cost of idle fuel consumption can be saved. It is assumed that on an average 50% of total single lane stoppage time, the vehicles will be turned on. Hence through the construction of the proposed road, the fuel consumption otherwise occur during idling time can be saved. Savings in idle fuel consumption is worked out assuming that each type of vehicles consumes fuel in the following quantity.

Type of Vehicle	Idle Fuel consumption in ml. per hour	Fuel
2 Wheeler	200	Petrol
3 Wheeler	250	Diesel
Car / Jeep	667	Diesel
LCV	810	Diesel
BUS	920	Diesel
HCV	920	Diesel
Truck	942	Diesel

Average cost of fuel per litter considered for economic analysis is as per"IRC SP:30 -2009" is then converted to March 2017 WPI with corresponding index factors.

Fuel Type	March 2009 price without tax	March 2016 price without tax
Petrol	18.55	27.91
Diesel	18.2	27.62

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3.9.5 ECONOMIC RATE OF RETURN

The ERR through implementing road works out to 31.83%. The CBR (Project Benefits / Project Costs) of the project is 1.160. This indicates that the construction of the proposed road will yield an economic rate of return of 31.83% and this ERR is very attractive for an infrastructure investment. The CBR of more than 1 is acceptable for any infrastructure development and this project higher CBR. The CBR of 1.160 indicate that the total benefit derived from the project is 1.160 times than the total project related costs. The total Economic Cost and Benefits, component wise for the entire project period under consideration (ie. 20 years) is tabulated in the following table.

Particulars	Rs. in lakhs
Economic Cost of Project	
Capital Cost	-2623.58
Maintenance Cost	-1259.36
Total Cost	**-3882.94**
Economic Benefits	
Value of Travel time saving of passengers	24170.69
Value of Travel time saving for Cargo	53.31
Value of saving in idle fuel consumption	1552.99
Total Benefit	**25776.99**

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Table 3.15 Cost Benefit Analysis

Year	Project Costs		TOTAL PROJECT COSTS	Project Benefits			Total Project Benefits	Net Project Benefits
	Cost of Development	O&M cost of new bridge		Value of Travel Time Saving of Passengers (lakhs)	Value of Travel Time Saving of Commodities	Value of idling fuel cost Year		
2021	-1915.58		-1915.58	0	0	0	0	-1915.58
2022	-708.00	0	-708.00	0	0	0	0	-708.00
2023		0	0	859.18	1.89	55.20	916.27	916.27
2024		0	0	902.14	1.99	57.96	962.09	962.09
2025		-78.71	-78.71	947.24	2.09	60.86	1010.19	931.48
2026		-78.71	-78.71	994.60	2.19	63.90	1060.69	981.98
2027		-78.71	-78.71	1044.34	2.30	67.10	1113.74	1035.03
2028		-78.71	-78.71	1096.55	2.42	70.46	1169.43	1090.72
2029		-78.71	-78.71	1151.38	2.54	73.98	1227.90	1149.19
2030		-78.71	-78.71	1208.95	2.67	77.68	1289.30	1210.59
2031		-78.71	-78.71	1269.40	2.80	81.56	1353.76	1275.05
2032		-78.71	-78.71	1332.87	2.94	85.64	1421.45	1342.74
2033		-78.71	-78.71	1399.50	3.09	89.92	1492.51	1413.80
2034		-78.71	-78.71	1469.48	3.24	94.41	1567.13	1488.42
2035		-78.71	-78.71	1542.95	3.41	99.14	1645.50	1566.79
2036		-78.71	-78.71	1620.10	3.57	104.09	1727.76	1649.05
2037		-78.71	-78.71	1701.11	3.75	109.30	1814.16	1735.45
2038		-78.71	-78.71	1786.17	3.94	114.76	1904.87	1826.16
2039		-78.71	-78.71	1875.48	4.14	120.50	2000.12	1921.41
2040		-78.71	-78.71	1969.25	4.34	126.53	2100.12	2021.41
2041		-78.71	-78.71	2067.71	4.56	132.85	2205.12	2126.41
TOTAL	-2623.58	-1259.36	-3882.94	24170.69	53.31	1552.99	25776.99	21894.05
TOTAL PROJECT COST			**-3882.94**	**TOTAL PROJECT BENEFITS**			**25776.99**	

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Table 3.16 Daily Traffic Projection

Year	Cycle	Bike	Auto	Car	LCV	Bus	Truck
2018	1	4151	570	3229	402	2	879
2019	1	4359	599	3390	422	2	923
2020	1	4577	629	3560	443	2	969
2021	1	4806	660	3738	465	2	1017
2022	1	5046	693	3925	488	2	1068
2023	1	5298	728	4121	512	2	1121
2024	1	5563	764	4327	538	2	1177
2025	1	5841	802	4543	565	2	1236
2026	1	6133	842	4770	593	2	1298
2027	1	6440	884	5009	623	2	1363
2028	1	6762	928	5259	654	2	1431
2029	1	7100	974	5522	687	2	1503
2030	1	7455	1023	5798	721	2	1578
2031	1	7828	1074	6088	757	2	1657
2032	1	8219	1128	6392	795	2	1740
2033	1	8630	1184	6712	835	2	1827
2034	1	9062	1243	7048	877	2	1918
2035	1	9515	1305	7400	921	2	2014
2036	1	9991	1370	7770	967	2	2115
2037	1	10491	1439	8159	1015	2	2221
2038	1	11016	1511	8567	1066	2	2332
2039	1	11567	1587	8995	1119	2	2449
2040	1	12145	1666	9445	1175	2	2571
2041	1	12752	1749	9917	1234	2	2700

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Table 3.17 Average passenger trip

Year	Bike	Auto	Car	Bus
Average Occupancy	1.5	3	4.8	43
Percentage of work passenger /Year	0.85	0.85	0.85	0.85
2018	5292.53	1453.5	13174.32	73.1
2019	5557.16	1526.18	13833.04	76.76
2020	5835.02	1602.49	14524.69	80.6
2021	6126.77	1682.61	15250.92	84.63
2022	6433.11	1766.74	16013.47	88.86
2023	6754.77	1855.08	16814.14	93.30
2024	7092.51	1947.83	17654.85	97.97
2025	7447.14	2045.22	18537.59	102.87
2026	7819.50	2147.48	19464.47	108.01
2027	8210.48	2254.85	20437.69	113.41
2028	8621.00	2367.59	21459.57	119.08
2029	9052.05	2485.97	22532.55	125.03
2030	9504.65	2610.27	23659.18	131.28
2031	9979.88	2740.78	24842.14	137.84
2032	10478.87	2877.82	26084.25	144.73
2033	11002.81	3021.71	27388.46	151.97
2034	11552.95	3172.80	28757.88	159.57
2035	12130.60	3331.44	30195.77	167.55
2036	12737.13	3498.01	31705.56	175.93
2037	13373.99	3672.91	33290.84	184.73
2038	14042.69	3856.56	34955.38	193.97
2039	14744.82	4049.39	36703.15	203.67
2040	15482.06	4251.86	38538.31	213.85
2041	16256.16	4464.45	40465.23	224.54

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Table 3.18 Passenger time saving

Type of Vehicle	2w	Auto	car/jeep	bus	Time value of passengers per day	Yearly passeneger time cost
Time savings in minute	7	7	7	7		
Average trips wise passenger time cost	5.66	5.66	11.06	6.99		
2018	29982	8234	145708	511	184435	67318775
2019	31481	8646	152993	537	193657	70684805
2020	33055	9078	160643	563	203339	74218735
2021	34708	9532	168675	592	213507	77930055
2022	36443	10009	177109	621	224182	81826430
2023	38266	10509	185964	652	235391	85917715
2024	40179	11034	195263	685	247161	90213765
2025	42188	11586	205026	719	259519	94724435
2026	44297	12165	215277	755	272494	99460310
2027	46512	12774	226041	793	286120	104433800
2028	48838	13412	237343	832	300425	109655125
2029	51280	14083	249210	874	315447	115138155
2030	53843	14787	261671	918	331219	120894935
2031	56536	15526	274754	964	347780	126939700
2032	59362	16303	288492	1012	365169	133286685
2033	62330	17118	302916	1062	383426	139950490
2034	65447	17974	318062	1115	402598	146948270
2035	68719	18872	333965	1171	422727	154295355
2036	72155	19816	350663	1230	443864	162010360
2037	75763	20807	368197	1291	466058	170111170
2038	79551	21847	386607	1356	489361	178616765
2039	83529	22940	405937	1424	513830	187547950
2040	87705	24087	426234	1495	539521	196925165
2041	92090	25291	447545	1570	566496	206771040

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Table 3.19 Savings in Commodity carrying cost

Year	LCV	Truck	TOTAL COMMODITY CARRYING COST PER DAY	YEARLY COMMODITY CARRYING COST PER YEAR
Commodity holding cost Rs/vehicle	0.05	0.43		
2018	20.10	386.76	407	148555
2019	21.11	406.10	427	155855
2020	22.17	426.41	449	163885
2021	23.28	447.73	471	171915
2022	24.44	470.12	495	180675
2023	25.66	493.63	519	189435
2024	26.94	518.31	545	198925
2025	28.29	544.23	573	209145
2026	29.70	571.44	601	219365
2027	31.19	600.01	631	230315
2028	32.75	630.01	663	241995
2029	34.39	661.51	696	254040
2030	36.11	694.59	731	266815
2031	37.92	729.32	767	279955
2032	39.82	765.79	806	294190
2033	41.81	804.08	846	308790
2034	43.90	844.28	888	324120
2035	46.10	886.49	933	340545
2036	48.41	930.81	979	357335
2037	50.83	977.35	1028	375220
2038	53.37	1026.22	1080	394200
2039	56.04	1077.53	1134	413910
2040	58.84	1131.41	1190	434350
2041	61.78	1187.98	1250	456250

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Table 3.20 Savings in Idle fuel cost

Average Idling Time		6	minutes					
	Mar-09		Mar-18					
WPI	123.5		187.4					
Petrol	18.55		28.15					
Diesel	18.2		27.62					
Type of Vehicle	**2w**	**Auto**	**car/ jeep**	**LCV**	**bus**	**truck**	**Total idling cost per day**	**Total idling fuel cost per year**
Average hourly idling fuel Consumption (ml)	200	250	667	810	920	942		
Average idling cost per trip	0.56	0.69	1.84	2.24	2.54	2.6		
2018	2324.56	393.30	5941.36	900.48	5.08	2285.40	11850	4325250
2019	2440.79	412.97	6238.43	945.50	5.33	2399.67	12443	4541695
2020	2562.83	433.62	6550.35	992.78	5.60	2519.65	13065	4768725
2021	2690.97	455.30	6877.87	1042.42	5.88	2645.63	13718	5007070
2022	2825.52	478.07	7221.76	1094.54	6.17	2777.91	14404	5257460
2023	2966.80	501.97	7582.85	1149.27	6.48	2916.81	15124	5520260
2024	3115.14	527.07	7961.99	1206.73	6.80	3062.65	15880	5796200
2025	3270.90	553.42	8360.09	1267.07	7.14	3215.78	16674	6086010
2026	3434.45	581.09	8778.09	1330.42	7.50	3376.57	17508	6390420
2027	3606.17	610.14	9216.99	1396.94	7.88	3545.4	18384	6710160
2028	3786.48	640.65	9677.84	1466.79	8.27	3722.67	19303	7045595
2029	3975.80	672.68	10161.73	1540.13	8.68	3908.80	20268	7397820
2030	4174.59	706.31	10669.82	1617.14	9.11	4104.24	21281	7767565
2031	4383.32	741.63	11203.31	1698.00	9.57	4309.45	22345	8155925
2032	4602.49	778.71	11763.48	1782.90	10.05	4524.92	23463	8563995
2033	4832.61	817.65	12351.65	1872.05	10.55	4751.17	24636	8992140
2034	5074.24	858.53	12969.23	1965.65	11.08	4988.73	25867	9441455
2035	5327.95	901.46	13617.69	2063.93	11.63	5238.17	27161	9913765
2036	5594.35	946.53	14298.57	2167.13	12.21	5500.08	28519	10409435
2037	5874.07	993.86	15013.5	2275.49	12.82	5775.08	29945	10929925
2038	6167.77	1043.55	15764.18	2389.26	13.46	6063.83	31442	11476330
2039	6476.16	1095.73	16552.39	2508.72	14.13	6367.02	33014	12050110
2040	6799.97	1150.52	17380.01	2634.16	14.84	6685.37	34665	12652725
2041	7139.97	1208.05	18249.01	2765.87	15.58	7019.64	36398	13285270

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3.10 ENVIRONMENTAL ASPECTS AND SUSTAINABILITY

Objective of the EIA study is to understand and analyses the Environmental and Social Impacts associated with the proposed road alignment in the coastal region of Kerala. However, the subject project – construction of Coastal highway from Kolavipalam to Kottakkal kadavu will not attract item 7 of schedule of EIA notification of 2006 as the maximum width of land required for the construction coastal highway and road will be 15.60 m. Hence this project does not require prior environmental clearance.

3.10.1 ENVIRONMENTAL SETTING PROJECT AREA

The district of Kozhikode is one of the coastal districts of Kerala. Kozhikode district is bounded on the north by Kannur district, on the east by Wayanad district, on the south by Malappuram district and the district is divided into 4 taluks and 12 developmental blocks and 70 panchayats for administrative purposes.

The district has one corporation (Kozhikode) and seven Municipalities. It has a total of 117 revenue villages. Out of the total area of 2344 Sq. Kms 336 Sq. Kms fall under urban area and the remaining 2008 Sq. Kms falls under rural area. The district has a total population of 30, 89,543 persons as per 2011 census. It lies between North latitudes 11º 08’ and 11º 50’ and East longitudes 75 º 30’ and 76 º 8’.

The road from Kolavipalam to Kottakkal kadavu passes along the coastal belt of Payyoli municipality which connects Vadakara and Koyilandy taluks. Geographically, Vadakara is situated about 49 km to the north of Kozhikode City, approximately 44 km to the south of Kannur City and it is proximate to Mahi. The town lies by the side of a river known by different names including the Moorad river, Kuttiyadi river, and Kottakkal river.

The proposed Coastal highway from Kolavipalam to Kottakkal kadavu is an alternative route to National Highway 66 and can reduce the traffic problems. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in the district.

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The proposed road will fall under coastal area. Hence it should get coastal clearance from Coastal Regulations Zone authority (CRZ). No mandatory or other rare species of trees will not be destroyed during the construction of the project and no wild animals found in the localities of populated area of the proposed project locations.

3.10.2 RAINFALL AND CLIMATE

Kozhikode district experienced an average annual rainfall of 3698 mm. The District has more or less the same climate conditions prevalent elsewhere in the state viz. dry season from December to February and hot season from March to May, the southwest monsoon from June to September and North East monsoon from October to December. The SW and NE monsoons mainly contribute rainfall in the area with 82.77 % of the rainfall. The South West monsoon is usually very heavy and merely 72.15% of the rain fall is received during this season. North East monsoon contributes nearly 10.63%. During winter (January to March) it is 0.49% and during summer (April and May) it is16.74%.The month of June experiences maximum rainfall. The months of July, August and October also receive heavy rainfall. The agricultural activity of the district depends on the onset of SW tropical monsoon.

3.10.3 OTHER METEOROLOGICAL PARAMETERS

3.10.3.1 Temperature

The climate is generally hot and humid. March and April months are the hottest and January and February months are the coldest. The minimum temperature ranges between 22 and 25.8º C and the maximum between 28.2 and 32.9º C. The temperature starts rising from January and reaches its peak in the month of March and April and then decreases during the monsoon month and again rising from September onwards.

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3.10.3.2 Relative Humidity

The relative humidity ranges from 74 to 92 % during morning hours and from 64 to 89% in evening hours. The monsoon months (June to September) record high humidity.

3.10.3.3 Wind speed

The wind is predominant from east as well as west during morning and evening hours. The wind speed ranges from 8.1 to 12.6 km/h. The maximum wind speed is during April and minimum in November.

3.10.3.4 Potential Evapotranspiration

The annual Potential Evapotranspiration (PET) is 1505.7 mm. The monthly PET ranges from 92.9 to 170.2 mm. The PET is less than the rainfall during May to November and hence the possibility of recharge to ground water regime is more during these months.

3.10.3.5 Geology

The district can be divided into three geological belts viz., (i) a linear NW-SE trending gneissic belt, along the middle extending from north to south, (ii) a charnockite belt occupying areas in the northeast and south, extending to the adjacent districts and also occurring as pockets within the gneissic terrain and (iii) a narrow coastal belt.

3.10.3.6 Geomorphology

Geomorphology is the study of the features that make up the earth's surface and their relationship to the underlying geology. There is a well-developed beach all along the coast with sea cliffs and rocky beaches near Quilandy, Payyoli and Vadakara. Vadakara Sand banks beach is where locals and tourists throng to view the confluence of the Kottakkalkadavu and the Arabian Sea.

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3.10.3.7 Soil types

The soils of the district are alluvial soil, lateritic soil and forest loam. As the project area is very near to sea, the soil in the proposed locations is sandy and clay in nature. Mainly the Arabian Sea deposits a large quantity of sandy soil.

3.10.3.8 Groundwater scenario

Groundwater occurs in the weathered, fractured, crystalline and alluvial formations in the district. Phreatic conditions exist in weathered formation and are mostly developed by dug wells for domestic and irrigation purposes. Semi-confined conditions exist in deep fractures and storage and movement of groundwater is mainly controlled by the fracture system. Deep high yielding bore wells are located along fractures / lineaments. The district is divisible into two hydrological provinces viz., (i) the eastern Wayanad Plateau where dug wells give moderate yield and bore wells are feasible along fracture planes and (ii) the western mountains, which are generally unsuitable for groundwater development but the valleys with thick alluvium sustain dug wells. All the four blocks in the district are having similar hydrogeological conditions. The major water bearing formations in the district are weathered/fractured crystalline, alluvium and valley fills.

3.10.3.9 Air and Noise Pollution

Air and Noise pollution are the adverse impacts mainly during construction phase. Dust depressing measure will be done aimed at prevention of air pollution through watering of access roads and construction site. During construction air pollution level will be increased mostly by machine operations for earthwork. The main pollutants caused by these operations include exhaust gases emitted by machines and dust caused by the earthwork. Regular sprinkling of water during construction works will depress the dust thus reducing impact on workers. Additional measures planned to maintain air quality include locating concrete mixing plant and stockpiles in isolated area as well as confining working vehicles to designated

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routes only following the established schedule. Trucks loaded with loose construction materials (such as gravel, sand, soil, etc) shall be covered to minimise dust emissions during transportation. Vehicles and machinery should be fitted with effective exhaust silencers and maintained in good and efficient working order. Machinery in intermittent use should be shut down or throttled down to a minimum when not in use.

3.10.4 ENVIRONMENTAL ASPECTS

3.10.4.1 Positive Impacts of the Project

The potential positive environmental impacts due to project apart from its economic importance include the following.

- **Reduced noise and air pollution**. With the proposed construction of road, noise and air pollution levels on National Highway is expected to go down, because the overall human exposure to noise and air pollution will be minimal due to less congestion.
- **Reduced risk of accidents**. The proposed road alignment shall provide adequate safety measures and proper sight distances thereby resulting in reduced accidents and traffic congestions. Moreover with expected decrease in overall traffic density on National Highway, the chances of accidents will reduce considerably.
- **Improved accessibility and connectivity**

  The proposed road is an alternative route to National Highway. Hence the traders can easily access the market without entering the national highway. The goods and other commodities for trade have to be brought through this road. People from the nearby Panchayat depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion.

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- **Savings in fuel consumption.** Savings in fuel consumption can be attributed to low traffic congestion and relatively less travel time due to proposed improvements.
- **Improved quality of life.** The proposed project is expected to improve the quality of life of the people residing in the project zone in terms of their economic, social and health status. Land value in the nearby areas of the proposed alignment will increase substantially.

3.10.4.2 Negative Impacts of the Project

The likely adverse environment impacts during the construction phase of the project will include the following.

- Degradation of soil, landscape and soil erosion due to improper disposal of excavated materials and construction waste;
- Spillage of oil and other substances during the construction;
- Pollution of water resources and soil by construction run-offs;
- Use of temporary construction sites (access roads, camps, machinery sites, storage facilities, etc ;)
- Use of borrow pits; extraction of aggregate material, such as gravel, sand, granite;
- Temporary air pollution related to increased truck traffic during the construction;
- Release of dust from digging-loading works and heavy machinery operation;
- Noise and vibration disturbances;
- Safety hazards during implementation of construction works.

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3.11 RISK ASSESSMENT AND MITIGATION MEASURES

3.11.1 GENERAL

Risk is an uncertainty that matters; it can affect project objectives negatively or positively. The uncertainty may be about a future event that may or may not happen and the unknown magnitude of the impact on project objectives if it does happen. Thus, a "risk" is characterized by its probability of occurrence and its uncertain impact on project objectives.

Risk of many types can occur prior to work and at the time of construction. The occurrence of the unexpected events may adversely affect the timely completion of the project. For a smooth running of the project these should be assessed and should take measures to mitigate the same. The chances of such occurrences are verified and the mitigation measures are proposed.

Table 3.21 Risk Assessment and Risk Management Plan

Risks	Assessment without Mitigation	Management Plan or Measure	Assessment with Mitigation
Project road will not be built, maintained, and operated to the specified standards	High	To ensure high quality design and supervision, Kerala Public Works Department will be executing the work. Highly qualified technical persons of DRIQ board of KPWD have designed the bridge structure. Supervision at all stage of construction will be done by Technically highly qualified persons of National Highway wing of KPWD. Procurement for the highway and bridge contract included a prequalification to ensure only contractors with experience of successfully completing of similar scale and type would be permitted to bid for the contract.	Low
Major traffic accidents	Medium	There will exist both workers and traffic during the construction period. So for reducing the accidents safety jackets and temporary warning signals are providing.	Low

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Boundary arguments	High	Revenue authorities will be directed to fix the boundary of acquired land in advance in coordination with District administration	Low
Land acquisition	High	Land acquisition proposal should be given in advance to Revenue authorities. Compensation for the acquired land will be paid as per The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2015	Low
Environmental risks	Medium	Environmental management plans are incorporated in bid and contract documents for civil works; annual independent monitoring of compliance is required	Low
Social and resettlement risks	Medium	Implementation of a social action plan addressing social and gender issues will be monitored. Implementation of resettlement plans and income restoration programs will be independently monitored semi-annually to address resettlement-related risks. Even though the project involves land acquisition no direct effect on residential, commercial and other establishments.	Low
Utility Shifting	High	Advance notice will be issued to service providers like KSEB, KWA, BSNL and other private firms. Utility shifting charge has been included in the estimate for shifting electric post.	Low
Unforeseen construction delays	Medium	Mitigated through force majeure provisions of the construction contracts.	Low

3.12 PROJECT MANAGEMENT ORGANISATION

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorized to implement the proposed coastal highway project in Kozhikode district.

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3.13 CONTRACT MANAGEMENT STRATEGY

3.13.1 GENERAL

All contracts in India are to be within the framework of the Indian Contract Act, 1872, which lays down the general principles relating to formation, performance and enforceability of contracts, PWD NH Kerala officers responsible for drawing up the contract documents should keep these principles in mind.

3.13.2 DEFINITION

When two or more persons have a common intention communicated to each other to create some obligation between them, there is said to be an "agreement". An agreement which is enforceable by law is a "Contract".

3.13.2.1 The following steps are involved in procurement.

1. Preparation of Bid (Tender) Documents
2. Approval of Bid Documents by the tender accepting authority
3. Public invitation for Pre-qualification (where so specified)
4. Issue of instructions to Bidders, and Pre-qualification Criteria
5. Receipt of Applications for Pre-qualification, and their Evaluation
6. Approval of Pre-qualification
7. Invitation for Bids
8. Issue of Bid Documents to prospective bidders
9. Pre-bid meeting (if specified), issue of minutes and clarifications, with the approval of the authority who originally approved the bid documents.
10. Receipt of Bids
11. Scrutiny of Bids and their Evaluation
12. Negotiation (where warranted)

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13. Acceptance of Bid (or Rejection of Bids)

3.14 IMPLEMENTATION SCHEDULE AND WORK BREAK DOWN STRUCTURE

3.14.1 GENERAL

A Work Break down Structure (WBS), In Project management and systems Engineering , is a deliverable – oriented break down of a project into smaller components. WBS is a hierarchical and incremental decomposition of the project into phases deliverable and work packages. It shows a subdivision of effort required achieve an objective.

3.14.2 NEED FOR WBS

WBS (Work Breakdown Structure) is a critical phase in management. The time bound work schedule is an important part of every project because it helps in better handling of projects in planning, implementation etc. More over Work Breakdown Structure must be consistent in the way work gets performed.

WBS can considered as input to five key project management activities

- Cost Estimating
- Cost Budgeting
- Resource Planning
- Risk management Planning
- Activity Definition

3.14.2.1 WBS for Project Management

- Indicates the Project milestone and check point
- Helps to estimate project scope, time, risk, and other factors
- Gives a better understanding of the project
- Provides a frame work for managing and delegating work

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- Serves as a great decision – making tool

A detailed Work Program Schedule is enclosed with annexure IV having clear indication of completion of time and resources used. The start date indicated in the Work Breakdown Structure is first January2018. The end date can be shifted in accordance with the shift in date of start, keeping the period of construction constant. A detailed cash flow diagram is also appended in Annexure V.

3.15 STATUTORY CLEARANCE

A review of the project relevant legal policies, regulations and institutions at the International, National and State levels has been presented in this section. Applicable clearances required for the project under various regulations and role of various institutions in implementing various regulations and environmental management measures have been addressed below.

3.16 EIA NOTIFICATION 2006

The EIA notification dated 14 th September, 2006 imposes certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects on activities based on their potential environmental impacts as indicated in the schedule to the notification, being undertaken in any part of India unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy as approved by the Union Cabinet on 18th May,2006 and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Authority(SEIAA)

The notification has listed out the Projects or activities requiring prior environmental clearance under Category "A" and "B" based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade recourses. Category "A" projects require prior environmental clearance from MoEF & CC on the recommendations of an Expert Appraisal Committee (EAC) and Category "B" project require prior environmental clearance from State or Union territory Level Environment

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Impact Assessment Authority (SEIAA) on the recommendations of a State or Union territory Level Expert Appraisal Committee (SEAC). In the absence of a duly constituted SEIAA or SEAC, a category "B"project shall be treated as a Category "A" project.

New National Highways and expansion of National Highways greater than 100 Km, involving additional right of way greater than 40 m on existing alignment and 60m on realignment involving land acquisition is categorized as "A" New State Highways and expansion of State Highways project in hilly terrain (above 1000 on AMSL) and or ecologically sensitive areas is categorized as "B" . Any project specified in category "B" will be treated as category A, If located in whole or in part within 10Km from the boundary of (i) Protected Areas notified under the Wild life (Protection) Act, 1972, (ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time , (iii) Notified Eco-sensitive areas and (iv) inter-State boundaries and international boundaries.

As the new road will not come under hilly terrain or ecologically sensitive areas, the project will not attract EIA notification 2006.

3.16.1 COASTAL REGULATION ZONE (CRZ) CLEARANCE

As populations in coastal areas increase and the economic activity diversifies, all the impacts on coastal environment are bound to worsen threatening survival of several species, productivity of the biota, and render fishing an unsustainable proposition. It is, therefore, clear that unless governments and resource users take appropriate action, the degradation of the coastal and marine environment will become uncontrollable and there will be no possibilities for sustainable use of resources from these waters. The Coastal Regulation Zone (CRZ) Act notified by the Ministry of Environment and Forests in 1991 needs to be seen against this background. It declares coastal stretches as CRZ and regulates certain activities within the zone. The provisions of the act are to be implemented by the coastal states and Union Territories. It also envisages the creation of an appropriate authority at the state/UT level to be responsible for enforcement and enactment of these

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provisions. The request for CRZ clearance is applied through the corresponding local bodies. Provision for 5% of the estimated cost of work as lumpsum is included in the estimate as fee for CRZ clearance.

3.17 QUALITY MANAGEMENT PLAN

3.17.1 BACKGROUND

The Quality Management Plan is an integral part of any project management plan. The purpose of the Quality Management Plan is to describe how quality will be managed throughout the lifecycle of the project. It also includes the processes and procedures for ensuring quality planning, assurance, and control are all conducted. All stakeholders should be familiar with how quality will be planned, assured, and controlled.

Quality Assurance is defined as all the planned and systematic activities implemented within the Quality System and demonstrated as needed, to provide adequate confidence that an object will fulfil the requirements. The **PWD Quality Control Manual** provides a base document outlining policy, procedures, responsibilities, compliance, acceptance criteria and documentation.

3.17.2 ADOPTED STRATEGY

This section of the Quality Management Plan describes the approach the organization will use for managing quality throughout the project's life cycle. Quality must always be planned into a project in order to prevent unnecessary rework, waste, cost, and time. Quality should also be considered from both a product and process perspective.

3.17.3 STRUCTURE OF QUALITY MANAGEMENT WING

Quality control tests have been made mandatory for projects undertaken by state PWD from 1.9.2014. Clause 2401 and 2406 of Revised PWD Manual - 2012 stipulates that PWD shall follow a three-tier quality control system for ensuring quality of projects executed as per PWD Quality

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Control Manual. This includes technical audit after completion of construction. The system envisaged is as below:

3.17.3.1 First-tier QC testing

In first-tier QC testing, the Contractor has to carry out the required tests at his own cost during the course of a work. First tier quality control tests are mandatory for all projects

As per Govt. circular No. 23631/G2/2013/PWD dated 1.11.2013, Contractors shall establish field laboratories at the site. If any test cannot be carried out with the facilities available in the Contractor's laboratory, it shall be got done in an approved laboratory by the Contractor at his own cost.

If the QC test is done in the field laboratory established at site, the test results shall be signed by the Overseer/Assistant Engineer, whoever is supervising the work. It shall also be signed by the Contractor. Copy of test results shall be forwarded by the Assistant Engineer to the Assistant Executive Engineer/Executive Engineer for review. The same procedure shall be followed, in case of tests done in an approved laboratory also.

3.17.3.2 Second-tier QC testing

Second-tier QC checks/tests are to be done by the QC wing of PWD on a random basis. However, it is desirable that the QC wing does quality control tests for all major and important items of construction. The frequency of tests shall be as per PWD Quality Control Manual or as specified in the Contract. The QC wing is authorized to inspect all projects undertaken by PWD, and conduct quality tests.

3.17.3.3 Third-tier QC checking (Technical audit)

As per clause 2406 of the revised PWD Manual 2012, Technical audit shall be done by an external agency/expert empanelled for the purpose after the construction of a project is completed. This will form the third tier of QC system. Technical audit shall be done for projects, estimated cost of which is above Rs 5 crores. All tests carried out in the first-tier and second-tier QC

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testing shall be reviewed during technical audit. Technical Audit shall be completed within six months from the date of completion of construction. Non-destructive testing techniques shall be adopted if conventional testing techniques cannot be applied.

3.18 OPERATION AND MAINTENANCE PLAN

3.18.1 GENERAL

After the construction is completed, it is essential that the road structure is kept under observation and its condition monitored regularly so as to ascertain its performance and the efficiency of the measures adopted. The monitoring may involve inspections at frequent intervals, carrying out of certain laboratory and field-tests as well as condition surveys and measurements to detect even small strains, movements, changes in deformation etc.

3.18.2 INSPECTION OF WORK

Periodical inspection shall be conducted for all roads as per IRC guidelines. Detailed guidelines for highway road inspection and maintenance are contained in the following and the same should be invariably followed.

- IRC SP 57 - 2000 "Guidelines on Quality Systems for Roads"
- IRC:82 2015 "Code of Practice for Maintenance of Bituminous Road Surfaces".

3.18.3 MAINTENANCE

The purpose of detailed inspection as outlined above is to find out whether damage or deterioration has occurred in any part of the structure and if so immediate steps have to be taken for appropriate Remedial measures

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3.18.4 REMEDIAL MEASURES

- Wherever cracks, spalling of concrete, disintegration etc. are noted in wearing coat, drainage spouts, hand rails, footpaths and construction joints shall be rectified.
- Periodical maintenance of roads
- Corrosion of reinforcement shall be attended.
- Missing and broken footpath slab shall be replaced immediately

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4 LAND ACQUISITION

There is no development to the country without land. Land required for construction of Highways, Roads, Bridges, Railways, and Airports etc are acquired from public by implementing prevailing land acquisition rules. The Proposed road from Kolavipalam to Kottakkal kadavu which is a part of coastal highway also requires minimum land for construction. The land to be acquired and the number of families to be relocated for the construction of coastal highway is minimum in this stretch. The process of land acquisition for the construction of proposed road is carried out as per the 'The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2015'. The amount of compensation to be awarded for land owners as per the provisions of this act.

4.1 LAND ACQUISITION ACT, 2015

An Act to ensure, in consultation with institutions of local self-government and Gram Sabha's established under the Constitution, a humane, participative, informed and transparent process for land acquisition for industrialization, development of essential infrastructural facilities and urbanization with the least disturbance to the owners of the land and other affected families and provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition and make adequate provisions for such affected persons for their rehabilitation and resettlement and for ensuring that the cumulative outcome of compulsory acquisition should be that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto.

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4.1.1 APPLICATION OF ACT

The provisions of this Act relating to land acquisition, compensation, rehabilitation and resettlement, shall apply, when the appropriate Government acquires land for its own use, hold and control, including for Public Sector Undertakings and for public purpose, and shall include the following purposes, namely:

a) for strategic purposes relating to naval, military, air force, and armed forces of the Union, including central paramilitary forces or any work vital to national security or defense of India or State police, safety of the people; or

b) <u>for infrastructure projects,</u>

The provisions of this Act relating to land acquisition, consent, compensation, rehabilitation and resettlement, shall also apply, when the appropriate Government acquires land for the following purposes, namely:

a) for public private partnership projects, where the ownership of the land continues to vest with the Government, for public purpose as defined in sub-section (1)

b) For private companies for public purpose, as defined in sub - section (1)

4.1.1 LAND ACQUISITION COASTAL HIGHWAY FROM KOLAVIPALAM TO KOTTAKKAL KADAVU

The total land area to be acquired for the construction of proposed Coastal highway from Kolavipalam to Kottakkal kadavu is 4.0469 hectares. In this nearly 10% of land exists as public road and the remaining 90% to be acquired from private parties. The amount of compensation to be awarded for land owners as per the market value of the land at the premises.

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The details such as the extent of land to be acquired, survey number, type of land, taluk, village, Name of land owner is already submitted to Revenue Department. The Revenue Department is the acquiring authority and hence 5% of charge should be paid to them. Provision for the same is also included in the estimate.

4.1.2 LOCATION OF LAND ACQUISITION

A total area of 4.0469 hectares has to be acquired for the construction of coastal highway in this stretch. The land to be acquired lies in Iringal village in Koyilandy Thaluk, Kozhikode District, Kerala State.

4.2 CONCEPT NOTE

The proposed coastal highway from Kolavipalam to Kottakkal kadavu which passes along the coastal belt of Payyoli municipality connecting Koyilandy and Vadakara taluks in Kozhikode district. It is an alternative route to National Highway 66. This will surely help in saving time and fuel and reducing traffic congestion on the towns and in the national highway.

The proposed road from Kolavipalam to Kottakkal kadavu has two lanes having total length of 2.861km. The recommended width of the proposed coastal highway is 15.60 metres. While the carriage way will be 7m wide, two footpaths each having 1.55 m width will be constructed on both sides of the road wherever necessary. More over a 2.5m wide (including kerb) Cycle track have been proposed at the coastal side of the roadway to facilitate fast, safe and continuous movement of cyclists along major road corridors.

The proposed coastal highway is planned almost parallel to the National Highway 66 and is expected to divert a major share of the traffic from the NH and cities. Besides reducing the congestion in the NH corridors and in the cities, the Coastal Highway is expected to boost the tourism sector and help better integration with various other modes of transport.

The road is designed after detailed investigation and to be constructed according to requirement standards of traffic, nature of soil etc. The success

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of the project depends on a time-bound and early implementation of the entire package of the development proposals. The implementation shall be supplemented with timely maintenance activities to sustain the quality of road infrastructure and furniture.

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Assistant Executive Engineer
PWD NH Bypass Sub Division
Kozhikode

Thushara. K
Assistant Engineer
NH Bypass Section
Nellikkode

KERALA PWD
NH DIVISION KOZHIKODE

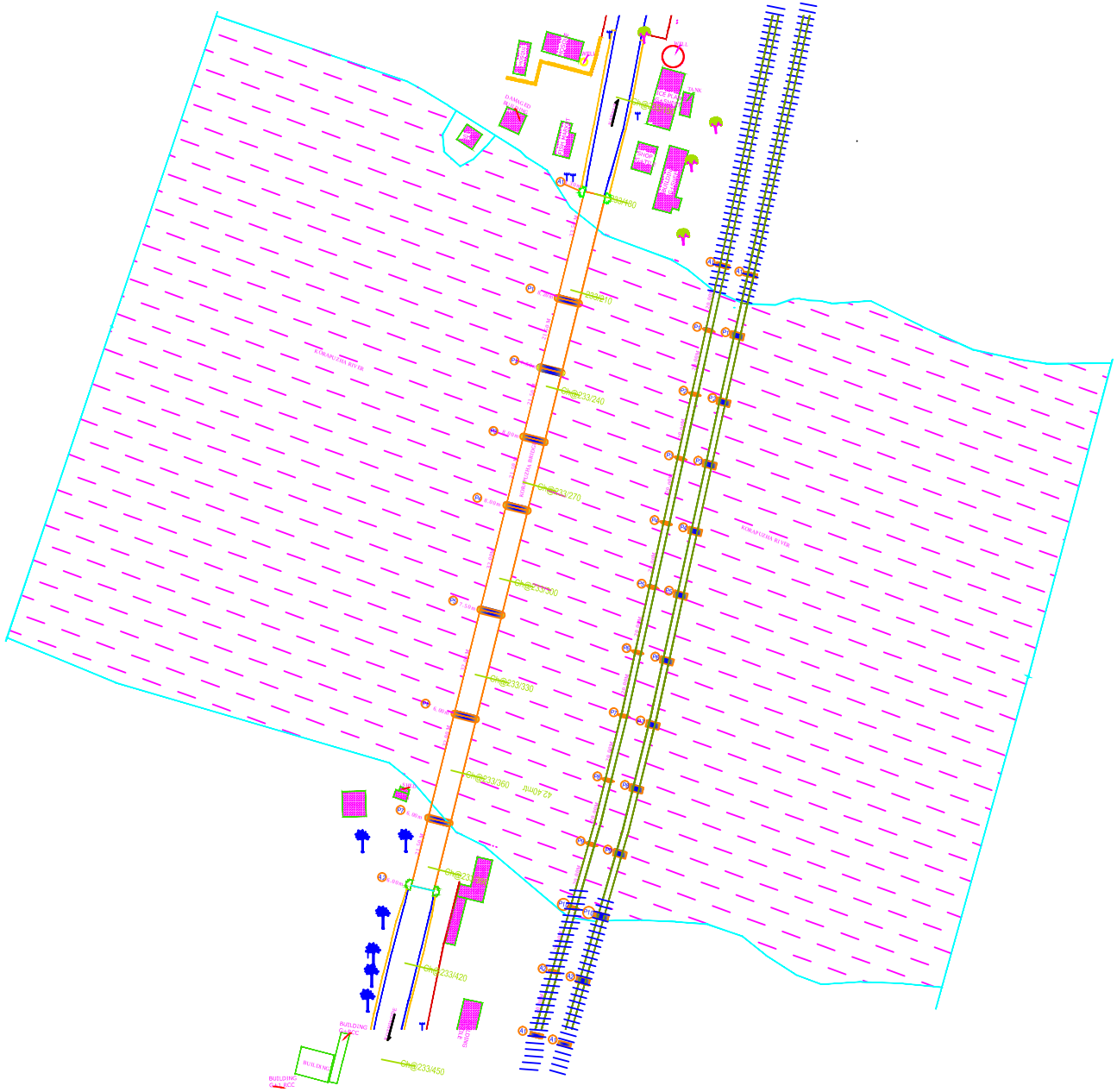
Investigation for the Re-construction of Korapuzha Bridge in NH66 (Old NH17) in Kozhikode District.

REPORT

The existing Korapuzha Bridge across Korapuzha was constructed nearly 80 years back and is in a state of distress. The width of bridge is only 5.5m and is without footpath. The bridge is thus a constriction in the NH. The traffic census data reveals that the traffic volume through the NH at the bridge location is 50000 PCU. With the completion of the last phase of Calicut Bypass the traffic through the old NH can be diverted through it to enable the reconstruction of the Korapuzha Bridge. Additional land for approaches will have to be acquired if the existing alignment of bridge is shifted. It is therefore proposed to construct the new bridge almost in the same location as that of the existing bridge after dismantling the existing one and temporarily diverting the traffic through the bridge.

Korapuzha river comes in the proposed National waterway and therefore vertical clearance of 7.5 m above MFL is to be provided. But the beam bottom levels of old and new railway bridges parallel to the Korapuzha road bridge are only 100.556 m and 100.719 m respectively. The beam bottom level of existing Korapuzha Bridge is 99.154 m and Finished Road Level 100.281 m. The HFL being 99.170 m, a vertical clearance of 7.5 m lifts the deck bottom to 106.67 m and FRL to 109.771 m, assuming a deck of 2.75 m depth. This in turn necessitates additional land 6 spans of 35m on Kozhikode side approach and 3 spans of 35m on Vatakara side approach in order to merge with the approach roads in addition to the 8 spans of 35m in the waterway. Service roads on both sides of the land spans to retain the existing connectivity also become essential, which in turn will increase the cost of the project in multitudes. It will therefore be appropriate to maintain the bottom level of deck same as that of the new railway bridge, i.e. 100.719 m and FRL at 102.800 m, in which case the existing roads can be utilized as approach roads with minimum alteration and the project cost can be limited to the cost of reconstruction of bridge with 8 spans in waterway alone. Necessary alteration to the bridge can be made in a similar fashion to that adopted for the existing railway bridges, in case of necessity with the commissioning of the National Waterway through the river. However the general arrangement drawing providing a vertical clearance of 7.5m above HFL is also prepared.

Bore holes have been taken by using rotary drilling adjacent to the pier and abutment locations of the existing Korapuzha Bridge. The borehole profiles indicate that hard rock exists at an average depth of 20m below the ground level. RCC Bored cast in situ piles can be provided for foundation.



NAME OF DRAWING:-

KORAPUZHA BRIDGE

CLIENT:-

LEGENDS:-

- T B M- RL :99.981
- LWL - 96.000
- MFL - 98.000
- HFL - 99.170
- COCONUT TREES
- ELECTRIC POST
- OTHER TREES

Surveyed by	PRASHOBH K K
Drawn by	RIJOB.C.V
Checked by	SUBEESH K P
Approved by	C. T .O
Scale:	Date :

Drg No. 225/ULCCS/PR/2015

Project. KORAPUZHA

ULCCS LTD.
AN ISO 9001:2000 ORGANISATION

URALUNGAL LABOUR CONTRACT
CO-OPERATIVE SOCIETY LTD.No.10957
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E mail: uralungal@yahoo.com
E mail: ulccssurvey@yahoo.in

Original

PROJECT	: Proposed Korapuzha Bridge
SITE	: Elathoor,Calicut
BORE HOLE NO.	: A1(Koilandy Side)
TYPE OF BORING	: Rotary Drilling

1/

DATE OF COMMENCE	: 16/10/2015
DATE OF COMPLETION	: 16/10/2015
GROUND WATER LEVEL	: Approx 0.70 m below G/L

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00										
1.20		Ordinary sand(Brown)	1.20							
2.80		Silty sand with shell dust (Y/Grey)	1.60	1.50	4	5	7	12		
		Silty sand(Yellow)	2.30	3.00	8	6	6	12		
				4.50	5	8	11	19		
5.10										
6.40		Very hard laterite(Red)	1.30	5.10	>50	-	-	>50		Pentn-3cm W/o sample
				Hard laterite boring done with TC.bit from 5.10m to 6.40m (1.30m)						
		Lateritic clay with sand (W/Red)	2.10	7.50	7	11	15	26		
8.50		Medium to hard laterite (W/Red)	2.70	9.00	11	35	15	>50		(Bal-11cm)
11.20				10.50	8	17	23	40		
		Lateritic clay with sand (W/Red)	2.80	12.00	5	9	7	16		
14.00				13.50	6	8	10	18		
		Silty clayey sand (Y/White)	6.50	15.00	2	4	5	9		
				17.00	3	5	7	12		
20.50				19.00	6	8	41	49		
21.50		Clayey silt with sand (W/Yellow)	1.00	21.00	9	15	30	45		
22.50		Hard rock(Grey)	1.00	21.50	SPT Rebounded W/o sample					
				Hard rock boring done with D/bit from 21.50m to 22.50m (1.00m) Recovery-0.50m						
		Bore Hole Terminated at 22.50 m Depth								

Site-in-charge

PROJECT	: Proposed Korapuzha Bridge	1/	DATE OF COMMENCE : 01/10/2015
SITE	: Koilandy,Calicut		DATE OF COMPLETION : 03/10/2015
BORE HOLE NO.	: P1		GROUND WATER LEVEL : HT-3.70m
TYPE OF BORING	: Rotary Drilling		LT-3.20m

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00										
		Water depth	3.70							
0.00 (Bed)				1.50	3	4	3	7		
		Clayey sand with silt (D/Grey)	3.60	3.00	5	5	10	15		
3.60										
		Lateritic clay with sand (R/White)	3.50	4.50	4	8	11	19		
				6.00	7	10	13	23		
7.10										
		Coarse sand with clay (R/Yellow)	1.20	7.50	8	14	21	35		
8.30										
		Coarse sand with silty clay(B/Grey)	5.20	9.00	6	8	10	18		
				10.50	4	9	14	23		
				12.00	8	12	17	29		
13.50										
		Clayey sand(Y/Grey)	3.50	13.50	6	9	9	18		
				15.00	8	10	11	21		
17.00										
		Silty sand(Yellow)	1.60	17.00	>50	-	-	>50		(Bal-36cm)
18.60				18.60	SPT Rebounded W/o sample					
		Soft rock(W/Grey)	0.70		Soft rock cleared with TC bit					
19.30				19.30						
		Hard rock(Grey)	1.00		Hard rock boring done with D/bit					
20.30				20.30	from 19.30m to 20.30m (1.00m)					
					Recovery-0.45m					
		Bore Hole Terminated at 20.30 m Depth								

Site in charge

PROJECT	: Proposed Korapuzha Bridge
SITE	: Koilandy,Calicut
BORE HOLE NO.	: P2(Under Water)
TYPE OF BORING	: Rotary Drilling

1/

DATE OF COMMENCE	: 04/10/2015
DATE OF COMPLETION	: 05/10/2015
GROUND WATER LEVEL	: HT-3.30m LT-2.80m

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00		Water depth	3.30							
0.00 (Bed)		Coarse sand (D/Grey)	2.10	1.50	4	6	9	15		
2.10		Lateritic clay with sand (R/Brown)	3.30	3.00	5	8	10	18		
				4.50	3	6	8	14		
5.40		Coarse sand (D/Grey)	1.50	6.00	9	13	20	33		
6.90		Lateritic clay with sand (W/Yellow)	2.90	7.50	5	8	14	22		
				9.00	10	12	17	29		
9.80		Coarse sand with silt (R/Yellow)	1.80	10.50	16	28	22	>50		(Bal-5cm)
11.60		Clayey sand(Yellow)	2.90	12.00	3	5	5	10		
				13.50	4	4	8	12		
14.50		Silty clay(Y/Grey)	3.60	15.00	6	9	14	23		
				17.00	4	7	9	16		
18.10		Clayey sand(Y/White)	1.40	19.00	7	10	10	20		
19.50										
		Cont. on page---2								

Site-in-charge

PROJECT	: Proposed Korapuzha Bridge
SITE	: Koilandy,Calicut
BORE HOLE NO.	: P3(Under Water)
TYPE OF BORING	: Rotary Drilling

1/

DATE OF COMMENCE	: 06/10/2015
DATE OF COMPLETION	: 07/10/2015
GROUND WATER LEVEL	: HT-3.60m LT-3.10m

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00		Water depth	3.60							
0.00 (Bed)		Clayey sand with silt (D/Grey)	2.10	1.50	3	4	7	11		
2.10		Lateritic clay with sand (Y/Red)	1.40	3.00	4	4	10	14		
3.50		Lateritic clay with sand & gravels(Y/White)	3.50	4.50	9	15	17	32		
				6.00	7	13	24	37		
7.00		Clayey sand(W/Yellow)	2.80	7.50	3	4	5	9		
				9.00	4	6	8	14		
9.80		Lateritic clay with sand (R/White)	2.90	10.50	6	9	13	22		
				12.00	5	7	10	17		
12.70		Clayey sand(W/Yellow)	7.70	13.50	7	7	7	14		
				15.00	4	8	9	17		
				17.00	6	11	10	21		
				19.00	5	8	10	18		
20.40		Silty weathered (W/Grey)	2.00	21.00	19	20	30	>50		(Bal-6cr
22.40		Soft rock(R/Grey)	1.60	22.40	>50	SPT Rebounded with sample Soft rock cleared with TC bit				
24.00		Hard rock(Grey)	1.00	24.00		Hard rock boring done with D/bit				
25.00				25.00		from 24.00m to 25.00m (1.00m) Recovery-0.49m				

Bore Hole Terminated at 25.00 m Depth

Site-in-charge

PROJECT	: Proposed Korapuzha Bridge
SITE	: Koilandy,Calicut
BORE HOLE NO.	: P4(Under Water)
TYPE OF BORING	: Rotary Drilling

1/

DATE OF COMMENCE	: 06/10/2015
DATE OF COMPLETION	: 07/10/2015
GROUND WATER LEVEL	: HT-3.60m LT-3.10m

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00		Water depth	4.40							
0.00 (Bed)		Lateritic clay with sand (Y/Red)	2.60	1.50	4	7	9	16		
2.60		Lateritic clay with sand & gravels(Y/White)	4.70	3.00	8	15	19	34		
				4.50	6	11	17	28		
				6.00	8	8	12	20		
7.30		Clayey sand(R/Yellow)	1.40	7.50	3	5	7	12		
8.70		Clayey sand(Yellow)	5.70	9.00	4	6	3	9		
				10.50	3	3	7	10		
				12.00	3	4	3	7		
				13.50	4	5	6	11		
14.40		Silty sand(Y/White)	3.70	15.00	7	9	12	21		
				17.00	10	15	19	34		
18.10		Silty clayey sand (Y/Grey)	3.60	19.00	13	17	22	39		
				21.00	18	21	26	47		
21.70		Silty sand(Y/Grey)	2.00	23.00	>50	-	-	>50		
23.70		Soft rock(R/Grey)	2.45	23.70	SPT Rebounded with sample Soft rock cleared with TC bit					
26.15		Hard rock(Grey)	1.00	26.15	Hard rock boring done with D/bit					
27.15		Bore Hole Terminated at 27.15 m Depth		27.15	from 26.15m to 27.15m (1.00m) Recovery-0.53m					

Site-in-charge

PROJECT	: Proposed Korapuzha Bridge
SITE	: Koilandy,Calicut
BORE HOLE NO.	: P5(Under Water)
TYPE OF BORING	: Rotary Drilling

1/

DATE OF COMMENCE	: 10/10/2015
DATE OF COMPLETION	: 11/10/2015
GROUND WATER LEVEL	: HT-4.20m LT-3.70m

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)
0.00			
0.00 (Bed)		Water depth	4.20
		Lateritic clay with sand (R/white)	3.60
3.60			
		Lateritic clay with sand & gravels(Red)	1.90
5.50			
		Lateritic Clayey sand (W/Yellow)	4.70
10.20			
		Clayey sand(W/grey)	1.50
11.70			
		Silty clayey sand with organic matter(D/grey)	1.30
13.00			
		Clayey sand with silt (W/grey)	2.80
15.80			
		Silty clayey sand (Yellow)	3.60
19.40			
		Silty weathered (Y/grey)	1.00
20.40			
		Soft rock(Y/Grey)	1.40
21.80			
		Hard rock(Grey)	1.00
22.80			

Bore Hole Terminated at 22.80 m Depth

Standard Penetration Test Data					Graph of 'N' Value	Remarks
Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
1.50	4	6	6	12		
3.00	7	9	10	19		
4.50	8	14	19	33		
6.00	4	5	6	11		
7.50	3	4	5	9		
9.00	5	7	6	13		
10.50	4	5	5	10		
12.00	3	3	5	8		
13.50	3	4	6	10		
15.00	8	13	17	30		
17.00	19	31	19	>50		(Bal-9cm)
19.00	22	19	31	>50		(Bal-5cm)
20.40	SPT Rebounded with sample					
	Soft rock cleared with TC bit					
21.80	Hard rock boring done with D/bit from 21.80m to 22.80m (1.00m)					
22.80	Recovery-0.43m					

Site-In-charge

PROJECT	: Proposed Korapuzha Bridge	1/	DATE OF COMMENCE : 11/10/2015
SITE	: Koilandy,Calicut		DATE OF COMPLETION : 12/10/2015
BORE HOLE NO.	: P6(Under Water)		GROUND WATER LEVEL : HT-3.80m
TYPE OF BORING	: Rotary Drilling		LT-3.30m

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00										
0.00 (Bed)		Water depth	3.80							
2.70		Lateritic clay with sand (R/white)	2.70	1.50	1	1	1	2		
		Stiff clay with sand (W/yellow)	5.60	3.00	7	11	16	27		
				4.50	6	8	12	20		
				6.00	8	10	13	23		
8.30				7.50	5	7	8	15		
		Clayey sand(Y/white)	3.30	9.00	2	3	7	10		
11.60				10.50	1	3	5	8		
		Silty clayey sand(Grey)	1.70	12.00	8	15	21	36		
13.30		Silty clayey sand (W/Grey)	1.30	13.50	6	10	13	23		
14.60		Silty clayey sand with gravel(Y/grey)	2.40	15.00	9	13	16	29		
17.00		Silty weathered (Y/grey)	1.70	17.00	>50	-	-	>50		(Bal-32cm)
18.70		Soft rock(W/Grey)	0.80	18.70	>50	SPT Rebounded with sample				
19.50		Hard rock(Grey)	1.00	19.50		Soft rock cleared with TC bit				
20.50				20.50		Hard rock boring done with D/bit from 19.500m to 20.50m (1.00m) Recovery-0.50m				

Bore Hole Terminated at 20.50 m Depth

Site-in-charge

PROJECT	: Proposed Korapuzha Bridge
SITE	: Koilandy,Calicut
BORE HOLE NO.	: P7
TYPE OF BORING	: Rotary Drilling

1/

DATE OF COMMENCE	: 13/10/2015
DATE OF COMPLETION	: 14/10/2015
GROUND WATER LEVEL	: Approx 0.60 m below G/L

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00										
1.10		Ordinary soil(Brown)	1.10							
2.50		Soft clay with sand (D/Grey)	1.40	1.50	1	0	0	0		
		Silty clayey sand with shell dust(Grey)	2.70	3.00	4	6	3	9		
				4.50	9	13	21	34		
5.20				6.00	8	16	27	43		
		Lateritic clay with sand & gravels(G/Yellow)	5.90	7.50	11	9	18	27		
				9.00	9	16	22	38		
11.10				10.50	7	9	14	23		
		Clayey sand(R/White)	5.70	12.00	3	5	3	8		
				13.50	4	4	6	10		
				15.00	5	7	6	13		
16.80										
		Silty weathered rock (Y/Grey)	2.30	17.00	>50	-	-	>50		(Bal-40cm)
				19.00	>50	-	-	>50		(Bal-35cm)
19.10				19.10	SPT Rebounded W/o sample					
19.50		Soft rock(W/Grey)	0.40	19.50	Soft rock cleared with TC bit					
		Hard rock(Grey)	1.00	20.50	Hard rock boring done with D/bit from 19.50m to 20.50m (1.00m) Recovery-0.48m					
20.50										
		Bore Hole Terminated at 20.50 m Depth								

Site in-charge

PROJECT	: Proposed Korapuzha Bridge	1/	DATE OF COMMENCE : 15/10/2015
SITE	: Koilandy,Calicut		DATE OF COMPLETION : 15/10/2015
BORE HOLE NO.	: A2		GROUND WATER LEVEL : Approx 1.80 m below G/L
TYPE OF BORING	: Rotary Drilling		

BORE LOG CHART & DATA SHEET

Depth in Meter	Soil Profile	Visual Description of Soil	Thickness of Layers (M)	Standard Penetration Test Data					Graph of 'N' Value	Remarks
				Depth (m)	15	30	45	'N' Value	10 20 30 40 50 >50	
0.00										
1.30		Ordinary soil(Brown)	1.30							
2.90		Soft clay with sand & organic matter(D/Grey)	1.40	1.50	1	0	0	0		
4.10		Clayey sand with shell dust(D/Grey)	1.40	3.00	1	0	2	2		
6.00		Silty sand(W/Grey)	1.90	4.50	2	2	3	5		
8.10		Lateritic clayey sand with gravel & shell dust (R/Grey)	2.10	6.00	4	2	8	10		
10.50		Lateritic clay with sand & gravels(R/White)	2.40	7.50	7	10	14	24		
15.80		Clayey sand(Y/Grey)	5.30	9.00	11	16	21	37		
18.00		Silty clayey sand (Yellow)	4.20	10.50	6	7	8	15		
20.00		Silty sand with weathered(W/Grey)	2.00	12.00	4	6	7	13		
20.30		Soft rock(W/Grey)	0.30	13.50	2	2	5	7		
21.30		Hard rock(Grey)	1.00	15.00	3	4	7	11		
		Bore Hole Terminated at 21.30 m Depth		17.00	7	11	14	25		
				18.00	>50	-	-	>50		(Bal-41cm)
				20.00	SPT Rebounded W/o sample					
				20.30	Soft rock cleared with TC bit					
				21.30	Hard rock boring done with D/bit from 20.30m to 21.30m (1.00m) Recovery-0.46m					

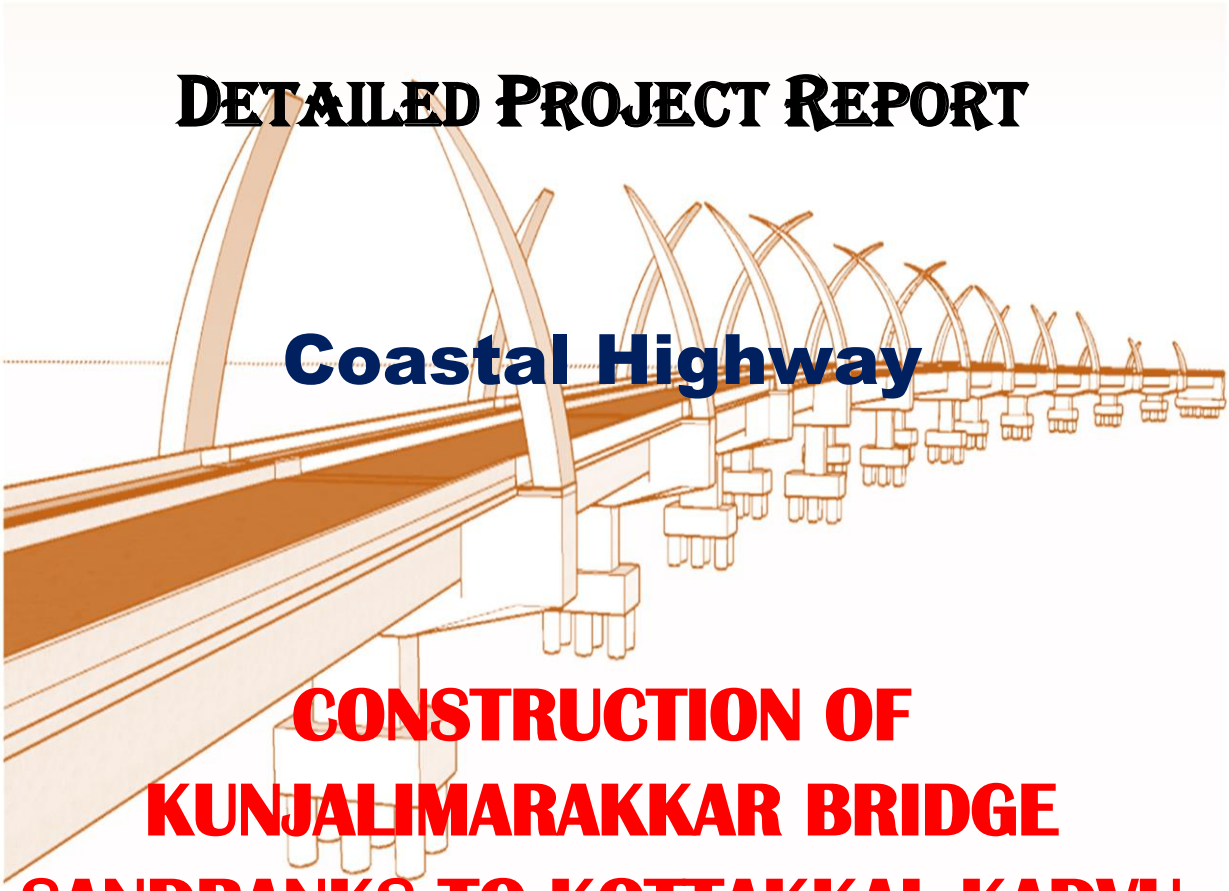
Site-in-charge

GOVERNMENT OF KERALA

Kerala Public Works Department

National Highways

DETAILED PROJECT REPORT



Coastal Highway

CONSTRUCTION OF KUNJALIMARAKKAR BRIDGE SANDBANKS TO KOTTAKKAL KADVU IN KOZHIKODE DISTRICT

Financial Assistance from

KERALA INFRASTRUCTURE INVESTMENT FUND BOARD

Implemented through

KERALA ROAD FUND BOARD
We build track that lead to torque

GOVERNMENT OF KERALA

Kerala Public Works Department

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1 SALIENT FEATURES

1	Title of the project	Construction of Coastal highway in Kozhikode Distrcit- Kunjalimarakkar Bridge (Kottakkal) from Kottakkal to Sandbanks across Kuttiyadi River
2	Department	Public works Department
3	Details of project location	
	i. District	Kozhikode
	ii.Taluk	Kozhikode
	iii. Corporation/Municipality/Panchayath	Vadakara Municipality and Payyoli municipality.
	iv. Assembly Constituency	Vadakara Koyilandy
4	Implementing agency/SPV	KIIFB
5	DPR prepared by	PWD National Highway Division, Kozhikode
6	Project outlay	Construction of bridge over Kuttiyadi River at Kottakkalkadavu-Sandbanks connecting Vadakara and Koyilandy taluk in Kozhikode District of approaches with gabion retaining wall. Drainage works- RCC side drains with cover slab. Shifting utilities- Electricity, Telephone, Water Supply Utility duct with 150 mm PVC pipe
7	Budget provision	Nil
8	Budget speech reference	budget speech for financial year 2017-18
9	Administrative sanction	G.O.(Rt)No.942/2017/PWD Dtd10/07/2017
10	Nature of the project (New bridge/ROB/reconstrucotion of existing bridge Strengthening of existing bridge/widening and Strenthening of existing bridge)	Construction of Kunjalimarakkar Bridge at Kottakkalkadavu-Sandbanks.

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11	Present status of existing bridges/roads	Presently No Bridge at the location
12	Need of the project	The Proposed bridge Location is a part of Coastal highway and it will connect Koyilandy and Vadakara taluks.
13	Type of bridge	RCC & PSC Integrated Bridge
	Total span length of bridge	537.25 m
	Overall and carriage way widths	15.60
	Provision of footpath	Yes on both sides
	IRC loading class	70R
	Other details of proposed bridge	Power Generating Bridge
14. 15	Length of approach roads	160.00 m on Kottakkal side and 90.00 m on Sandbanks side
	i. Other details of proposed bridge	
	ii. Details of investigations/surveys conducted	
	iii. Topographical	Yes
	iv. Hydraulic	Yes
	v. Geotechnical	Yes
	vi. Traffic	Yes
	vii. Others	
16	Whether Land Acquisition involved? If yes, furnish details	Yes (0.991 Ha) details Separately attached
17	Total estimated cost and item wise cost break up and details of Schedule of Rates	59 Crores SOR 2016
	Whether detailed estimate attached?	Yes
18	Details of revenue streams	KIIFB
19	Details of Cost Benefit Analysis (CBA value)	Attached
20	Details of project risks	Land acquisition Timely shifting of utilities Public involvement Availability of construction materials Mandatory approval and clearance from authorities
21	Details of project management organization strategy	Work to be managed by Engineering wing of PWD
22	Details of contract management strategy	Work to be executed by competent and approved

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		contracting firms through open competitive tender
23	Details of Project Implementation Schedule (PIS) & Work Breakdown Schedule (WBS) - Proposed duration to complete the project	Expecting the work to start during the financial year 2020-21 and complete by 2022-23 Duration of project- 24 months
24	Details of statutory clearances	Will be obtained from concerned departments before execution of work
25	Quality control infrastructure and mechanism	Contractor has to set up Quality Control lab and responsible for 1st tier QC 2nd and 3rd tier QC to be done/monitored by QC wing of PWD
26	Operations & Maintenance (O&M) arrangements of the project after completion	Defect liability period is 36 months after completion of project
27	Details of attached drawings	General Alignment Drawing Design drawings
28	Other attachments	Estimate Data LA Proposal

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2 EXECUTIVE SUMMARY

2.1 GENERAL

Government of Kerala has accorded administrative sanction for the construction of coastal highway vide GO (Rt)No.942/2017/PWD dt.10.07.2017. Kunjali marakkar Bridge at Kottakkalkadavu - Sandbanks Bridge along the coastal belt of Koyilandy and Vadakara in Kozhikode district comes in the alignment of above proposal.

Kozhikode formerly known as Calicut is a coastal and metropolitan city in the south Indian state of Kerala. Kozhikode is the third-most-populous town and the largest urban area in the state and 192nd largest urban area in the world. The city lies about 374 kilometres north of Thiruvananthapuram the state capital.

Vadakara is a coastal town in Kozhikode district and spread over an area of 23.33 km^2. Vadakara is situated 50 Km to the north of Kozhikode city. Vadakara has great historical importance. Historically Vadakara has been known as Kadathanadu. There are many tourist places such as Sargalaya, Sandbanks, Kunhali Marakkar Museum etc.

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorised to implement the proposed coastal highway project in Kozhikode district.

Kerala has a network of 11 National Highways, 72 state highways, many district roads and is having a long stretch of coastal line. Kerala has narrower national highways compared to other parts of India; hence the present road network is not in a position to accommodate the increasing traffic. So the government has been planning to revive the coastal highway project that runs parallel to the National Highway 66 to reduce the traffic conjunctions. The alignment of the proposed Coastal Highway which will

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traverse through nine districts from Thiruvananthapuram in the south to Kasargod in the north of Kerala state. The project is conceived not just to meet the transportation need of the state, but also to develop the coastal economy and living standards of the community living there.

The Kerala coast is 590 km long, laying in the direction of North-Northwest to South-Southeast, with many special features like sea cliff formed by the action of waves on the coast. Distributed on the coast, there are long patches of sandy beaches. The coast acts as major resource for coastal tourism development in the state. Nine out of fourteen districts of Kerala have coastline. Construction of coastal highway in Kerala is taken as a Government Policy. The coastal highways since it passes through the coastal area will provide better connectivity between fishing harbours and fish landing centres which will be giving a major savings in fuel costs and will promote tourism. It is seen that the traffic is increasing at a rate of 7% per year and the major corridors of the district are presently suffering from traffic congestion through most hours of the day.

As per the feasibility study report submitted by NATPAC the proposed length of the coastal highway is 657Km in which a length of 80.12 Km falls in Kozhikode District. The coastal highway project has been divided into three phases. And the construction of Kunjali marakkar Bridge at Kottakkalkadavu - Sandbanks Bridge is comes under first phase of project. It is having a total length of 537m which is planned over Kuttiyadi river at Kottakkalkadavu. The proposed coastal highway is almost parallel to the National Highway 66. It is expected to divert a major share of the traffic from the NH on completion and is also aimed at improving the road connectivity of the coastal belt of the State for the tourism development, transshipment of goods and sea foods. Besides reducing the congestion in the NH corridors and in the cities, the Coastal Highway is expected to boost the tourism sector and help better integration with various other modes of transport, especially water transport. Since the proposed bridge is to be constructed in the coastal line it is necessary to obtain permission from Coastal Regulation Zone. The land

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acquisition for the construction of bridge is minimum and there is no direct effect on residential, commercial buildings and other establishments.

2.2 PROJECT DESCRIPTION

The newly proposed bridge from Kottakkalkadavu to Sandbanks is an integrated structure. It has two lanes having total length of 537.25 m and approach road of 90.00 m on Kottakkal side and 160.00m on Sandbanks side. The bridge is composed of 18 spans in which 5 numbers are of 12.5m, 11 are of 35m and the two spans at the centre portion are of 45.00 m length. The recommended width of the proposed bridge is 15.60m. In addition to the above a view point has been made at center pier portion.

The main components of the proposed bridge are 8.5m Carriageway, 1.5m Footpath on both sides, 2.20 m cycle track, Shoulders, Kerbs, RCC precast panels, Drainage, Utility duct, Protection works, Safety barriers and pedestrian guard rails.

The length of two spans at the center is increased to facilitate the navigation and sea plane tourism in future and the footpath on both sides of the center support is designed in semicircular shape for accommodating the people to get a panoramic view of the estuary and natural beauty. The bridge is to be constructed across a national water way hence a clearance of 6m is provided. On the aesthetic point of view and to exhibit the cultural heritage of Kadathanadu/Vadakara RCC precast panels of sword shape are provided on the parapets of proposed bridge.

The RCC bored cast-in-situ pile of diameter 1.20m is proposed as foundation. Fender piles are proposed at locations P6, P7 and P8 to protect the structure from the impact or abrasion that may be caused from boats, ships or barges. Also, road accidents can be considerably reduced once the vehicle starts plying through the new road. The land acquisition for the construction of bridge is minimum and there is no direct effect on residential, commercial buildings and other establishments.

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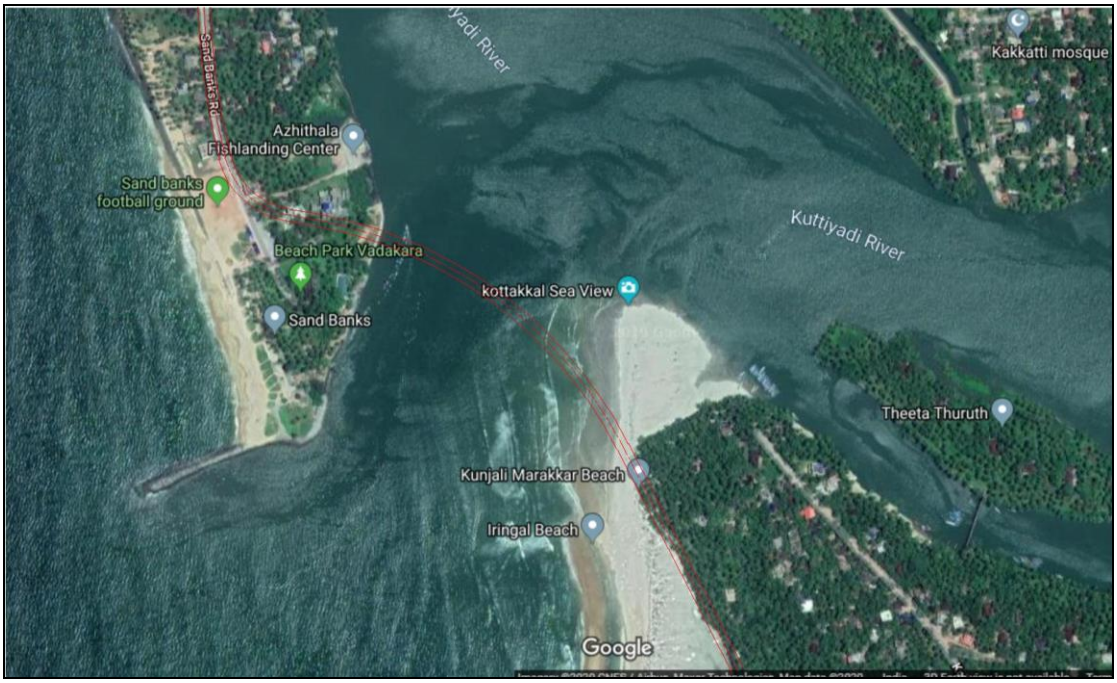

Figure 2.1 Location of the proposed bridge

2.3 APPROACH AND METHODOLOGY

Our Approach towards the project is in accordance with the project objectives and MoRT&H guide lines. All activities related to field studies, design and documentation are done as per the latest revisions and amendments of relevant guidelines of MoRTH, referring to the publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS).

2.4 NEED FOR THE PROJECT

Kerala's coastal belt is relatively flat, teeming with paddy fields, groves of coconut trees and heavily crisscrossed by a network of interconnected canals and rivers. The Kerala coastal area is the centre for many economic activities like agriculture, aquaculture, fishing, fish processing industry, chemical industry, mining and tourism. Beaches and backwaters are the major attraction of the tourists in this area.

The motor transport sector is an important and integral part of the State economy. The growth of vehicle population in Kerala is eight per cent over the previous year. The growth of motor vehicles creates traffic congestion and pollution. The proposed bridge is an alternative route to

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Vadakara from Kozhikode. There will be savings in time and fuel, if vehicles can ply over the New Bridge without stopping and waiting. More over the pedestrians get a new and safe way to cross the river, which is presently not available.

The coastal highway project was designed not only as a mere road project but as means to transform the coastal economy of the state. It will serve as a second transportation route for container and goods movement from major and other minor ports of the state. And it will also provide a boost to the tourism sector relying on its beautiful beaches and coasts.

The proposed bridge from Kottakkalkadavu to Sandbanks passes along the coastal belt of Vadakara in Kozhikode district. Vadakara Sandbanks is an attractive beach structure that supplements the seaside beauty of Vadakara. This beach is where the Kuttiyadi river meets the Arabian sea. Sandbanks is famous tourist place from the British era. Now it is famous fish landing center and is being promoted by the proposed project.

Kunhali marakkar memorial museum is located at kottakkal which is very near to the proposed bridge. Sargalaya arts and craft village is an exclusive place for traditional and fashionable products made by the traditional artisans.it is well known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. All these places are very near to the proposed bridge.

The proposed bridge is planned almost parallel to the National Highway 66 to divert a major share of the traffic from the NH. The Moorad bridge in NH66 is having 5.5m carriage way without footpath creates inconvenience to pedestrians and traffic congestions. The proposed bridge is near to Moorad bridge and thus, it will help to reduce the traffic congestion. So, there will be savings in time and fuel, if vehicles can move without stopping and waiting.

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2.5 SURVEY AND INVESTIGATION FOR DESIGN

All activities related to field studies design and documentation are done by National Highway division Kozhikode as per the latest revisions and amendments of relevant guidelines of MoRTH, referring the publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). International standard practices have been followed for aspects not covered under IRC / BIS All notations, abbreviations and symbols used in the reports, documents and drawings are as per IRC: 71-1977 the latest edition with amendments.

2.6 QUALITY ASSURANCE PLAN

The provisions of the IRC SP-19-2001, "Manual for survey, investigation and preparation of road projects" have been adhered for the rectification of the Design Engineering and report preparation of this project. For the quality control during execution of the project latest version of "PWD Quality Control Manual" and relevant IRC codes and BIS standards will be followed.

2.7 REVIEW OF DATA AND DOCUMENTS

All the available data and information relevant for the study, like climate, road inventory, geotechnical data etc. have been collected and analysed.

2.8 TRAFFIC SURVEYS

Traffic data is collected as per IRC: SP 19-2001. The traffic survey location for conducting the traffic volume count was identified at Puthiyappa as the location resemblance to the proposed location and Puthiyappa is also a part of coastal highway. A volume counts for 3 days within 10th April 2018 to 12th April 2018 was taken for 24hrs duration each. The method adopted was manual Classified Traffic Volume Count. Traffic surveys have been carried out on the project corridor in order to identify present and likely future scenarios so as to device suitable remedial measures and to evolve appropriate design

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method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement over the bridge.

2.9 RECONNAISSANCE AND ALIGNMENT

An in-depth study of the available land width (ROW), topographic maps, satellite imageries etc. have been done for the project area. Other available relevant information was collected for the existing alignment. Having got the information needed, efforts were made for minimizing the land acquisition process. Hence there is no direct effect on residential, commercial buildings and other establishments. The detailed ground reconnaissance was taken up immediately after the study of maps and other data collected.

Kunhali marakkar memorial museum is located at kottakkal which is very near to the proposed bridge. Sargalaya arts and craft village is an exclusive place for traditional and fashionable products made by the traditional artisans.it is well known tourist place in Kozhikode district. Lokanarkavu temple is an ancient Hindu temple situated in Vadakara and has great historical importance. All these places are very near to the proposed bridge.

Moorad Bridge in NH 66 is narrow and always makes traffic congestions. Sandbanks is famous tourist place from the British era. Now it is famous fish landing center. The Kuttiyadi river is belongs to the national water way. Currently tourism is being promoted here by speed boat and house boat facilities. Sand banks beach is where locals and tourists throng to view the confluence of the Kuttiyadi river and Arabian sea.

2.10 TOPOGRAPHIC SURVEYS

The basic objective of the topographic survey was to capture the essential ground features along the alignment identified during the reconnaissance survey, for finalising the alignment. The cost of improvements, rehabilitation and upgrading also can be worked out based on details from topographic survey.

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The work of topographic survey has been entrusted to M/s ULCCS Ltd Madapally College Vadakara. Sufficient area near the Bridge was surveyed for a length of 645 m (270+375) along road and 495.00m along the river using total station, a precision instrument required for finalizing alignment along the proposed route. Longitudinal sections and cross sections have been prepared on the basis of the detailed topographic surveys conducted.

2.11 GEOTECHNICAL INVESTIGATIONS AND SUB SOIL EXPLORATIONS

Geo-technical investigations and sub-surface explorations were done in August 2019 for the proposed Bridge and all relevant laboratory and field tests on soil and rock samples obtained were conducted. Twenty-one boreholes have been drilled using rotary power drilling equipment, two on either side of the River to a maximum depth of 30.3meters. Standard Penetration tests were conducted to ascertain the N value and the disturbed samples were collected, for further tests. Based on the investigations and studies, it was recommended to provide RCC bored cast in situ piles as foundation for the proposed New Bridge. Piles shall be taken up to the level of Hard Rock and rock penetration for 50cm.

2.12 DESIGN STANDARDS OF ROAD AND PAVEMENTS

Design Standards and material specifications have been evolved, primarily from IRC publications and MoRT&H specifications. The Design Standards evolved for the project have covered all aspects of detailed design including the design of geometric elements, pavement design, design of Bridge and structures, traffic safety, drainage system, arboriculture and materials.

Structural Design of the proposed bridge has been done by the DRIQ wing of Kerala PWD. For pavement design CBR for the filled earth is assumed as 10%

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2.13 ESTIMATION OF QUANTITIES AND PROJECT COSTS

Detailed estimates for quantities (considering designs and conveyance of materials) and the project cost (civil packages wise), including the cost of environmental and social safeguards, have been taken based on MoRT&H's Standard Data Book, latest Kerala PWD schedule of rates and PWD Project Information and Cost Estimation (PRICE) software. The estimation of quantities is based on detailed design of various components of the projects. The estimation of quantities and costs are worked out separately for each civil work Package. The total project cost including Land Acquisition ccomes to Rs 59 crores

Table 2.1 Abstract of Total Project Cost

Sl No	Heading Description	Amount
1	Construction of bridge	421012944.81
2	Road Work	57308478.29
3	Traffic Safety	714237.87
4	Utility shifting	1000000
5	Land Acquisition Charges	18400000.00
6	LA procedural Charges @5%	920000.00
7	CRZ and other Clarence charges@5%	24001783.00
	GST @ 12%	62802893.28
LS Round Off		3839662.75
Rounded Total		**590000000**
Rupees Fifty Nine Crore Only		

2.14 COST BENEFIT ANALYSIS

Though the construction of a bridge brings about a variety of benefits enjoyed practically by all sectors of the society, the prevailing condition of resource scarcity necessitates an economic evaluation of projects so that only the projects which are worth be taken up for implementation. The Indian Roads Congress special Publication No.30, Manual on Economic Evaluation of Highway Projects, contains the detailed procedure for economic evaluation and that is referred as guidance. The Economic Cost of New Bridge works out

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to Rs.4186.86 lakhs against the Financial Cost of Rs.5233.57 lakhs. The bridge project has various benefits and costs, which can be expressed in monetary terms, and which are difficult to be expressed in monitory terms. The period of analysis is taken as 20 years. All social benefits and costs possible to be expressed in monitory terms in accordance to IRC: SP: 30-2009 are tabulated and analyzed. From the analysis, the bridge yields a Cost Benefit Ratio of 1.229 and Economic Rate of Return of 32.59%.

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3 CHAPTERS

3.1 INTRODUCTION

3.1.1.1 General

Kerala is fairly well networked in the matter of transport. With a well-connected road network a rail the connecting all but two districts of the State, four international airports (at Thiruvananthapuram, Cochin ,Kozhikode and Kannur),National Waterway III consisting of the vast stretches of backwaters and canals, 17 seaports, international Transshipment Container Terminal at Vallarpadam, Cochin, Vizhinjam deep sea Transhipment Container etc., Kerala is poised to become the commercial and travel hub not only to the country but to the world all over. Kerala can be proud of having developed a good road network compared to other states in India. At present Transportation Infrastructure of Kerala consists of 3.72 Lakh km of road, 1257 km of railways, 1687 km. of inland waterways, 111 statute miles of airways and 18 ports. Even though it is comparatively better placed than most of the other states as regards to the road length, the quality and service level of many of these roads are poor.

During classical antiquity and the Middle Ages, Kozhikode was dubbed the "City of Spices" for its role as the major trading point of eastern spices. It was the capital of an independent kingdom ruled by the Samoothiris (Zamorins) in the Middle Ages and later of the erstwhile Malabar District under British rule. Arab merchants traded with the region as early as 7th century, and Portuguese explorer Vasco da Gama landed at Kozhikode on 20 May 1498, thus opening a trade route between Europe and Malabar. A Portuguese factory and fort was intact in Kozhikode for short period. the English landed in 1615 (constructing a trading post in 1665), followed by the French (1698) and the Dutch (1752). In 1765, Mysore captured Kozhikode as part of its occupation of the Malabar Coast. Kozhikode, once a famous cotton-weaving centre, gave its name to the Calico cloth.

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Vadakara is a coastal town in Kozhikode district and spread over an area of 23.33 km^2. Vadakara is situated 50 Km to the north of Kozhikode city. Vadakara has great historical importance. Historically Vadakara has been known as Kadathanadu. There are many tourist places such as Sargalaya, Sandbanks, Kunhali Marakkar Museum etc.

A good infrastructure facility is an essential pre-requisite for the growth and development of a region. Government of Kerala has designed to construct coastal highway along the coastal belt of Kerala. For the above work the fund will be allotted by KIIFB. For implementing the project KRFB is entrusted as SPV. National highway wing of Public Works Department will be executing the Project. At road junctions, considerable time is lost due to traffic congestions during signals. The traffic congestion resulting from the stop signal increases the loss towards fuel and precious time of lots of people.

Based on the Economic Review Report 2015, the total road length in Kerala increased from 3,31,372.261 Km in 2014-15 to 3,72,472.216 Km in 2015-16 Road density in the state is 8534 Km./100 sq.km. and the far ahead of the national average of 387 Km./100 sq.km. Road transport acts as the feeder service to rail, air and inland water transport. The vehicle density of the State is very high compared to many other States in India. The road freight services in the state are wholly owned and operated by the private sector. The transport system in Kerala is consumer oriented and passenger movements account for major portion of transportation. Goods transport in the State is mostly carried out through road transport. The tremendous increase in volume of road traffic in recent years caused increase in road accidents. The high vehicle population along with the under developed road network has resulted in high vehicle operating cost (VOC) and high level of environment pollution and road accidents.

Even though Kerala is graced with a good network of transportation the lack of a reliable and efficient road transport which is the feeder service to all other system, has adversely affected the growth prospects of the State. The inability to develop good quality transport infrastructure has stagnated

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both industrial and service sector and the GDP growth. Kerala State has got nearly 3% of the country's population, but it has recorded nearly 12% of country's road traffic accidents. The increasing trend of road accidents is a matter of great concern. The accident rate of Kerala is the highest in the country with 15 accidents per 1000 vehicles, twice that of all India average. Even bigger States the Uttar Pradesh, Madhya Pradesh, Gujarat, Rajasthan and Andhra Pradesh have reported far less number of accidents compared to Kerala. Having got an average, better than the national and still lagging behind in the quality of the roads is a very serious concern of the public.

3.1.1.2 Transport and Industrial

Generally, two transportation objectives are usually taken into consideration when firms make their choices of location namely: 1) low transportation cost and 2) satisfactory transportation service. Firms that consider transportation cost to be of major significance usually locate at places where the cost of supplying raw materials is minimized. Availability of an effective and efficient (satisfactory) transport system is also important to firms as it helps facilitate production by increasing accessibility and mobility.

When these two transportation objectives (low transportation cost and satisfactory transportation service) are available in regions, there is high attractiveness to investors because they are assured of lower distribution cost and improved access for both employees and customers. Thus, investing in transport yields growth in a number of firms and expansion of the already existing ones and firm growth implies more job opportunities.

Expansion of existing firms will lead to greater profitability and/or increased market share, and as a result, employment and income will increase as the firms grow. Furthermore, expansion of existing businesses together with the just-created ones will demand more raw material and components from their suppliers. Retail and wholesale businesses can expand as employees will spend more as a result of their additional income.

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3.1.1.3 Socio-Economic-Significance of Transports:

Transport system is catalyst of the Socio-economic development.

1. Transport system is catalyst of the Socio-economic development.
2. Promotes industrialization.
3. Provides access to rural area.
4. Provides the vital linkage between production and consumption.
5. Is the key factor to link dispersed areas.
6. Increase the economic efficiency of resources.
7. Provides mobility of labour and boost Tourism Industry.
8. Creates competitive environment.
9. Promotes social welfare.
10. Helps to stabilize prices.
11. Curbs monopoly of the trader.
12. Discovery of new market.
13. Provides large employment opportunities.
14. Adequate transport facilities in a country help to combat the natural calamities.
15. Is helpful in funding revenue to the Govt.

Traffic congestion, longer travel time and high level of air pollution are just some of the growing problems faced by the people today. The intensity of traffic in the State High ways, National Highways as well as in the Major District Road is very high; it not only delays the traffic but also invites fatal accidents.

3.1.1.4 Aim and Significance

The coastal highways since it passes through the coastal area will provide better connectivity between fishing harbors and fish landing centers which will be giving a major savings in fuel costs and will promote tourism. It is seen that the traffic is increasing at a rate of 7% per year and the major

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corridors of the district are presently suffering from traffic congestion through most hours of the day.

The proposed bridge is planned almost parallel to the National Highway 66 to divert a major share of the traffic from the NH. The Moorad bridge in NH66 is having 5.5m carriage way without footpath creates inconvenience to pedestrians and traffic congestions. The proposed bridge is near to Moorad bridge and thus, it will help to reduce the traffic congestion. So, there will be savings in time and fuel, if vehicles can move without stopping and waiting.

The proposed coastal highway from Kottakkal kadavu to Sand banks which passes along the coastal belt of Vadakara connecting Koyilandy and Vadakara taluks in Kozhikode district. It is an alternative route to Vadakara from Kozhikode. Construction of proposed bridge can help the passengers to travel without entering Vadakara town. This will surely help in saving time and fuel and reducing traffic congestion on the towns and in the national highway. Also, road accidents can be considerably reduced once the vehicle starts plying through the new road. The above factors necessitate the formation of the coastal highway as per MoRTH standards. At the proposed bridge location major district roads / village roads is already available on the both sides up to the approach area of beach.

3.1.2 PROJECT DEFINITION, CONCEPT AND SCOPE

An in-depth study of the available land width (ROW) using topographic maps, satellite imageries etc. have been done at the proposed bridge location over Kuttiyadi river. Other available relevant information is collected for the existing alignment. Having received the information needed efforts is made for minimizing land acquisition as far as possible. The detailed ground reconnaissance was taken up immediately after the study of maps and other data collected from various sources.

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3.1.3 PROJECT BACKGROUND

3.1.3.1 General

Government of Kerala has accorded administrative sanction for the construction of coastal highway vide GO (Rt)No.942/2017/PWD dt.10.07.2017. Kottakkalkadavu - Sandbanks Bridge along the coastal belt of Vadakara connecting Koyilandy and Vadakara in Kozhikode district comes in the alignment of above proposal.

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National Highway wing of the Public Works Department (PWD) is authorized to implement the proposed coastal highway project in Kozhikode district. On behalf of KRFB National Highway Bypass Sub Division has done detailed investigation and prepared Detailed Project Report for construction of Kottakkal kadavu- Sandbanks bridge for onward submission to KIIFB for approval.

3.1.3.2 Bridge construction Background Information

1. Span arrangements: Five spans of 12.5 meter RCC, eleven spans of 35 meter RCC and two center spans of 44.5meter RCC making a total length of 537meter and the approach road on both sides is having a length of 150m.
2. The bridge is constructed as integral structure for comfort of the users.
   a) From support A1 to A2 bridge is proposed as RCC integrated structure.
   b) The supports P5- P10, P10-P12, P12-A2 are designed as integrated structure with PSC Girders.
   c) PSC Girder Bridge is monolithically connected to Pier head/pile cap by concreting with diaphragm.

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3. The span arrangements proposed are as mentioned above, with seventeen intermediate piers and two end abutment walls integrated to the pile caps.
4. RCC bored cast-in-situ pile of 1.2m diameter is proposed as bridge foundation. The depth of rock strata are varying at all bore holes, so the minimum depth of pile foundation is 18.16m and maximum is 38.1 m. Piles are penetrated 50cm to the rock strata.
5. Fender piles are to be constructed at locations P10, P11 and P12 to protect the structure from the impact or abrasion that may be caused from boats, ships or barges.
6. On the aesthetic point of view and to exhibit the cultural heritage of Kadathanadu/Vadakara RCC precast panels of sword shape are provided on the parapets of proposed bridge.
7. The length of two spans at the centre is increased to facilitate the navigation and will also facilitate the requirement of sea plane tourism in future. At the center support (P11) the footpath on both sides is designed in semicircular shape for accommodating the people to get a panoramic view of the estuary and natural beauty.
8. The bridge is to be constructed across a national water way hence a clearance of 6m is provided

3.1.3.3 Materials for Construction

As per IRC 112-2011, code of practice for Concrete Road Bridges and as the location is susceptible to severe exposure condition, the pile and pile cap are to be constructed with Fe 500 steel and M40 grade concrete by using Portland Slag cement for better result against sulphate attack. It is expected to have water loss during the construction of Piles as the location is of sandy soil in nature and having lesser N value. Pier and pier cap are to be constructed with Fe 500 steel and M40 grade concrete by using Portland Slag cement. Super structure girders are of PSC and of M45 grade concrete.

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On the aesthetic point of view and to exhibit the cultural heritage of Kadathanadu/Vadakara RCC precast panels of sword shape are provided on the parapets of proposed bridge. The newly proposed bridge is of 537m long.

On both the sides gabion retaining walls are proposed for the construction of embankment. The soil on both the sides are of sandy nature and unequal settlement are expected at this region. In order to overcome the damages due to this gabion retaining walls are proposed.

Bituminous macadam and bituminous concrete provided as per IRC 35, codes for guidelines on design of flexible pavement. For the construction of duct, drain and footpath RCC grade M20 is proposed.

Samples of 20mm broken stone, M sand WMM and GSB has been collected from different quarries and put under testing. Most suited and relevant to corresponding codes has been identified. Test results have been kept as appendix VI.

As the locality is very near to sea and is of saline nature, the water for all construction activity and curing purpose has to be collected from Payyoli cheerp. Test results have been kept as appendix VI.

For ensuring the quality the of concrete, contractor can arrange a ready-mix plant in the vicinity of project area.

3.1.3.4 Additional works

- The carriage way parameters are designed based on field data and projected 20-year traffic.
- Required road furniture like mandatory/cautionary and informatory signage are proposed in the estimate. Road marking with retro reflective point at centre, edge line and reflective studs are proposed in the estimate based on Road Safety Audit Crash Barrier is proposed on the sides of the bridge.
- 2m wide cycle track is provided along the carriage way
- footpath having 1.5m width will be constructed on both sides of the road along with the kerb

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- RCC precast panels of sword shape are provided on the parapets of proposed bridge.
- The land acquisition for the construction of bridge is minimum and there is no direct effect on residential, commercial buildings and other establishments.

3.1.4 PROJECT DETAILS

Kottakkalkadavu - Sandbanks Bridge is constructed across Kuttiyadi River in coastal line of the Vadakara connecting Koyilandy and Vadakara taluks in Kozhikode District. The bridge can be a connecting link in the proposed Coastal highway. The tourism and fisheries sectors in the district are likely to get a boost with the construction of Kunjali Marakkar Bridge at Kottakkalkadavu - Sandbanks.

The coastal highway which is planned almost parallel to the national highway 66 is also expected to divert a major share of the traffic from the NH on completion. The land acquisition for the construction of bridge is minimum and there is no direct effect on residential, commercial buildings and other establishments.

The newly proposed bridge from Kottakkalkadavu to Sandbanks is an integrated structure with 537.35 m length and approach road of 160m on Kottakkal side and 90.00 m on sandbanks side. One side service road is provided on both sides for lengths of 160.00m and 90.00 m. It has two lanes and having 18 spans. The recommended width of the proposed bridge is 15.6 m at all spans.

The length of two spans at the centre is increased to facilitate the navigation and sea plane tourism in future and the footpath on both sides of the center support is designed in semicircular shape for accommodating the people to get a panoramic view of the estuary and natural beauty. The bridge is to be constructed across a national water way hence a clearance of 6m is provided. On the aesthetic point of view and to exhibit the cultural

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heritage of Kadathanadu/Vadakara RCC precast panels of sword shape are provided on the parapets of proposed bridge. The pile foundation of diameter 1.2m is proposed. Fender piles are proposed at locations P10, P11 and P12 to protect the structure from the impact or abrasion that may be caused from boats, ships or barges. Also, road accidents can be considerably reduced once the vehicle starts plying through the new road.

This project helps a major growth to the tourism industry in the area with the development of coastal highway. Vadakara sandbanks, kunhali marakkar museum, Sargalaya arts and crafts village and boating facilities at Kottakkal are major destinations along this coastal line.

3.1.5 OBJECTIVE AND SCOPE OF THE WORK

3.1.5.1 Objective

3.1.5.1.1.1 The main objective of the work is to establish the technical and environmental viability of the project with a view to construct river bridge across Kuttiyadi river in the alignment of coastal highway at Kottakklkadavu- Sandbanks and to prepare the detailed project reports with designs estimates and drawings. The major objectives covered under the proposal are

- Engineering and economic studies of the proposed bridge
- Engineering design of proposed Bridge
- Estimate the cost of the project
- Cost benefit analysis
- Detailed Project Report for construction of Kottakkalkadavu - Sandbanks Bridge
- Land acquisition proposal

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3.1.5.2 Scope of the Work

- To carry out reconnaissance survey to assess all the engineering characteristics of the existing project including but not limited to carriageway details, geometrics, terrain, soil and drainage condition and cross drainage details.
- To assess and forecast traffic using data from traffic studies and Reports
- To carry out surveys to identify sources of materials having adequate quantity and quality required for the works
- To carry out preliminary design for the project.
- To prepare cost estimates with prevailing schedule of rates
- To identify utility services and their likely cost of shifting based on the rates of the respective utility agencies.
- To prepare GAD for river bridge and other structures
- To prepare alignment plan and profile.
- To carry out all engineering surveys in detail viz. topographical, geo-technical, traffic etc. along the accepted alignment and requisite tests of the materials at identified sources to ensure quality & quantity of materials.
- To carryout economic evaluation of the project improvements based on road user cost analysis.
- To acquire the land for the construction of bridge and its components from private land owners.

3.2 STATUS FEASILBILTY STUDIES

Feasibility study has been conducted at three locations by the department. The first proposal was from Kottakkalkadavu to Sandbanks side

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over the fish landing center. But the radius of curvature at the intersection of sandbank road was not sufficient and may affect the functioning of fish landing center.

The second proposal was from Sandbanks to Kottakkalkadavu in the direction of Kolavipalam which is parallel to the sea and the shortest way. The rare species of olive ridely turtles are found in Kolavipalam beach side. This proposal was also rejected because it will affect the turtle hatchery and ecology of the surroundings.

The third and finalized proposal is from Kottakkal kadavu to Sandbanks where there exist MDR/Village road on both the sides up to the proposed approach road area and which is in line with coastal highway proposal of NATPAC. In this alignment land acquisition is minimum and there is no direct effect on residential, commercial and other establishments.

3.3 REQUIREMENT/ DEMAND ANALYSIS

Kozhikode or Calicut is a city in the state of Kerala in southern India on the Malabar Coast. It is the third most populous city in the Kerala state. The proposed bridge from Kottakkal kadavu to Sandbanks lies in coastal belt of Vadakara in Kozhikode district. It also connects the two taluks namely Vadakara and Koyilandy.

Historically Vadakara has been known as Kadathanadu. This place has a great cultural heritage. Kunhali marakkar memorial museum is located at kottakkal which is very near to the proposed bridge. Sargalaya arts and craft village is an exclusive place for traditional and fashionable products made by the traditional artisans. It is well known tourist place in Kozhikode district. The historical Lokanarkavu temple is also famous through the vadakkan pattukal is situated in Vadakara. All these places are near to the proposed bridge.

The Moorad bridge in NH66 is having 5.5m carriage way without footpath creates inconvenience to pedestrians and traffic congestions. The proposed bridge is near to Moorad bridge and thus, it will help to reduce the

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traffic congestion. So, there will be savings in time and fuel, if vehicles can move without stopping and waiting.

Vadakara is also an important trade center other than Kozhikode. The traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this bridge.

People from the nearby Panchayath depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion. Area near by the bridge is a developing fish landing center and tourism sector. Beneficiaries of this project includes all the above including the daily commuters. The project will have much positive impact for the beneficiaries in terms of saving in travel time, safety, tourism developments and finally it will lead to overall development of the area.

Overhead and underground power cables, water line, telecommunication line, etc. which come in the way of the bridge alignment have to be relocated or re-routed before the commencement of the project. Prior information to be given to concerned departments and the people of the affected area before the start of work. The information to public regarding the work will be given though paper notification.

3.4 ENGINEERING SURVEYS AND INVESTIGATIONS

3.4.1 TOPOGRAPHIC SURVEY

3.4.1.1 GENERAL

The basic objective of the topographic survey is to capture the essential ground features along the alignment in order to consider improvements and for working out improvements, rehabilitation and upgrading costs. The detailed topographic survey was taken up after the completion of reconnaissance surveys.

The work of topographic survey has been entrusted to M/s ULCCS Ltd Madapally Colege Vadakara. Sufficient area near the Bridge was surveyed

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along the road and river using total station, a precision instrument required for finalizing alignment along the proposed route. Longitudinal sections and cross sections have been prepared on the basis of the detailed topographic surveys conducted.

3.4.1.2 Standards and Codes of Practises

All activities related to field studies, design and documentation are done as per the latest revisions and amendments of relevant guidelines of MoRTH and publications of Indian Roads Congress (IRC) and Bureau of Indian Standards (BIS). For aspects not covered by IRC and BIS, international standard practices are followed. All notations, abbreviations and symbols used in the reports, documents and drawings shall be as per IRC: SP 19-2001

3.4.1.3 Quality Assurance Plan

The provisions of the IRC: SP 19-2001 (Manual for survey, investigation and preparation of Road over Bridge Projects in the Design, Engineering and Report preparation of the Project) have been adhered to.

3.4.1.4 Survey

The topographic survey is one of the most important and crucial field tasks under the project. The detailed field survey is carried out using high precision instruments i.e. Total stations. The data from the topographic surveys is made available in (x, y, z) format for use in a sophisticated digital terrain model (DTM). The survey plan is attached. The detailed field surveys essentially included the following activities.

- Topographic Survey along the alignment options identified in the reconnaissance survey for sufficient width of 50m (at least two times the width of proposed Right of Way as required for finalizing alignment) by running a continuous open traverse along the proposed alignment, and fixation of all cardinal points such as horizontal intersection points (HIP's), centre points and transit points etc. and properly referencing the same with a pair

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of reference pillars fixed on either side of the centreline at safe places within the Right of Way.

- Collection of details for all features such as structures (bridges, culverts etc.) utilities, existing roads, demarcation stones, electric and telephone installations, buildings, fencing and trees (with girth greater than 0.3 metre) etc. falling within the extent of survey.

3.4.1.5 Longitudinal and Cross Sections

- The topographic surveys for longitudinal and cross-sections cover the following:
- Longitudinal section levels along final centre line at suitable locations of curve points, small streams, and intersections and at the locations of change in elevation.
- Cross sections at required interval in full extent of survey covering sufficient number of spot levels on the proposed bridge location and adjacent ground for profile correction course and earth work calculations. Cross sections shall be taken at closer interval at curves.
- Longitudinal section for cross roads for length adequate for design and quantity estimation purposes.
- Longitudinal and cross sections for river

Recommendations contained in IRC Special Publication No. 13 (Guidelines for the Design of Small Bridges and Culverts) and IRC:5-1998 ("Standard Specifications & Code of Practice for Road Bridges, Section 1 - General Features of Design"). Detailed topographic survey was conducted at the proposed bridge location.

3.4.2 SOIL INVESTIGATION

Geo-technical investigations and sub-surface explorations were done in September 2019 for the proposed Bridge and all relevant laboratory and field

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tests on soil and rock samples obtained were conducted. Twenty-one boreholes have been drilled using rotary power drilling equipment, 12 boreholes have been taken in river portion, five on A1 side and four on A2 side. The hard strata was found at a maximum depth of 30.3 meters below the ground level. Standard Penetration tests were conducted to ascertain the N value and the disturbed samples were collected, for further tests. Based on the investigations and studies, it was recommended to provide RCC bored cast in situ piles as foundation for the proposed new bridge. Piles shall be taken up to the level of hard rock and to penetrate 50 cm in to the hard rock. Details attached as Annexure III.

3.4.3 TRAFFIC SURVEYS AND ANALYSIS

3.4.3.1 Introduction

Traffic studies are the initial step of any Road project. These studies play important role in fixing components such as carriage way width, lane width etc. Since the project is through a new alignment the traffic census taken at Puthiyappa which is a point in the existing coastal highway stretch in Kozhikode District is used for analysis and design purpose. Survey is conducted for three days and 24 hours in April 2018. The procedure for conducting survey and the data collection are briefly dealt in following sections

3.4.3.2 Project Background

The proposed Kottakkalkadavu - Sandbanks bridge is on the coastal belt of Vadakara and Koyilandy taluk in Kozhikode district which can be a connecting link in the proposed Coastal highway.

Vadakara is also an important trade center other than Kozhikode. The traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this bridge.

People from the nearby Panchayath depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the

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railway station without any traffic congestion. Area near by the bridge is a developing fish landing center and tourism sector. Beneficiaries of this project includes all the above including the daily commuters.

The tourism and fisheries sectors in the district are likely to get a boost with the construction of Kunjalimarakkar Bridge at Kottakkalkadavu - Sandbanks along coastal highway in Vadakara and Koyilandy taluk in Kozhikode district.

The coastal highway which is planned almost parallel to the national highway 66 is also expected to divert a major share of the traffic from the NH on completion. The land acquisition for the construction of bridge is minimum and there is no direct effect on residential, commercial buildings and other establishments.

The length of two spans at the center is increased to facilitate the navigation and sea plane tourism in future and the footpath on both sides of the center support is designed in semicircular shape for accommodating the people to get a panoramic view of the estuary and natural beauty. The bridge is to be constructed across a national water way hence the clearance of 6m is provided. On the aesthetic point of view and to exhibit the cultural heritage of Kadathanadu/Vadakara RCC precast panels of sword shape are provided on the parapets of proposed bridge. The pile foundation of diameter 1.2m is proposed. Fender piles are used at locations P10, P11 and P12 to protect the structure from the impact or abrasion that may be caused from boats, ships or barges. Also, road accidents can be considerably reduced once the vehicle starts plying through the new road.

This project helps a major growth to the tourism industry in the area with the development of coastal highway. Vadakara sandbanks, Kunhali marakkar museum, Sargalaya arts and crafts village and boating facilities at Kottakkal are major destinations along this coastal line.

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3.4.3.3 Purpose of Traffic Study

Traffic surveys have been carried out on the project area in order to identify suitable remedial measures and to evolve appropriate design method. The primary objectives of these traffic surveys are to determine the characteristics of traffic movement along the road. All the traffic surveys and further analysis is carried out as per the guidelines given in IRC: SP 19-2001, IRC: 108-1996, IRC SP: 41-1994, IRC: 102-1988 and IRC: 09-1972. For making the proper assessment of traffic volume, base year traffic and its projection necessary traffic surveys and investigations are carried out in the location. The base year traffic data is the primary input for determination of future traffic demand. With a view to estimate the base year traffic volume in respect of goods and passenger carrying vehicles, the Classified Traffic Volume Count (CTVC) Survey was conducted. For the purpose of traffic estimation and projections, the year 2018 is taken as the base year

3.4.3.4 Traffic Survey Schedule

The survey schedule was prepared as per the requirements of the study. The schedule of Traffic Surveys and locations are given in Table 3.1

Table 3.1 Schedule of Traffic Surveys

Item No.	Type of Survey	Survey Location	Direction	Duration	Date of Survey
1	Classified Traffic Volume Count Survey (CTVC)	Near Puthiyappa Harbour	Kozhikode to Kannur & Kannur to Kozhikode	3 Days, 24 hours	10-04-2018, 11-04-2018, 12-04-2018

The traffic survey is carried out in accordance with the guidelines specified by IRC: 9-1972 and IRC: 102-□□□□□T□□ □ □□□odo□o□y adop□□d □or □□□ □ra□□□ □□□dy □□d□□a□□d □□□o□

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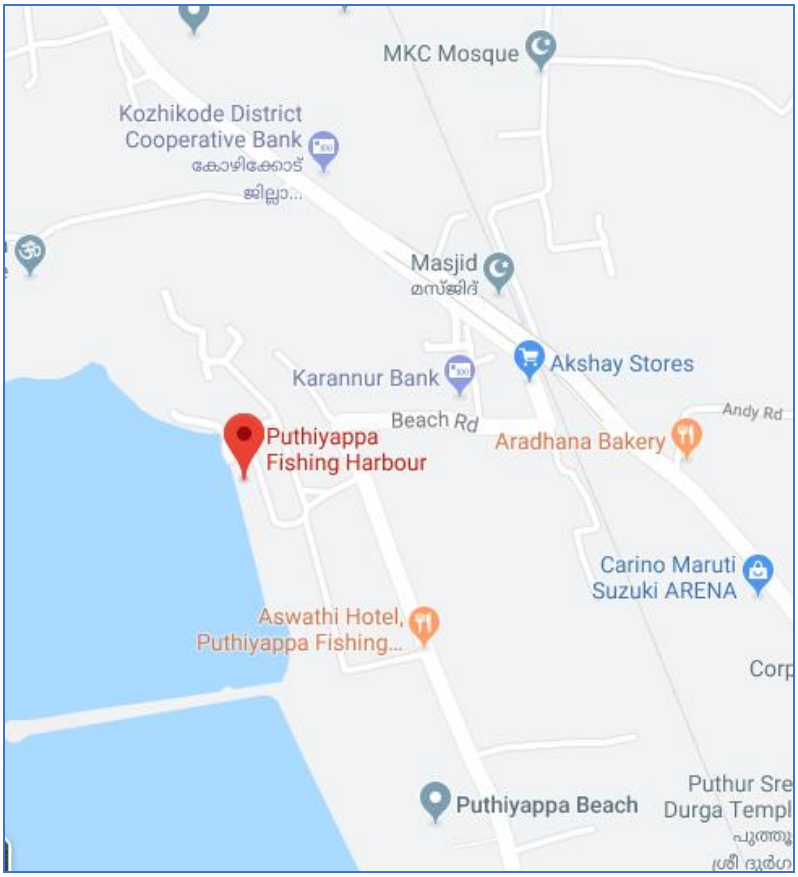

Figure 3.1 Traffic Survey Location

3.4.3.5 Methodology Adopted For Traffic Surveys

3.4.3.5.1 Classified Traffic Volume Count (CTVC) Survey

The Classified Traffic Volume Count survey was conducted at proposed road. The count was conducted for 3 days and 24 hours as per IRC: SP: 19 – 2001, 'Manual for Survey, Investigation and Preparation of Road Projects'. Fig 3-2 shows the traffic survey location for carrying out the traffic count. The vehicles were grouped under following categories as given in Table 3-2. For the purpose of smooth counting, a day was divided into three shifts of 8 hours each and groups of enumerators with a supervisor were assigned for each shift in both directions.

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Table 3.2 Vehicle Classification System (Fast & Slow)

Fast moving vehicles	
Two wheelers: Motor Cycle, Scooter etc.	
Car/ Jeeps/ Taxies/Van/Three Wheelers (Autorickshaw)	
Passenger Car	Car, jeep, taxi & van (Old & new technology vehicles)
Bus	Mini Bus
	Govt. Bus
	Private Bus
	Two axle truck and Tanker
	Multi axle trucks, tanker trailors etc.
Other Vehicles	Agriculture Tractor, Tractor & Trailer
Slow moving vehicles	
	Bicycle
	Cycle Rickshaw
	Animal drawn (Bullock cart/Horse cart/)

For the purpose of smooth counting, a day was divided into three shifts of 8 hours each and groups of enumerators with a supervisor were assigned for each shift in both directions. The count data was recorded at 10-minute intervals for each vehicle group for each direction of travel separately. This traffic data is used for working out traffic characteristics analysis, traffic forecast, economic and financial analyses

3.4.3.6 Data Analysis

The classified traffic volume survey data of coastal highway from Francis road junction to Puthiyappa in Kozhikode District, Proposed Road location is analysed in order to obtain the following traffic characteristics:

- Average Daily Traffic (ADT) Volume
- Average Hourly Variation of Traffic Volume
- Daily Variation of Traffic volume
- Peak Hour Factor
- Average Composition of Traffic

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Daily and hourly variation of classified traffic flow is recorded by conducting 3-day continuous traffic count at Puthiyappa which is a location in the existing beach road in Kozhikode District and □□ra□□d □o□ IRC□□□ – □990, 'Guideline□ □or Capa□□y o□Road□ □n Rural Areas'□

Table 3.3 Vehicle Classification along with their PCU factor

Vehicle Type	PCU Factor
Motorized Vehicle	
Car, Jeep, Van	1.0
Two-Wheeler (Motor Cycle)	0.5
Three Wheeler (Auto-Rickshaw)/ Mini LCV	1.0
Mini Bus	1.5
Govt. Bus	3.0
Private Bus	3.0
School Bus	3.0
Light Commercial Vehicle (LCV)	1.5
2-Axle Truck	3.0
3-Axle Truck	3.0
Multi Axle Vehicle (MAV)	4.5
Agricultural Tractor	1.5
Agricultural Tractor with Trailer	4.5
Non-Motorized Vehicle	
Cycle	0.5
Cycle Rickshaw	2.0
Animal Drawn Cart	6.0

(*Source: IRC: 64-1990)*

3.4.3.6.1 **Average Daily Traffic (ADT)**

The traffic volume data collected during the survey was averaged to arrive at the Average Daily Traffic (ADT) on the project location. The summary of ADT in terms of vehicles and PCU is presented in table 3.4. After the completion of the coastal highway full connectivity will be attained and traffic from Puthiyappa which is location in existing beach road is expected to ply through the bridge. Hence the traffic count observed at Puthiyappa is considered for the analysis purpose. The total traffic volume observed at Puthiyappa is 9235 (8377 PCU).

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Table 3.4 Average Daily Traffic Volume (ADT)

Type of Vehicles		ADT in Nos	PCU factor	ADT in PCUs
Fast Moving Vehicles	Two-wheeler (Motor Cycle, Scooter etc.)	4151	0.5	2076
	Car/ Jeeps/ Taxies/Van/Three Wheelers (Auto)	3799	1	3799
	LCV (Light commercial vehicle eg.Mini truck)	402	1.5	603
	Bus	2	3	6
	Two axle truck and Tanker	674	3	2022
	Multi axle trucks, tanker trailors etc.	205	4.5	923
	Agriculture tractor with trailor	0	4.5	0
Slow Moving Vehicles	Cycle	1	0.5	1
	Bullock cart/Horse cart/Other animal powered	0	6	0

3.4.3.6.2 **Average Hourly Variation of Traffic Volume**

The analysis has been carried out to study the hourly variation and peak hour traffic characteristics. The morning peak hour is observed between 9 am to 10 am and the evening peak hour is observed between 3 pm to 4 pm at the count location. The Peak Hour share is defined as the ratio of the number of vehicles counted during the peak hour to the total vehicles counted in a day. The peak hour share on the survey location is 7.70 % for morning and 8.12 % for evening. The hourly variation of traffic at the location is illustrated in Figure 3.3

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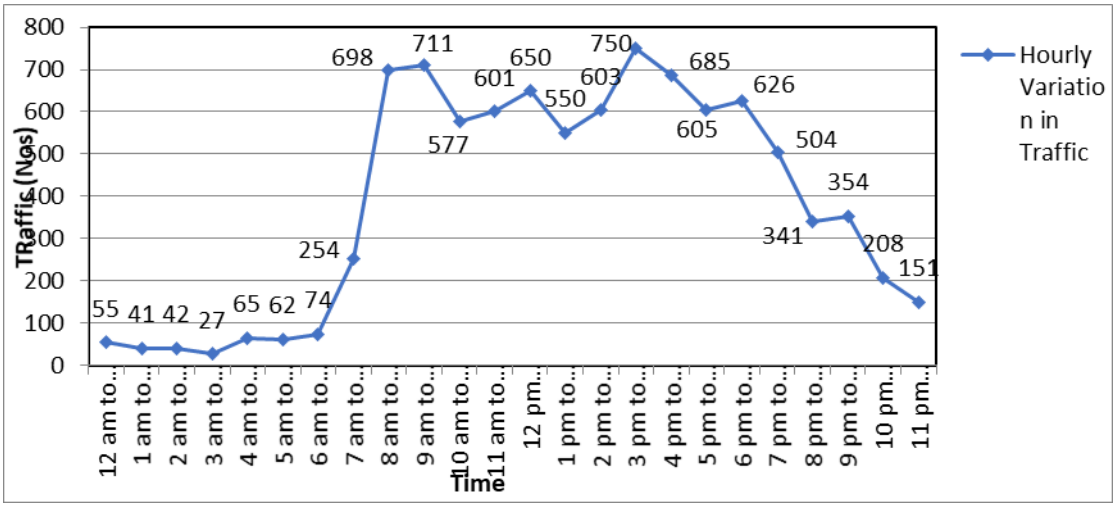

Figure 3.2 Hourly Variation of Traffic

3.4.3.6.3 **Daily Variation of Traffic Volume**

Daily variation of traffic at the count location is presented in Table 3.5. At the location, daily variation of traffic with respect to ADT is generally not noticeable as most of the daily volume being near to ADT volumes. The maximum traffic is observed on Thursday with 9494 Vehicles (8655 PCU).

The daily traffic varies with total traffic being lowest on Tuesday with 8971 Vehicles (8102 PCU) and highest on Thursday with 9494 Vehicles (8655 PCU) and is illustrated in Figure 3.5

Table 3.5 Daily Variation of Traffic for 3 days

Day	Date	Total Vehicles in Numbers	Total Vehicles in PCU
Day 1 (Tuesday)	10-04-2018	8971	8102
Day 2 (Wednesday)	11-04-2018	9239	8373
Day 3 (Thursday)	12-04-2018	9494	8655

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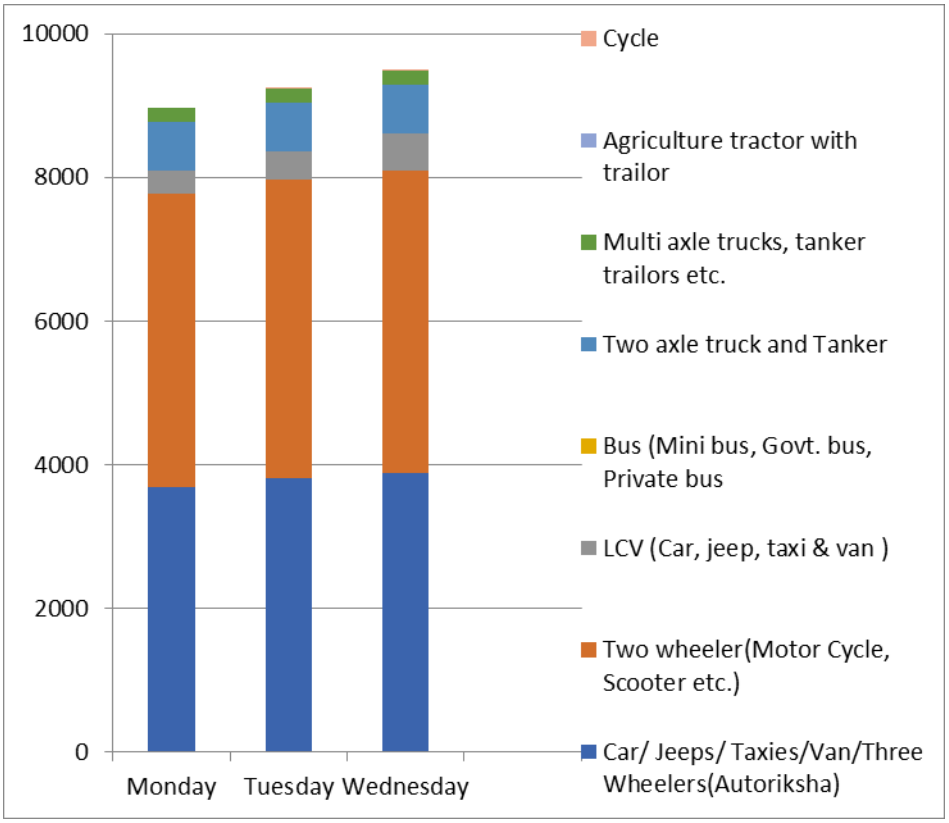

Figure 3.3 Daily Variation of Traffic for 3 days

3.4.3.6.4 **Composition of Traffic**

The traffic composition observed shows that major portion of the vehicles passing proposed road are fast moving passenger vehicles which includes Car, Bus and two wheelers. 46% of the traffic comprises of Car, Jeeps, Taxies, Van, Three Wheelers (Auto) and 41% is of Two-wheeler traffic. Two axle truck and Tanker contribute major share of commercial vehicle traffic. Figure 3.5 shows the traffic composition observed.

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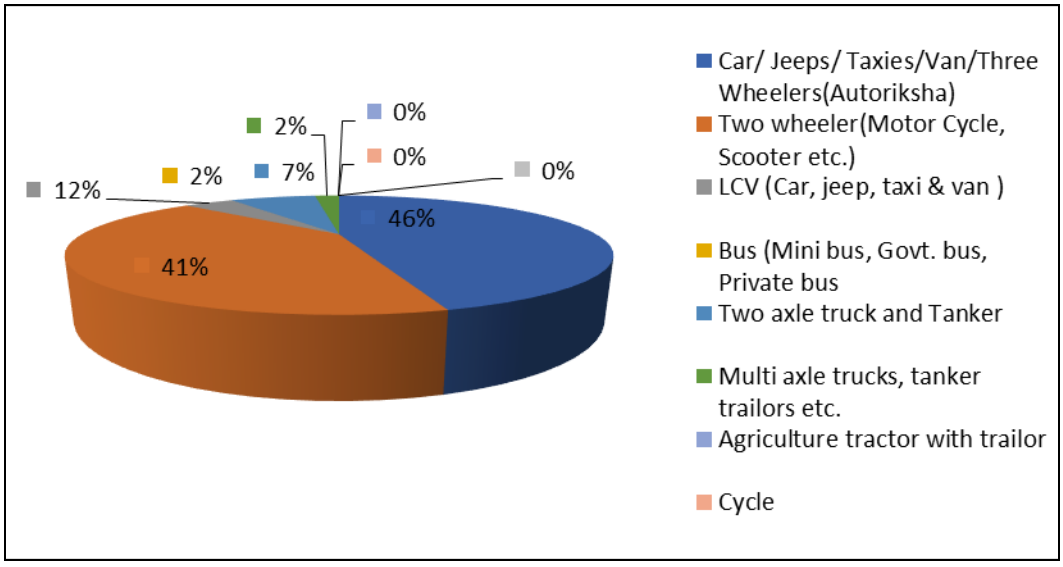

Figure 3.4 Traffic Composition Observed

3.4.3.7 TRAFFIC FORECAST

The traffic growth rate is normally established by studying the past trends in traffic growth and socio- economic parameters. In the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic. Annual growth rate of 5% is considered for the projection of traffic.

3.4.3.8 CONCLUSION

Construction of coastal highway in this reach is useful for diverting the long route traffic from the already congested National Highway. More than this it is providing transport facility to the coastal areas without any present transport facility.

3.4.4 PAVEMENT DESIGN

Deign of the pavement is an important part of detailed engineering study. Flexible pavement has been designed incompliance with IRC: 37-2012 "Guidelines for the design of flexible pavement". Flexible pavement has been proposed for the approach road and service road of Kunjalimarakkar Bridge from Kottakkal kadavu to Sand banks.

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3.4.4.1 Design of Flexible Pavement

3.4.4.1.1 **Introduction**

New Pavement composition has been estimated on the basis of various factors such as traffic loading, Subgrade strength and environmental characteristic. Proposed new □o□ po□□□on □ □□□□arry □□□ ra□□□ oad□ □ □or □□□ d□□□□n p□r□od and □□o□d pro□d□ □□ oo□□ and □a□ r□d□ □□r a□□□ S□r□n□□□□n□ o□□□□□□□n□ pa□□□ □n□o □□□ □□□□o□n□□ □on□r□□□□on □a□ □□□n d□□□□n□d □□□p□ □ □□□□ o□ □□□ □□□□□□n□ pa□□□ □n□□o□ po□□□on□ □□□ □rad□ □r□n□□□ and □□□□□□n□ pa□□□ □n□ □ond□□on□ T□o□an□ □□o□□ay □arr□a□□□ay □on□□□□ra□□on□ □a□□ p□ann□d □or □□□ □□□□□on□□

The following three main steps have been followed in designing the new flexible pavement.

- Estimating the volume of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life of 20 years.
- Assessing the strength of the sub grade soil over which the road is to be built.
- Selecting the most economical combination of pavement materials and layer thickness that will provide satisfactory service for the design life of the pavement.

3.4.5 DESIGN PARAMETERS

3.4.5.1.1 **Initial Traffic**

As per IRC 37-2018, one of the important design parameters for pavement design is the project traffic which is indicated in terms of million standard axles (MSA). For the design of flexible pavement, only commercial vehicles with gross weight above 3000 Kg are considered out of the spectrum of vehicles counted in the traffic volume count. Accordingly, from the 3 day 24 hours classified traffic volume count data average daily traffic plying on the

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project location is estimated. The estimated Average Daily Traffic (ADT) is presented in Table 3.6 for the base year 2018.

Table 3.6 Base Year Traffic (ADT)

Sl No	Vehicle Type	ADT
1	Bus	2
2	LCV	402
3	Two axle	674
4	Multi axle	205
Total		**1283**

3.4.5.1.2 **Design Period**

The design period to be adopted for pavement design is the time span considered appropriate for the road pavement to function without major rehabilitation. It is recommended that a design period of 20 years may be adopted for the structural design of pavements for National Highways, State Highways and Urban Roads. Hence a design life of 20 years has been considered here for the design of pavement

3.4.5.1.3 **Traffic Growth Rate**

For estimating the cumulative traffic expected to use the pavement over the design period, it is necessary to estimate the rate(s) at which the commercial traffic will grow over the design period. The traffic growth rate is normally established by studying the past trends in traffic growth and socio-economic parameters. The present-day traffic has to be projected for the end of design life at growth rates (r) estimated by studying and analysing the following data:

- Past trends of traffic growth
- Demand elasticity of traffic with respect to macro-economic parameters (like GDP or SDP) and expected demand due to

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specific developments and land use changes likely to take place during design life period.

As per IRC 37-2018 cl 4.2.2, in the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic. Hence an annual growth rate of 5% has been assumed.

3.4.5.1.4 **Vehicle Damage Factor (VDF)**

The Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration into the number of repetitions of Standard axle load of magnitude 80 kN. It is defined as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration and axle loading.

As per IRC:37-2018 Cl 4.4.6, For small projects, in the absence of weigh pad, the axle loads of typical commercial vehicles plying on the road may be estimated approximately from the type of goods carried. Where information on the axle loads is not available and the proportion of heavy vehicles using the road is small, the indicative values of vehicle damage factor given in Table 4.2 can be used. These indicative VDF values have been worked out based on typical axle load spectrums and taking into consideration the legal axle load limits notified in the Gazette of India dated 16th July 2018. Assumed values of VDF values are appended below in Table 3.7.

Table 3.7Indicative VDF Values

Initial Traffic Volume in Terms of Commercial Vehicles Per Day	Terrain	
	Rolling/Plain	Hilly
0-150	1.7	0.6
150-1500	3.9	1.7
More than 1500	5.0	2.8

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Since total commercial vehicle per day comes in between 150-1500 Category and project location falls in plain terrain, a VDF value of 3.9 has been assumed for the design of flexible pavement.

Lateral distribution

Lateral distribution of commercial traffic on the carriageway is required for estimating the design traffic (equivalent standard axle load applications) to be considered for the structural design of pavement. As per IRC:37-2018 Cl 4.5.1.3, for Two-lane two-way roads the design should be based on 50 per cent of the total number of commercial vehicles in both directions.

3.4.5.1.6 **Subgrade Strength**

The strength of sub grade is assessed by California Bearing Ratio (CBR) tests. The select soil forming the subgrade should have a minimum CBR of 8 per cent for roads having traffic of 450 commercial vehicles per day or higher. Minimum CBR of 10% is considered for the design of flexible pavement. Hence, borrow material used for filling the approaches of the bridge should have a minimum CBR of 10%.

3.4.5.2 Design Traffic

The design traffic is calculated in terms of the cumulative number of standard axles to be carried during the design life of the proposed road. It requires the estimation of initial commercial vehicles per day, lateral distribution of traffic, traffic growth rate, the design life and the vehicle damage factor (number of equivalent standard axle for commercial vehicle) to convert commercial vehicles to standard axles.

The following equation has been used to calculate the design traffic

$$N = \frac{365\{(1+r)^n - 1\}}{r} \times A \times D \times F$$

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Where,

N = the Cumulative number of standard axles to be catered in the design

A = Initial traffic, in the year of completion of construction, in term of the number of commercial vehicles per day duly modified to account for lane distribution.

$A = P(1+r)^x$

Where P number of commercial vehicles per day as per last count, In this case P = 1283 as per traffic census conducted during April 2018

x is the number of years between the last count and the year of completion of construction taken as 3 in this case.

r = Annual growth rate of commercial vehicles taken as 5%

n = Design life in years taken as 20 years

D = Lane distribution factor taken as 0.50

F = Vehicle damage factor i.e. number of equivalent standard axles per Commercial vehicle. Here 3.9

The design traffic calculated using the above formula is 33 msa.

3.4.5.3 Proposed Pavement Thickness – Approach Road

Based on the traffic (33 msa) and the assumed CBR value (10%), the thickness of flexible pavement has been obtained by interpolation from IRC: 37-2018, Cl.10.1, Plate 6 and proposed layer thickness is given in Table 3.8 and illustrated in Figure 3.6. Plate 6 of IRC 37-2018 is given as Figure 3.7.

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Table 3.8 Estimated and Proposed Pavement Compositions

Crust Details	Thickness (mm)		Remarks
	Estimated	Proposed	
BC	40	40	
DBM	88	88	
WMM	250	250	
GSB	200	200	
Subgrade	500	500	

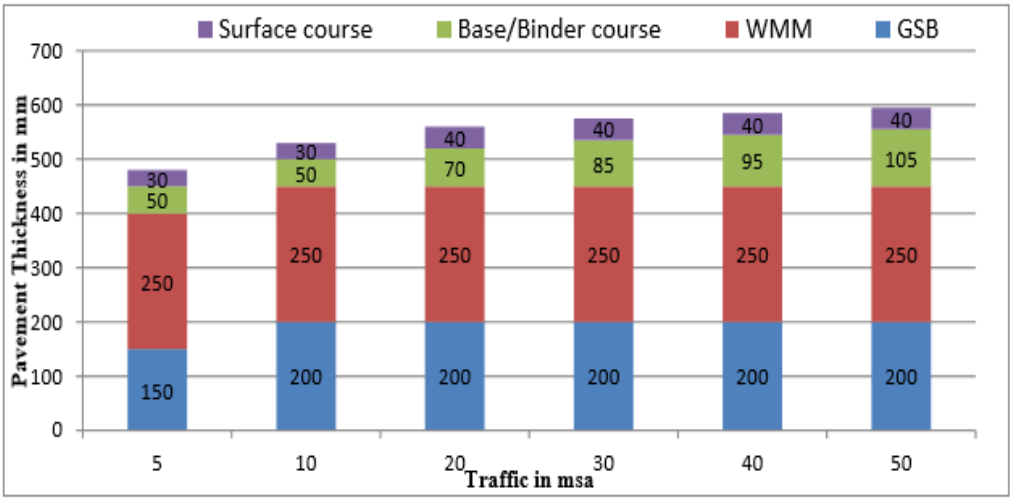

Figure 12.6 Catalogue for pavement with bituminous surface course with granular base and sub-base - Effective CBR 10% (Plate-6)

Figure 3.5 Catalogue for pavement as per IRC:37-2018

3.4.5.4 Proposed Pavement Thickness – Service Road

For the service road minimum thickness as per Plate-6 of IRC 37-2018 is proposed since there is no traffic census data for service road

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Table 3.9 Proposed Pavement Compositions for service Road

Crust Details	Thickness Proposed	Remarks
BC	30	
DBM	50	
WMM	250	
GSB	150	
Subgrade	500	

3.5 FUNCTIONAL DESIGN

The functional design of the project is mainly achieved through field study and documentation using existing information and specification from various standards. The field study includes all engineering studies viz. reconnaissance survey, topographic survey, geotechnical investigation, traffic survey etc. Documentation is done as per the latest revisions and amendments of the relevant guidelines of the MoRTH/IRC/BIS standards.

The new bridge at Kottakal kadavu – sand baks is proposed in the alignment of the coastal highway. The alignment of the new bridge is proposed in such a way that the land acquisition are minimum and with out any rehabilitation.

The proposed bridge is of 7.50 m wide carriage way with footpath on either side. Cycle track on western side etc. This will help the road users to safely cross Kuttiyadi river without traffic conjunction.

3.6 ENGINEERING DESIGN

The structural design for the Kunjalimarakkar bridge at Kottakkal Kadavu- Sandbanks is done by DRIQ board of Kerala Public Works Department.

3.6.1 STANDARDS AND CODES OF PRACTISES

All activities related to field studies, design and documentation is done as per the latest revisions and amendments of relevant guidelines of MoRTH/ Indian Railways and publications of Indian Roads Congress (IRC) and Bureau

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of Indian Standards (BIS). All notations, abbreviations and symbols used in the reports, documents and drawings are as per IRC: 71-1977 latest edition with amendments.

3.6.2 GEOMETRIC DESIGN

The design for geometric elements has covered the major aspects including longitudinal profile, Cross-sectional elements and required Service roads. Cross section details issued by KIIFB is adopted for the bridge.

3.6.3 ALIGNMENT SELECTION

The proposed bridge is located at Vadakara in Kozhikode district can be a connecting link in the proposed Coastal highway. General Arrangement Drawing (GAD) and Alignment Plan showing the salient features of the bridge and structures proposed to be constructed are covered under the study. These salient features such as alignment, overall length, span arrangement, cross section, deck level, founding level, type of road bridge components (superstructure, substructure, foundations, bearings, expansion joint etc.) are finalized based on the detailed topographic and geotechnical studies.

The bridge approach is proposed with a slope of 1 in 30 on both kottakkalkadavu and sandbanks side. Length of approach comes to be 160.00m on Kottakkal side and 90.00 m on Sandbanks side. The structure follows an undivided 2 lane configuration and extends a length of 537m. The width of the bridge is 15.60m with 7.50 m carriage way and footpath on both sides. The estimated cost of the Project is 5900.00 lakhs.

3.6.4 DESIGN OF EMBANKMENTS AND FLEXIBLE PAVEMENT

The approach roads are designed with Gabion Retaining wall. The design as done in similar conditions and has been adopted for the purpose. The work consists of Gabion retaining wall, approach slab and suitable backfill material. Pavement design follows IRC 37-2012(guidelines on design of flexible pavement) for approach road and service road.

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3.7 FINANCIAL ESIMATES AND COST PROJECTIONS

3.7.1 GENERAL

The project cost estimates have been prepared considering various items of works associated with the identified improvements. Detailed estimates for quantities (considering preliminary designs and conveyance of materials) and cost for the entire project (civil packages wise), is worked out based on Standard Data Book of MoRT&H and latest Kerala PWD schedule of rates as per PWD Project Information and Cost Estimation (PRICE) software.

The estimate is based on PWD PRICE and cost index of 31.06% of Kozhikode district. Where the data is not available, rates are worked out based on market rates.

Project Information and Cost Estimation (PRICE) software is a total solution for estimate preparation and online approval. It is developed for the Public Works Department Kerala. PRICE is based on CPWD Schedule of Rates, Specification, Rate Analysis and cost index.

The project cost estimates have been prepared considering the various items of works associated with Identified improvements so as to assess financial and economic costs for evaluating viability of the Project.

3.7.2 APPROACH AND METHODOLOGY

3.7.2.1.1.1The cost estimate is grouped as follows.

- Part 1: Bridge works -The cost of bridge structure and its components comes under this.
- Part 2: Road work -Detailed estimate of Embankment construction, road pavement layers, cost of Drainage system and its components comes under this
- Part 3: Traffic Safety: Installation of signboards, road studs and thermoplastic etc comes under this
- Part 4: Utility Shifting is approximated as Rs 10000000.00

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- PART 5: Cost of land acquisition comes under this head
- PART 6: Cost of land acquisition procedures is included in this
- PART 7: Expenditure of CRZ and other clearances is included in this

3.7.3 ESTIMATION OF QUANTITIES

The quantities of major items of work for the Project Road have been estimated on the basis of geometric designs, pavement designs and preliminary structural designs. The quantities of the following major items of works have been estimated separately.

- Site Clearance and Earth work
- Granular Pavement Courses
- Bituminous Courses
- Pile foundation
- Substructure and super structure
- Embankment for approach portion with Gabion retaining walls
- Kerbs, Drainage and Protective works
- Road Furniture and Safety Works
- Relocation of Utilities
- Major features of the New Bridges are as under.
- The total length of the New Bridge will be 537m.
- Embankments with retaining walls are proposed on both the sides at a slope of 1in 30.
- Pre stressed I girder and cast in situ deck slab with 18 spans and 15.60m total width are proposed.
- Footpath is considered on both the sides and RCC crash barrier is considered on either sides of the carriage way.

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- The total width of the two-lane approach is 15.60 m. Carriage way width is 7.5m with Crash barrier on either sides
- RCC precast panels of sword shape are to be provided on the parapet of proposed bridge

Detailed estimate is given as Annexure I

Table 3.10 Abstract of Estimate

Sl.No.	Description	Amount
1	Bridge Work	421012944.81
2	Road Work	57308478.29
3	Traffic Safety	714237.87
4	Utility Shifting	1000000.00
5	Land Acquisition - cost of land	18400000.00
6	Land Acquisition Procedures	920000.00
7	CRZ and other clearances cost	24001783.00
	Total	**523357443.97**
	GST @ 12.0%	62802893.28
	Total with GST	586160337.25
	Lumpsum Round off	3839662.75
	TOTAL	**590000000.00**
		59 Crores

3.7.4 COST OF THE PROJECT

AS has been issued by the govt. vide order no: G.O.(Rt)No.942/2017/PWD Dtd10/07/2017. The state has to mobilize the entire amount required for the reconstruction of the bridge.

3.7.5 COST OF CONSTRUCTION OF COASTAL HIGHWAY

The cost of bridge includes the cost of the construction of bridge, cost of the approach portion and service roads. This works out to Rs.3988 lakhs for the project as detailed below.

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Table 3.11 Cost of Construction

Sl.No.	Description	Amount
1	Bridge Work	421012944.81
2	Road Work	57308478.29
3	Traffic Safety	714237.87
	TOTAL	**479035661.97**

3.7.6 COST OF SHIFTING OF UTILITIES

Overhead and underground power cables, water line, telecommunication line, etc. which come in the way of the bridge alignment have to be relocated or re-routed. The total amount for shifting of electric posts, cables, transformers ect comes to be Rs. 1000000/- .

3.8 REVENUE STREAMS

Levee may be imposed from service providers for using the utility duct proposed.

3.9 COST-BENEFIT ANALYSIS (CBA)

3.9.1 GENERAL

An infrastructure project is subjected to economic appraisal to ensure that the investment proposed would yield appropriate return to the national economy. The basic purpose of the economic analysis is to enable the decision-makers in the Government to decide whether the project is worthy of investment keeping in view the benefits to the society. Economic analysis is not concerned about past events and investments.

The Economic Analysis Proposal for the construction of Kunjalimarakkar Bridge accrued to the society. The very basis of economic analysis being the selection of the most attractive option and it is necessary that evaluates a number of possible alternatives. The basic alternative is the 'do-nothing', or the continuation of the present situation. All other alternatives are evaluated against this basic condition.

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Economic analysis estimates future traffic, costs and benefits. The Cost Benefit Analysis (CBA) is the implicit or explicit assessment of the benefits and costs (i.e., advantages and disadvantages) associated with an investment project. Benefits and costs may be nonmonetary and monetary.

Some of the non-monitory benefits, which are difficult to be expressed in monitory terms through development of Bridge are reduction in air pollution and noise pollution as described below

3.9.2 COST-BENEFIT ANALYSIS (CBA)

3.9.2.1 Reduction in Air Pollution

An Air Quality Index (AQI) up to 50 is regarded as good while the 51-100 range is considered moderate. A reading exceeding 100 is considered unhealthy for sensitive groups, such as those having lung diseases. The air is unhealthy for

the people if the AQI is in the range of 151-200. AQI in the 201-300 range indicates very unhealthy air. A reading above 300 is hazardous. The growing number of vehicles and stoppage due to Traffic Congestion causes considerable ecological damage through emissions from internal combustion engines. Aggregation of vehicles at Traffic Congestion leads to high quantum of air pollution and thereby causes various health issues for the people in the nearby areas. Presently all the vehicles are plying through the existing bridge in NH where traffic congestion is very high. The proposed Bridge will reduce the air pollution in the area due to seamless flow of vehicles.

3.9.2.2 Reduction in Noise Pollution

The noise pollution in the nearby NH area during Traffic Congestion is at an alarming rate. If a bus horn honks, it creates 92-94 decibels (dB) of sound, and hearing it repeatedly can cause hearing loss. Noises, which are below 75 dB, are harmless. But constant exposure to noise levels of 80-85 dB can increase the risk of hearing loss. The magnitude of sound of a two-wheeler horn is between 81 and 85 dB, and that of a car horn is between 83

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and 88 dB. As there are congestion during the traffic block, honking of horns by the vehicles is high and there by the noise Pollution in the area is also high. Through the introduction of Bridge, vehicles are enrouted though new road and there will have seamless flow of vehicles and hence can avoid the noise pollution in the area.

Economic Rate of Return (ERR) and Cost Benefit Ratio (Benefit / Cost) are some of the measure to arrive at the social benefits from any infrastructure project. The financial analysis appraises the project in terms of return on investment while the economic analysis appraises the project contribution to the social and economic welfare of the city, region or country.

Though all the cost and benefits from an infrastructure project is not possible to be expressed in monitory terms, all possible costs and benefits are being measured in monitory terms and evaluated to arrive at a conclusion whether an infrastructure project is worth to the society. There are various methods to evaluate the economic benefits from any infrastructure projects. The economic evaluation of the proposed Bridge project is carried out based on the IRC SP 30, 2009, which describes about "Economic Evaluation of Highway Projects in India".The Economic Evaluation carried out based on IRC SP 30, 2009 for the Kunjalimarakkar Bridge at Kottakkal Kadavu- Sandbaks is detailed in the following section.

3.9.3 BASIS FOR ARRIVING AT COST AND BENEFITS

All the cost and benefits are taken at constant price without factoring the inflation so as to have better overview. The basis for arriving at each component of costs and benefits from the proposed Bridge based on IRC SP 30, 2009 is detailed below

3.9.3.1 Project Cost

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices, as these are not real costs to the economy, but are only transfer payments.

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All financial costs have been converted into economic costs by applying a Standard Conversion Factor (SCF) of 0.80, as suggested in IRC: SP: 30-2009. The cost for the project consists of two main components:

- Capital cost
- Operation and Maintenance cost

3.9.3.2 Capital Cost

The capital cost includes the cost of construction of bridge, retaining wall works, road works, and cost of traffic diversion etc. These are estimated in financial terms i.e. at market prices. The total project cost worked out is amounting to Rs.5,900.00 lakhs with cost for land acquisition and construction amounting Rs.5,233.57 lakhs. The capital cost of all the project in financial and economic terms are summarized below.

Total Cost	Finance Cost (Lakhs)	Economic Cost (Lakhs)
Construction of Coastal Highway in Kozhikode district- Kunjalimarakkar bridge from Kottakkal to Sandbanks	5233.5	4186.86

3.9.3.3 Operation & Maintenance Cost

Maintenance costs are recurring costs, comprising routine and periodic maintenance components. The routine maintenance involves day-to-day repairs and maintenance of ROB and road etc.

The routine maintenance cost would start incurring from the third year from the date of commencement of operation (in this case 2020 is assumed as the starting year of the project and the construction is expected to complete in 2022).

The total project financial cost is estimated to Rs.5900 lakhs. And this is faced during 24 months construction period.

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3.9.4 PROJECT BENEFITS

There are various benefits through provision of proposed coastal highway which include social benefits such as savings in time of travel, reduction in accidents due to congestion during peak hours, reduction in sound pollution through avoidance of horns, reduction in air pollution etc.

The benefits (which are converted in to monitory terms) considered from the construction of the proposed road are as under:

- Travel Time savings of passengers
- Savings in the cost of maintenance of old road (operating cost of warning signals and Police man engaged for traffic control etc).
- Savings in idle fuel consumption
- Less pollution from vehicles
- Helps in tourism development
- Provision of proper drainage system
- Cycle riders can enjoy riding

3.9.4.1 Travel Time savings of passengers

Generally, passengers, car passengers and two-wheeler riders enjoy savings in travel time. Through the proposed bridge, a considerable amount of travel time can be saved due to seamless flow of vehicles by avoiding waiting time in the rail way cross. Time Value of Passenger (Work Trips and Non Work/leisure trip) is arrived based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP:30 -2009)".

The value of travel time of passengers for each category of travelers as specified in the IRC SP 30, 2009 is based on the March 2009 prices and is reproduced below;

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Table 3.12 Value of Travel Time of Passengers (Rs/hour) – 2009 prices

Sl.No	Nature of Journey by Passenger	Value of Time
		Primary Route
1	Cars	62.5
2	Two Wheelers	32
3	Ordinary Bus Passenger	39.5

Note: Average 365 days a year is considered to arrive at the value of passenger time saved.

These values of 2009 are revised based on the wholesale price index to arrive at the current price. The monthly WPI index for all products from the website of "Office of the Economic Adviser Govt. of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIPP)" (http://www.eaindustry.nic.in/display_data.asp) is considered to arrive a "Value Indexation Factor" (VIF) to arrive at the current price levels of the time value provided in the IRC SP 30, 2009. The calculation of VIF is provided below;

Wholesale Price Index			
As on Mar-2009	123.5		
As on Aug-2018	187.40	Index Multipier	1.5174

The current value arrived at through multiplying with VIF is provided below

Table 3.13 Value of Travel Time of Passengers (Rs/hour) March-17 prices

Sl.No	Nature of Journey by Passenger	Value of Time
		Primary Route
1	Cars	94.84
2	Two Wheelers	48.56
3	Auto*	48.56
4	Ordinary Bus Passenger	59.94

* Assumed same as Two Wheelers

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Note: For the economic evaluation the value for 'value of time' for the primary route is considered. Out of the total travellers it is assumed that 85% of the total population travels is considered as work travel and the balance 15% as leisure travel. The time saved through proposed brige for leisure travel is not considered as benefit under this head.

To arrive at the value of time saved, the average occupancy of vehicles passing □ro□□□ □□□ ra□□ro□□ □□ □on□d□r□d a□ □o□o□□

Table 3.14 Average Passenger Occupancy

Sl.No	Nature of Journey by Passenger	Passenger Occupancy
1	Cars	4.80
2	Two Wheelers	1.50
3	Auto	3.00
4	Ordinary Bus Passenger	43.00

3.9.4.2 Time Value of Cargo

With regard to time value of cargo, as the travel time reduces the inventory carrying cost of the cargo also reduces. Reduced travel time for cargo leads to;

- Use of lesser number of commercial vehicles and
- Leads to reduction in the fixed charges per km which every operator has to pay
- Results in time savings to the vehicle crew

The savings in travel time are an important component of the benefits from the provision of bridge. Theoretically, it is possible to visualize the savings in cost of holding inventories by working out the value of goods held during the transport and deriving the interest payment thereon.

The Average value of time for commodity is considered for the working based on "Manual of Economic evaluation of Highway Projects in India ("IRC SP: 30 - 2009)". Equivalent cost of commodity in 2016-2017 is determined using multiplying the WPI as specified in IRC SP: 30 – 2009 with Value

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Indexation Factor" (VIF) (as detailed in the previous section). The value of time saving of commodity transport as specified under IRC SP: 30 – 2009 and its indexed value are provided in the following table.

Table 3.15 Commodity Holding cost

Vehicle type	Value of Commodity (Rs./t)	Average Load (t/Vehicle)	Commodity Holding Cost (Rs/day)	
			As on 2009 March	As on 2018 march
LCV	35300	3.2	58.10	88.16
HCV	38750	9	178.00	270.10
MAV	36300	18.3	333.00	505.29

Note: For the calculation of time value saving for commodities, 365 days a year is considered.

Through the development of Bridge, the cost of idle fuel consumption can be saved. It is assumed that on an average 50% of total Congestion stoppage time, the vehicles will be turned on. Hence through the proposed BridgeB, the fuel consumption otherwise occur during idling time can be saved. Savings in idle fuel consumption is worked out assuming that each type of vehicles consumes fuel in the following quantity.

Type of Vehicle	Idle Fuel consumption in ml. per hour	Fuel
2 Wheeler	200	Petrol
3 Wheeler	250	Diesel
Car / Jeep	667	Diesel
LCV	810	Diesel
BUS	920	Diesel
HCV	920	Diesel
Truck	942	Diesel

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Average cost of fuel per litter considered for economic analysis is as per"IRC SP:30 -2009" is then converted to March 2017 WPI with corresponding index factors.

Fuel Type	March 2009 price without tax	March 2016 price without tax
Petrol	18.55	27.91
Diesel	18.2	27.62

3.9.5 ECONOMIC RATE OF RETURN

The ERR through implementing Bridge works out to 32.59 %. The CBR (Project Benefits / Project Costs) of the project is 1.229. This indicates that the proposed bridge will yield an economic rate of return of 32.59% and this ERR is very attractive for an infrastructure investment. The CBR of more than 1 is acceptable for any infrastructure development and the proposed bridge yields far higher CBR. The CBR of 1.229 indicate that the total benefit derived from the project is 1.229 times than the total project related costs. The total Economic Cost and Benefits, component wise for the entire project period under consideration (ie. 20 years) is tabulated in the following table.

Particulars	Rs. in lakhs
Economic Cost of Project	
Capital Cost	4186.86
Maintenance Cost	2009.76
Total Cost	**6196.62**
Economic Benefits	
Value of Travel time saving of passengers	44998.95
Value of Travel time saving for Cargo	57.87
Value of saving in idle fuel consumption	2252.87
Total Benefit	**47309.69**

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Table 3.16 Cost Benefit Analysis

Year	Project Costs		TOTAL PROJECT COSTS	Project Benefits			Total Project Benefits	Net Project Benefits
	Cost of Development	O&M cost of new bridge		Value of Travel Time Saving of Passengers (lakhs)	Value of Travel Time Saving of Commodities	Value of idling fuel cost Year		
2021	-3677.54	0	-3677.54	0	0	0	0.00	-3677.54
2022	-509.32	0	-509.32	0	0	0	0.00	-509.32
2023		0	0	1473.49	1.89	73.77	1549.15	1549.15
2024		0	0	1547.17	1.99	77.46	1626.62	1626.62
2025		0	0	1624.52	2.09	81.33	1707.94	1707.94
2026		-125.61	-125.61	1705.75	2.19	85.40	1793.34	1667.73
2027		-125.61	-125.61	1791.04	2.30	89.67	1883.01	1757.40
2028		-125.61	-125.61	1880.59	2.42	94.15	1977.16	1851.55
2029		-125.61	-125.61	1974.62	2.54	98.86	2076.02	1950.41
2030		-125.61	-125.61	2073.35	2.67	103.80	2179.82	2054.21
2031		-125.61	-125.61	2177.02	2.80	108.99	2288.81	2163.20
2032		-125.61	-125.61	2285.87	2.94	114.44	2403.25	2277.64
2033		-125.61	-125.61	2400.16	3.09	120.17	2523.42	2397.81
2034		-125.61	-125.61	2520.17	3.24	126.17	2649.58	2523.97
2035		-125.61	-125.61	2646.18	3.41	132.48	2782.07	2656.46
2036		-125.61	-125.61	2778.48	3.57	139.11	2921.16	2795.55
2037		-125.61	-125.61	2917.41	3.75	146.06	3067.22	2941.61
2038		-125.61	-125.61	3063.28	3.94	153.36	3220.58	3094.97
2039		-125.61	-125.61	3216.45	4.14	161.03	3381.62	3256.01
2040		-125.61	-125.61	3377.27	4.34	169.08	3550.69	3425.08
2041		-125.61	-125.61	3546.13	4.56	177.54	3728.23	3602.62
TOTAL	-4186.86	-2009.76	-6196.62	44998.95	57.87	2252.87	47309.69	41113.07
TOTAL PROJECT COST			**-6196.62**	**TOTAL PROJECT BENEFITS**			**47309.69**	

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Table 3.17 Daily Traffic Projection

Year	Cycle	Bike	Auto	Car	LCV	Bus	Truck
2018	1	4151	570	3229	402	2	879
2019	1	4359	599	3390	422	2	923
2020	1	4577	629	3560	443	2	969
2021	1	4806	660	3738	465	2	1017
2022	1	5046	693	3925	488	2	1068
2023	1	5298	728	4121	512	2	1121
2024	1	5563	764	4327	538	2	1177
2025	1	5841	802	4543	565	2	1236
2026	1	6133	842	4770	593	2	1298
2027	1	6440	884	5009	623	2	1363
2028	1	6762	928	5259	654	2	1431
2029	1	7100	974	5522	687	2	1503
2030	1	7455	1023	5798	721	2	1578
2031	1	7828	1074	6088	757	2	1657
2032	1	8219	1128	6392	795	2	1740
2033	1	8630	1184	6712	835	2	1827
2034	1	9062	1243	7048	877	2	1918
2035	1	9515	1305	7400	921	2	2014
2036	1	9991	1370	7770	967	2	2115
2037	1	10491	1439	8159	1015	2	2221
2038	1	11016	1511	8567	1066	2	2332
2039	1	11567	1587	8995	1119	2	2449
2040	1	12145	1666	9445	1175	2	2571
2041	1	12752	1749	9917	1234	2	2700

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Table 3.18 Average passenger trip

Year	Bike	Auto	Car	Bus
Average Occupancy	1.5	3	4.8	43
Percentage of work passenger /Year	0.85	0.85	0.85	0.85
2018	5292.53	1453.50	13174.32	73.10
2019	5557.16	1526.18	13833.04	76.76
2020	5835.02	1602.49	14524.69	80.60
2021	6126.77	1682.61	15250.92	84.63
2022	6433.11	1766.74	16013.47	88.86
2023	6754.77	1855.08	16814.14	93.30
2024	7092.51	1947.83	17654.85	97.97
2025	7447.14	2045.22	18537.59	102.87
2026	7819.50	2147.48	19464.47	108.01
2027	8210.48	2254.85	20437.69	113.41
2028	8621.00	2367.59	21459.57	119.08
2029	9052.05	2485.97	22532.55	125.03
2030	9504.65	2610.27	23659.18	131.28
2031	9979.88	2740.78	24842.14	137.84
2032	10478.87	2877.82	26084.25	144.73
2033	11002.81	3021.71	27388.46	151.97
2034	11552.95	3172.80	28757.88	159.57
2035	12130.60	3331.44	30195.77	167.55
2036	12737.13	3498.01	31705.56	175.93
2037	13373.99	3672.91	33290.84	184.73
2038	14042.69	3856.56	34955.38	193.97
2039	14744.82	4049.39	36703.15	203.67
2040	15482.06	4251.86	38538.31	213.85
2041	16256.16	4464.45	40465.23	224.54

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Table 3.19 Passenger time saving

Type of Vehicle	2w	Auto	car/jeep	bus	Time value of passengers per day	Yearly passeneger time cost
Time savings in minute	12	12	12	12		
Average trips wise passenger time cost	9.71136	9.71136	18.97	11.99		
2018	51398	14115	249917	876	316306	115451690
2019	53968	14821	262413	920	332122	121224530
2020	56666	15562	275533	966	348727	127285355
2021	59499	16340	289310	1015	366164	133649860
2022	62474	17157	303776	1065	384472	140332280
2023	65598	18015	318964	1119	403696	147349040
2024	68878	18916	334913	1175	423882	154716930
2025	72322	19862	351658	1233	445075	162452375
2026	75938	20855	369241	1295	467329	170575085
2027	79735	21898	387703	1360	490696	179104040
2028	83722	22993	407088	1428	515231	188059315
2029	87908	24142	427442	1499	540991	197461715
2030	92303	25349	448815	1574	568041	207334965
2031	96918	26617	471255	1653	596443	217701695
2032	101764	27948	494818	1735	626265	228586725
2033	106852	29345	519559	1822	657578	240015970
2034	112195	30812	545537	1913	690457	252016805
2035	117805	32353	572814	2009	724981	264618065
2036	123695	33970	601454	2109	761228	277848220
2037	129880	35669	631527	2215	799291	291741215
2038	136374	37452	663104	2326	839256	306328440
2039	143192	39325	696259	2442	881218	321644570
2040	150352	41291	731072	2564	925279	337726835
2041	157869	43356	767625	2692	971542	354612830

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Table 3.20 Savings in Commodity carrying cost

Year	LCV	Truck	TOTAL COMMODITY CARRYING COST PER DAY	YEARLY COMMODITY CARRYING COST PER YEAR
Commodity holding cost Rs/vehicle	0.05	0.43		
2018	20.10	386.76	407	148555
2019	21.11	406.10	427	155855
2020	22.17	426.41	449	163885
2021	23.28	447.73	471	171915
2022	24.44	470.12	495	180675
2023	25.66	493.63	519	189435
2024	26.94	518.31	545	198925
2025	28.29	544.23	573	209145
2026	29.70	571.44	601	219365
2027	31.19	600.01	631	230315
2028	32.75	630.01	663	241995
2029	34.39	661.51	696	254040
2030	36.11	694.59	731	266815
2031	37.92	729.32	767	279955
2032	39.82	765.79	806	294190
2033	41.81	804.08	846	308790
2034	43.90	844.28	888	324120
2035	46.10	886.49	933	340545
2036	48.41	930.81	979	357335
2037	50.83	977.35	1028	375220
2038	53.37	1026.22	1080	394200
2039	56.04	1077.53	1134	413910
2040	58.84	1131.41	1190	434350
2041	61.78	1187.98	1250	456250

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Table 3.21 Savings in Idle fuel cost

Average Idling Time		8	minutes					
	Mar-09		Mar-17					
WPI	123.5		187.4					
Petrol	18.55		28.15					
Diesel	18.2		27.62					
Type of Vehicle	**2w**	**Auto**	**car/ jeep**	**LCV**	**bus**	**truck**	**Total idling cost per day**	**Total idling fuel cost per year**
Average hourly idling fuel Consumption (ml)	200	250	667	810	920	942		
Average idling cost per trip	0.75	0.92	2.46	2.98	3.39	3.47		
2018	3113.25	524.40	7943.34	1197.96	6.78	3050.13	15836	5780140
2019	3268.91	550.62	8340.51	1257.86	7.12	3202.64	16628	6069220
2020	3432.36	578.15	8757.54	1320.75	7.48	3362.77	17459	6372535
2021	3603.98	607.06	9195.42	1386.79	7.85	3530.91	18332	6691180
2022	3784.18	637.41	9655.19	1456.13	8.24	3707.46	19249	7025885
2023	3973.39	669.28	10137.95	1528.94	8.65	3892.83	20211	7377015
2024	4172.06	702.74	10644.85	1605.39	9.08	4087.47	21222	7746030
2025	4380.66	737.88	11177.09	1685.66	9.53	4291.84	22283	8133295
2026	4599.69	774.77	11735.94	1769.94	10.01	4506.43	23397	8539905
2027	4829.67	813.51	12322.74	1858.44	10.51	4731.75	24567	8966955
2028	5071.15	854.19	12938.88	1951.36	11.04	4968.34	25795	9415175
2029	5324.71	896.90	13585.82	2048.93	11.59	5216.76	27085	9886025
2030	5590.95	941.75	14265.11	2151.38	12.17	5477.60	28439	10380235
2031	5870.50	988.84	14978.37	2258.95	12.78	5751.48	29861	10899265
2032	6164.03	1038.28	15727.29	2371.90	13.42	6039.05	31354	11444210
2033	6472.23	1090.19	16513.65	2490.50	14.09	6341.00	32922	12016530
2034	6795.84	1144.70	17339.33	2615.03	14.79	6658.05	34568	12617320
2035	7135.63	1201.94	18206.30	2745.78	15.53	6990.95	36296	13248040
2036	7492.41	1262.04	19116.62	2883.07	16.31	7340.50	38111	13910515
2037	7867.03	1325.14	20072.45	3027.22	17.13	7707.53	40017	14606205
2038	8260.38	1391.40	21076.07	3178.58	17.99	8092.91	42017	15336205
2039	8673.40	1460.97	22129.87	3337.51	18.89	8497.56	44118	16103070
2040	9107.07	1534.02	23236.36	3504.39	19.83	8922.44	46324	16908260
2041	9562.42	1610.72	24398.18	3679.61	20.82	9368.56	48640	17753600

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3.10 ENVIRONMENTAL ASPECTS AND SUSTAINABILITY

Objective of the EIA study is to understand and analyze the Environmental and Social Impacts associated with the proposed bridge alignment in the coastal region of Kerala. However, the subject project – construction of Kottakkal kadavu -Sandbanks Bridge will not attract item 7 of schedule of EIA notification of 2006 as the maximum width of land required for the construction coastal highway and bridge will be 15.6 m. Hence this project does not require prior environmental clearance.

3.10.1 ENVIRONMENTAL SETTING PROJECT AREA

The district of Kozhikode is one of the coastal districts of Kerala. Kozhikode district is bounded on the north by Kannur district, on the east by Wayanad district, on the south by Malappuram district and The district is divided into 4 taluks and 12 developmental blocks and 70 panchayats for administrative purposes.

The district has one corporation (Kozhikode) and seven Municipalities. It has a total of 117 revenue villages. Out of the total area of 2344 Sq. Kms 336 Sq. Kms fall under urban area and the remaining 2008 Sq. Kms falls under rural area. The district has a total population of 30, 89,543 persons as per 2011 census. It lies between North latitudes 11º 08’ and 11º 50’ and East longitudes 75 º 30’ and 76 º 8’.

The proposed bridge is situated in coastal belt of Vadakara connecting Vadakara and Koyilandy taluks. Geographically, Vadakara is situated about 49 km to the north of Kozhikode City, approximately 44 km to the south of Kannur City and it is proximate to Mahi. The town lies by the side of a river known by different names including the Moorad river, Kuttiyadi river, and Kottakkal river.

The proposed Kottakkal kadavu -Sandbanks Bridge is an alternative route Vadakara and can reduce the traffic problems in the Moorad bridge and Vadakara Town. The work can be executed with minimum land acquisition

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and there is no direct effect on residential, commercial buildings and other establishments.

The proposed bridge will fall under coastal area. Hence it should get coastal clearance from coastal regulations zone authority. Where ever the depth of water is large, contours will be used for the construction of piles. No mandatory or other rare species of trees will not be destroyed during the construction of the project and no wild animals found in the localities of populated area of the proposed project locations.

By constructing above bridge only 12 pier points has to be established in the river, which will not affect the flow of river. And no harmful chemicals are used hence there is no threat to flora, fauna and habitat features in the project area.

3.10.2 RAINFALL AND CLIMATE

Kozhikode district experienced an average annual rainfall of 3698 mm. It has been noticed that rainfall displays an increasing trend towards north-eastern areas of the district. The District has more or less the same climate conditions prevalent elsewhere in the state viz. dry season from December to February and hot season from March to May, the southwest monsoon from June to September and North East monsoon from October to December. The SW and NE monsoons mainly contribute rainfall in the area with 82.77 % of the rainfall. The South West monsoon is usually very heavy and merely 72.15% of the rain fall is received during this season. North East monsoon contributes nearly 10.63%. During winter (January to March) it is 0.49% and during summer (April and May) it is16.74%. The month of June experiences maximum rainfall. The months of July, August and October also receive heavy rainfall. The agricultural activity of the district depends on the onset of SW tropical monsoon.

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3.10.3 OTHER METEOROLOGICAL PARAMETERS

3.10.3.1 Temperature

The climate is generally hot and humid. March and April months are the hottest and January and February months are the coldest. The minimum temperature ranges between 22 and 25.8º C and the maximum between 28.2 and 32.9º C. The temperature starts rising from January and reaches its peak in the month of March and April and then decreases during the monsoon month and again rising from September onwards.

3.10.3.2 Relative Humidity

The relative humidity ranges from 74 to 92 % during morning hours and from 64 to 89% in evening hours. The monsoon months (June to September) record high humidity.

3.10.3.3 Wind speed

The wind is predominant from east as well as west during morning and evening hours. The wind speed ranges from 8.1 to 12.6 km/h. The maximum wind speed is during April and minimum in November.

3.10.3.4 Potential Evapotranspiration

The annual Potential Evapotranspiration (PET) is 1505.7 mm. The monthly PET ranges from 92.9 to 170.2 mm. The PET is less than the rainfall during May to November and hence the possibility of recharge to ground water regime is more during these months.

3.10.3.5 Geology

The district can be divided into three geological belts viz., (i) a linear NW-SE trending gneissic belt, along the middle extending from north to south, (ii) a charnockite belt occupying areas in the northeast and south, extending to the adjacent districts and also occurring as pockets within the gneissic terrain and (iii) a narrow coastal belt.

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3.10.3.6 Geomorphology

Geomorphology is the study of the features that make up the earth's surface and their relationship to the underlying geology. There is a well-developed beach all along the coast with sea cliffs and rocky beaches near Quilandy, Payyoli and Vadakara. Vadakara Sand banks beach is where locals and tourists throng to view the confluence of the Kottakkalkadavu and the Arabian Sea.

3.10.3.7 Soil types

The soils of the district are alluvial soil, lateritic soil and forest loam. As the project area is very near to sea, the soil in the proposed locations are sandy in nature. Mainly the Kuttiyadi river deposits a large quantity of sandy soil..

3.10.3.8 Groundwater scenario

Groundwater occurs in the weathered, fractured, crystalline and alluvial formations in the district. Phreatic conditions exist in weathered formation and are mostly developed by dug wells for domestic and irrigation purposes. Semi-confined conditions exist in deep fractures and storage and movement of groundwater is mainly controlled by the fracture system. Deep high yielding bore wells are located along fractures / lineaments . The district is divisible into two hydrological provinces viz., (i) the eastern Wayanad Plateau where dug wells give moderate yield and bore wells are feasible along fracture planes and (ii) the western mountains, which are generally unsuitable for groundwater development but the valleys with thick alluvium sustain dug wells. All the four blocks in the district are having similar hydrogeological conditions. The major water bearing formations in the district are weathered/fractured crystalline, alluvium and valley fills.

3.10.3.9 Air and Noise Pollution

Air and Noise pollution are the adverse impacts mainly during construction phase. Dust depressing measure will be done aimed at

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prevention of air pollution through watering of access roads and construction site. During construction air pollution level will be increased mostly by machine operations for earthwork. The main pollutants caused by these operations include exhaust gases emitted by machines and dust caused by the earthwork. Regular sprinkling of water during construction works will depress the dust thus reducing impact on workers. Additional measures planned to maintain air quality include locating concrete mixing plant and stockpiles in isolated area as well as confining working vehicles to designated routes only following the established schedule. Trucks loaded with loose construction materials (such as gravel, sand, soil, etc) shall be covered to minimise dust emissions during transportation. Vehicles and machinery should be fitted with effective exhaust silencers and maintained in good and efficient working order. Machinery in intermittent use should be shut down or throttled down to a minimum when not in use.

3.10.3.10 Air and Noise Pollution

The potential for soil erosion and impacts on water quality are greatest during construction, when removal of vegetation for initial clearing and grading activities exposes soil and makes it more susceptible to erosion. Temporary and permanent erosion control methods may include silt fences, flotation silt curtains, retention basins, detention ponds etc. Drainage systems, including ditches on private lands, will be maintained, restored or re-established in a manner that will not impound water. Storm water detention ponds will be constructed at feasible location

3.10.3.11 River Substrate/Habitat Impacts

Construction of the bridge piers for the Preferred Alternative may result in some disturbance of the river substrate. Based on river analyses conducted, it is anticipated that construction barges can be used during bridge construction. Direct impacts to river substrate/habitat will be avoided to the greatest extent possible by planning construction activities to minimize disturbance of the river bottom.

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The project is not expected to have any significant or irreversible negative environmental impacts neither at the construction, nor at operation phases. Impacts of the construction phase will be typical for all medium scale construction activities, short term and limited to the project sites. Control of dust and noise becomes crucial during construction phase

3.10.4 ENVIRONMENTAL ASPECTS

3.10.4.1 Positive Impacts of the Project

The potential positive environmental impacts due to project apart from its economic importance include the following.

- **Reduced noise and air pollution**. With the proposed construction of bridge, noise and air pollution levels on Moorad bridge and Vadakara town are expected to go down, because the overall human exposure to noise and air pollution will be minimal due to less congestion.
- **Reduced risk of accidents**. The proposed bridge alignment shall provide adequate safety measures and proper sight distances thereby resulting in reduced accidents and traffic congestions. Moreover with expected decrease in overall traffic density on Moorad bridge and Vadakara town, the chances of accidents will reduce considerably.
- **Improved accessibility and connectivity**
- The proposed bridge is an alternative route to Vadakara. Hence the traders can easily access the market without entering the city. The goods and other commodities for trade have to be brought through this bridge. People from the nearby Panchayat depend on Vadakara railway station for rail connectivity to the rest of the nation. They can reach the railway station without any traffic congestion on Moorad bridge and Vadakara Town.

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- **Savings in fuel consumption.** Savings in fuel consumption can be attributed to low traffic congestion and relatively less travel time due to proposed improvements.
- **Improved quality of life.** The proposed project is expected to improve the quality of life of the people residing in the project zone in terms of their economic, social and health status. Land value in the nearby areas of the proposed alignment will increase substantially.

3.10.4.2 Negative Impacts of the Project

The likely adverse environment impacts during the construction phase of the project will include the following.

- Degradation of soil, landscape and soil erosion due to improper disposal of excavated materials and construction waste;
- Spillage of oil and other substances during the construction;
- Pollution of water resources and soil by construction run-offs;
- Use of temporary construction sites (access roads, camps, machinery sites, storage facilities, etc ;)
- Use of borrow pits; extraction of aggregate material, such as gravel, sand, granite;
- Temporary air pollution related to increased truck traffic during the construction;
- Release of dust from digging-loading works and heavy machinery operation;
- Noise and vibration disturbances;
- Safety hazards during implementation of construction works.

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3.11 RISK ASSESSMENT AND MITIGATION MEASURES

3.11.1 GENERAL

Risk is an uncertainty that matters; it can affect project objectives negatively or positively. The uncertainty may be about a future event that may or may not happen and the unknown magnitude of the impact on project objectives if it does happen. Thus, a "risk" is characterized by its probability of occurrence and its uncertain impact on project objectives.

Risk of many types can occur prior to work and at the time of construction. The occurrence of the unexpected events may adversely affect the timely completion of the project. For a smooth running of the project these should be assessed and should take measures to mitigate the same. The chances of such occurrences are verified and the mitigation measures are proposed.

Table 3.22 Risk Assessment and Risk Management Plan

Risks	Assessment without Mitigation	Management Plan or Measure	Assessment with Mitigation
Project road and bridges will not be built, maintained, and operated to the specified standards	High	To ensure high quality design and supervision, Kerala Public Works Department will be executing the work. Highly qualified technical persons of DRIQ board of KPWD have designed the structure. Supervision at all stage of construction will be done by Technically highly qualified persons of National Highway wing of KPWD. Procurement for the main bridge contract included a prequalification to ensure only contractors with experience of successfully completing of similar scale and type would be permitted to	Low

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		bid for the contract.	
Major traffic and vessels collision accidents	Medium	For avoiding the hitting o vessels on bridge fender piles has been provided along with navigation area so that the main structure will always safe from hitting/collision of vessels in the river.	Low
Climate change impacts the accessibility of roads and bridges	Medium	The road profile and waterway structure clearances have been designed to compensate for potentially higher flood levels, rainfall intensity, and other climate change impacts.	Low
Land acquisition	High	Land acquisition proposal should be given in advance to Revenue authorities in advance. compensation for the acquired land will be paid as per The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Low

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Environmental risks	Medium	Environmental management plans are incorporated in bid and contract documents for civil works; annual independent monitoring of compliance is required	Low
Social and resettlement risks	Medium	Implementation of a social action plan addressing social and gender issues will be monitored. Implementation of resettlement plans and income restoration programs will be independently monitored semi-annually to address resettlement-related risks. Even though the project involves land acquisition no direct effect on residential, commercial and other establishments.	Low
Utility Shifting	High	Advance notice will be issued to service providers like KSEB, KWA, BSNL and other private firms. Utility shifting charge has been included in the estimate for shifting electric post.	Low
Unforeseen construction delays	Medium	Mitigated through force majeure provisions of the construction contracts.	Low

3.12 PROJECT MANAGEMENT ORGANISATION

Kerala Road Fund Board (KRFB) has been appointed as the special purpose vehicle (SPV) for the implementation of the project using funds from the Kerala Infrastructure Investment Fund Board (KIIFB) and National

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Highway wing of the Public Works Department (PWD) is authorized to implement the proposed coastal highway project in Kozhikode district.

3.13 CONTRACT MANAGEMENT STRATEGY

3.13.1 GENERAL

All contracts in India are to be within the framework of the Indian Contract Act, 1872, which lays down the general principles relating to formation, performance and enforceability of contracts, PWD NH Kerala officers responsible for drawing up the contract documents should keep these principles in mind.

3.13.2 DEFINITION

When two or more persons have a common intention communicated to each other to create some obligation between them, there is said to be an "agreement". An agreement which is enforceable by law is a "Contract".

3.13.2.1 The following steps are involved in procurement.

1. Preparation of Bid (Tender) Documents
2. Approval of Bid Documents by the tender accepting authority
3. Public invitation for Pre-qualification (where so specified)
4. Issue of instructions to Bidders, and Pre-qualification Criteria
5. Receipt of Applications for Pre-qualification, and their Evaluation
6. Approval of Pre-qualification
7. Invitation for Bids
8. Issue of Bid Documents to prospective bidders
9. Pre-bid meeting (if specified), issue of minutes and clarifications, with the approval of the authority who originally approved the bid documents.
10. Receipt of Bids

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11. Scrutiny of Bids and their Evaluation
12. Negotiation (where warranted)
13. Acceptance of Bid (or Rejection of Bids)

3.14 IMPLEMENTATION SCHEDULE AND WORK BREAK DOWN STRUCTURE

3.14.1 GENERAL

A Work Break down Structure (WBS), In Project management and systems Engineering, is a deliverable – oriented break down of a project into smaller components. WBS is a hierarchical and incremental decomposition of the project into phases deliverable and work packages. It shows a subdivision of effort required achieve an objective.

3.14.2 NEED FOR WBS

WBS (Work Breakdown Structure) is a critical phase in management. The time bound work schedule is an important part of every project because it helps in better handling of projects in planning, implementation etc. More over Work Breakdown Structure must be consistent in the way work gets performed.

WBS can considered as input to five key project management activities

- Cost Estimating
- Cost Budgeting
- Resource Planning
- Risk management Planning
- Activity Definition

3.14.2.1 WBS for Project Management

- Indicates the Project milestone and check point
- Helps to estimate project scope, time, risk, and other factors
- Gives a better understanding of the project

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- Provides a frame work for managing and delegating work
- Serves as a great decision – making tool

A detailed Work Program Schedule is enclosed with annexure IV having clear indication of completion of time and resources used. The start date indicated in the Work Breakdown Structure is first January2018. The end date can be shifted in accordance with the shift in date of start, keeping the period of construction constant. A detailed cash flow diagram is also appended in Annexure V.

3.15 STATUTORY CLEARANCE

A review of the project relevant legal policies, regulations and institutions at the International, National and State levels has been presented in this section. Applicable clearances required for the project under various regulations and role of various institutions in implementing various regulations and environmental management measures have been addressed below.

3.16 EIA NOTIFICATION 2006

The EIA notification dated 14 th September, 2006 imposes certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects on activities based on their potential environmental impacts as indicated in the schedule to the notification, being undertaken in any part of India unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy as approved by the Union Cabinet on 18 th May,2006 and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Authority(SEIAA)

The notification has listed out the Projects or activities requiring prior environmental clearance under Category "A" and "B" based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade recourses. Category "A" projects require prior environmental clearance from MoEF& CC on the recommendations of an

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Expert Appraisal Committee (EAC) and Category "B" project require prior environmental clearance from State or Union territory Level Environment Impact Assessment Authority (SEIAA) on the recommendations of a State or Union territory Level Expert Appraisal Committee (SEAC). In the absence of a duly constituted SEIAA or SEAC, a category "B"project shall be treated as a Category "A" project.

New National Highways and expansion of National Highways greater than 100 Km, involving additional right of way greater than 40 m on existing alignment and 60m on realignment involving land acquisition is categorized as "A" New State Highways and expansion of State Highways project in hilly terrain (above 1000 on AMSL) and or ecologically sensitive areas is categorized as "B" . Any project specified in category "B" will be treated as category A, If located in whole or in part within 10Km from the boundary of (i) Protected Areas notified under the Wild life (Protection) Act, 1972, (ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time , (iii) Notified Eco-sensitive areas and (iv) inter-State boundaries and international boundaries.

As the new bridge will not come under hilly terrain or ecologically sensitive areas, the project will not attract EIA notification 2006.

3.16.1 COASTAL REGULATION ZONE (CRZ) CLEARANCE

As populations in coastal areas increase and the economic activity diversifies, all the impacts on coastal environment are bound to worsen threatening survival of several species, productivity of the biota, and render fishing an unsustainable proposition. It is, therefore, clear that unless governments and resource users take appropriate action, the degradation of the coastal and marine environment will become uncontrollable and there will be no possibilities for sustainable use of resources from these waters. The Coastal Regulation Zone (CRZ) Act notified by the Ministry of Environment and Forests in 1991 needs to be seen against this background. It declares coastal stretches as CRZ and regulates certain activities within the zone. The provisions of the act are to be implemented by the coastal states and Union

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Territories. It also envisages the creation of an appropriate authority at the state/UT level to be responsible for enforcement and enactment of these provisions. The request for CRZ clearance is applied through the corresponding local bodies. Provision for 5% of the estimated cost of work as lumpsum is included in the estimate as fee for CRZ clearance.

3.17 QUALITY MANAGEMENT PLAN

3.17.1 BACKGROUND

The Quality Management Plan is an integral part of any project management plan. The purpose of the Quality Management Plan is to describe how quality will be managed throughout the lifecycle of the project. It also includes the processes and procedures for ensuring quality planning, assurance, and control are all conducted. All stakeholders should be familiar with how quality will be planned, assured, and controlled.

Quality Assurance is defined as all the planned and systematic activities implemented within the Quality System and demonstrated as needed, to provide adequate confidence that an object will fulfil the requirements. The PWD Quality Management Manual provides a base document outlining policy, procedures, responsibilities, compliance, acceptance criteria and documentation.

3.17.2 ADOPTED STRATEGY

This section of the Quality Management Plan describes the approach the organization will use for managing quality throughout the project's life cycle. Quality must always be planned into a project in order to prevent unnecessary rework, waste, cost, and time. Quality should also be considered from both a product and process perspective.

3.17.3 STRUCTURE OF QUALITY MANAGEMENT WING

Quality control tests have been made mandatory for projects undertaken by state PWD from 1.9.2014. Clause 2401 and 2406 of Revised PWD Manual - 2012 stipulates that PWD shall follow a three-tier quality

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control system for ensuring quality of projects executed. This includes technical audit after completion of construction. The system envisaged is as below:

3.17.3.1 First-tier QC testing

In first-tier QC testing, the Contractor has to carry out the required tests at his own cost during the course of a work. First tier quality control tests are mandatory for all projects

As per Govt. circular No. 23631/G2/2013/PWD dated 1.11.2013, Contractors shall establish field laboratories at the site. If any test cannot be carried out with the facilities available in the Contractor's laboratory, it shall be got done in an approved laboratory by the Contractor at his own cost.

If the QC test is done in the field laboratory established at site, the test results shall be signed by the Overseer/Assistant Engineer, whoever is supervising the work. It shall also be signed by the Contractor. Copy of test results shall be forwarded by the Assistant Engineer to the Assistant Executive Engineer/Executive Engineer for review. The same procedure shall be followed, in case of tests done in an approved laboratory also.

3.17.3.2 Second-tier QC testing

Second-tier QC checks/tests are to be done by the QC wing of PWD on a random basis. However, it is desirable that the QC wing does quality control tests for all major and important items of construction. The frequency of tests shall be as per PWD Quality Control Manual or as specified in the Contract. The QC wing is authorized to inspect all projects undertaken by PWD, and conduct quality tests.

3.17.3.3 Third-tier QC checking (Technical audit)

As per clause 2406 of the revised PWD Manual 2012, Technical audit shall be done by an external agency/expert empanelled for the purpose after the construction of a project is completed. This will form the third tier of QC system. Technical audit shall be done for projects, estimated cost of which is

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above Rs 5 crores. All tests carried out in the first-tier and second-tier QC testing shall be reviewed during technical audit. Technical Audit shall be completed within six months from the date of completion of construction. Non-destructive testing techniques shall be adopted if conventional testing techniques cannot be applied.

3.18 OPERATION AND MAINTENANCE PLAN

3.18.1 GENERAL

After the construction is completed, it is essential that the bridge structure is kept under observation and its condition monitored regularly so as to ascertain its performance and the efficiency of the measures adopted. The monitoring may involve inspections at frequent intervals, carrying out of certain laboratory and field-tests as well as condition surveys and measurements to detect even small strains, movements, changes in deformation etc.

3.18.2 INSPECTION OF WORK

Periodical inspection shall be conducted for all bridges as per IRC guidelines. Detailed guidelines for highway bridge inspection and maintenance are contained in the following and the same should be invariably followed.

- IRC SP 35 "Guidelines for Inspection and Maintenance of Bridges",
- IRC Special Publication No 18 "Manual for Highway Bridge Maintenance Inspection"
- IRC: 52-1998 "Bridge Inspection's Reference Manual".

3.18.3 MAINTENANCE

The purpose of detailed inspection as outlined above is to find out whether damage or deterioration has occurred in any part of the structure and if so immediate steps have to be taken for appropriate Remedial measures

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3.18.4 REMEDIAL MEASURES

- Where there is any growth of vegetation, shrub, etc. in the masonry or concrete part of the structure, the removal of such vegetation and steps to prevent such growth.
- Wherever bearings are provided the greasing or oiling of such bearings
- Periodical painting of steel and cast iron structures of parts of bridges. Normally painting shall be done once every year unless special circumstances warrant changing the periodicity.
- Wherever scours are noted, filling up the scours with stones of suitable size in such a manner as is found best suited to circumstances.
- Wherever cracks, spalling of concrete, disintegration etc. are noted in wearing coat, drainage spouts, hand rails, footpaths and construction joints shall be rectified.
- Corrosion of reinforcement shall be attended.
- Missing and broken footpath slab shall be replaced immediately

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4 LAND ACQUISITION

There is no development to the country without land. Land required for construction of Highways, Roads, Bridges, Railways, Airports etc. The Proposed bridge at Kottakkalkadavu -Sandbanks which is a part of coastal highway also require minimum land for construction. The land acquisition for the construction of bridge is minimum and there is no direct effect on residential, commercial buildings and other establishments. The process of land acquisition for the construction of proposed bridge is carried out as per the 'The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013'. The amount of compensation to be awarded for land owners as per the provisions of this act.

4.1 LAND ACQUISITION ACT, 2015

An Act to ensure, in consultation with institutions of local self-government and Gram Sabha's established under the Constitution, a humane, participative, informed and transparent process for land acquisition for industrialization, development of essential infrastructural facilities and urbanization with the least disturbance to the owners of the land and other affected families and provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition and make adequate provisions for such affected persons for their rehabilitation and resettlement and for ensuring that the cumulative outcome of compulsory acquisition should be that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto.

4.1.1 APPLICATION OF ACT

- The provisions of this Act relating to land acquisition, compensation, rehabilitation and resettlement, shall apply, when the appropriate Government acquires land for its own use, hold and control, including

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for Public Sector Undertakings and for public purpose, and shall include the following purposes, namely:

a. for strategic purposes relating to naval, military, air force, and armed forces of the Union, including central paramilitary forces or any work vital to national security or defense of India or State police, safety of the people; or
b. for infrastructure projects,

- The provisions of this Act relating to land acquisition, consent, compensation, rehabilitation and resettlement, shall also apply, when the appropriate Government acquires land for the following purposes, namely:

a. for public private partnership projects, where the ownership of the land continues to vest with the Government, for public purpose as defined in sub-section (1)
b. For private companies for public purpose, as defined in sub - section (1)

The total land area to be acquired for the construction of proposed bridge at Kottakkalkadavu-Sandbanks is 0.99 Ha. In this 10% of land exists as public road and the remaining 90% to be acquired from private parties. The amount of compensation to be awarded for land owners as per the market value of the land at the premises.

The details such as the extent of land to be acquired, survey number, type of land, taluk, village, Name of land owner is already submitted to Revenue Department. The Revenue Department is the acquiring authority and hence 5% of charge should be paid to them

4.1.1 LAND ACQUISITION BRIDGE FROM KOTTAKKAL TO SANDBANKS

The total land area to be acquired for the construction of proposed Coastal highway from Kolavipalam to Kodikkal beach is 2.446 acres. In this nearly 20% of land exists as public road and the remaining 80% to be

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acquired from private parties. The amount of compensation to be awarded for land owners as per the market value of the land at the premises.

The details such as the extent of land to be acquired, survey number, type of land, taluk, village, Name of land owner is already submitted to Revenue Department. The Revenue Department is the acquiring authority and hence 5% of charge should be paid to them. Provision for the same is included in the estimate as lumpsum amount.

4.1.2 LOCATION OF LAND ACQUISITION

A total area of 0.991 hectors has to be acquired for the construction of coastal highway in this stretch. The land to be acquired lies in three villages namely Iringal village and in Vadakara village in Koyilandi Thaluk and Vadakara Thaluk in Kozhikode District, Kerala State.

KERALA PWD
NH DIVISION KOZHIKODE

5 GREEN POWER GENERATING BRIDGE

The Kunjali marakkar bridge at kottakkalkadavu sandbanks is proposed as 537 m long bridge. For lighting arrangements in this bridge, it requires 10950-unit power in a year which has to be obtained from KSEB or can be produced by solar panels fitted on the light poles. In this proposal a row of solar panels is proposed on both the sides of bridge which will generate 142-kilowatt power without affecting the functional, structural and aesthetics of bridge. This power bill be more than that that required for the lighting of the bridge.

Solar panels will be installed and maintained by KSEB and Rent for the solar panel area can be paid by KSEB in terms of power for lighting arrangements along the bridge and on newly proposed coastal highway.

Solar panels can be installed parallel to the bridge and it will be 75 cm away from the bridge body. The panels can be installed for a length of 475 m on both the sides of the bridge which will provide an area of 1425 m square of solar panel. According to KSEB they can produce 142-kilowatt power from this area, that is 414640 unit of power in a year.

A small pothhead yard can be made under the bridge on sandbank side from which power can be transmitted to the grid. For the installation of solar panel, a GI bar MS "C" channels can be taken out from the sides of the deck slab for a length of 1.2 metre. The solar panel can be fitted over this C channels provision for which has been included in this DPR.

KERALA PWD
NH DIVISION KOZHIKODE

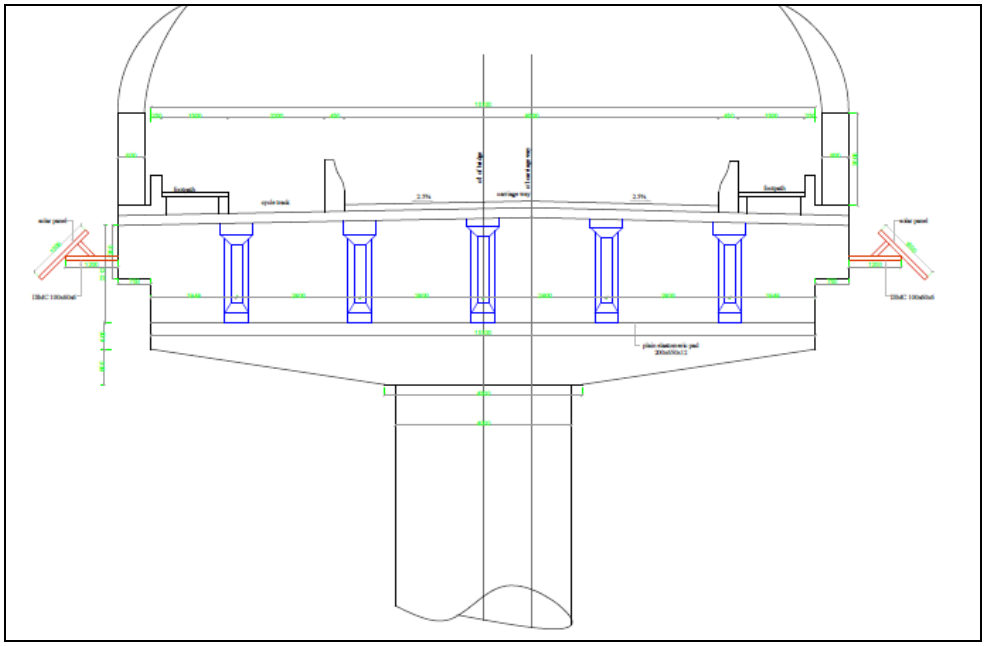


Figure 5.1 Installation of solar pannel

The installation and maintenance cost of solar panels and all other accessories excluding C channels has to be borne by the KSEB. By installing solar panels on this bridge can produce 414640 units in a year.

The total consumption of power for lighting arrangements in this bridge is worked out to be 10950 units in a year. 403690 units of electricity will be saved in a year. This will come to Rs. 27.5 lakhs and the cost of power for the lighting arrangements on the bridge.

Installation of the solar panels on bridge will not affect the functional, structural and aesthetics of the bridge.

The green power generating Kunjali marakkar bridge will be a new concept for the bridges in India as well as for the power producing agencies like Kerala state electricity board. Moreover, it will be a revenue-generating bridge.

KERALA PWD
NH DIVISION KOZHIKODE

6 CONCEPT NOTE

The proposed coastal highway Bridge from Kottakkal kadavu to Sand banks which passes along the coastal belt of Vadakara connecting Koyilandy and Vadakara taluks in Kozhikode district. It is an alternative route to Vadakara from Kozhikode. Construction of proposed bridge can help the passengers to travel without entering Vadakara town. This will surely help in saving time and fuel and reducing traffic congestion on the towns and in the national highway. The proposed Kunjalimarakkar bridge from Kottakkalkadavu to Sandbanks is an integrated structure. It has two lanes having total length of 537m and approach road of 160.00 m on Kottakkal side and 90.00 m on Sandbanks side. The recommended width of the proposed bridge is 15.60m. The main components of the proposed bridge are 7.5m Carriageway, 1.5m Footpath, 2m cycle track, Shoulders, Kerbs, RCC precast panels, Drainage, Utility duct, Protection works, Safety barriers and pedestrian guard rails. Provision for holding solar panel is given in the estimate so that the electricity can be generated from the bridge itself.

The proposed coastal highway is planned almost parallel to the National Highway 66 is expected to divert a major share of the traffic from the NH and cities. Besides reducing the congestion in the NH corridors and in the cities, the Coastal Highway is expected to boost the tourism sector and help better integration with various other modes of transport.

The bridge is designed after detailed investigation and to be constructed according to requirement standards of traffic, nature of soil etc.

KERALA PWD
NH DIVISION KOZHIKODE

The success of the project depends on a time-bound and early implementation of the entire package of the development proposals. The implementation shall be supplemented with timely maintenance activities to sustain the quality of road infrastructure and furniture.

Baiju. P. B
Assistant Executive Engineer
PWD NH Bypass Sub Division
Kozhikode

Thushara. K
Assistant Engineer
NH Bypass Section
Nellikkode

KERALA PWD
NH DIVISION KOZHIKODE

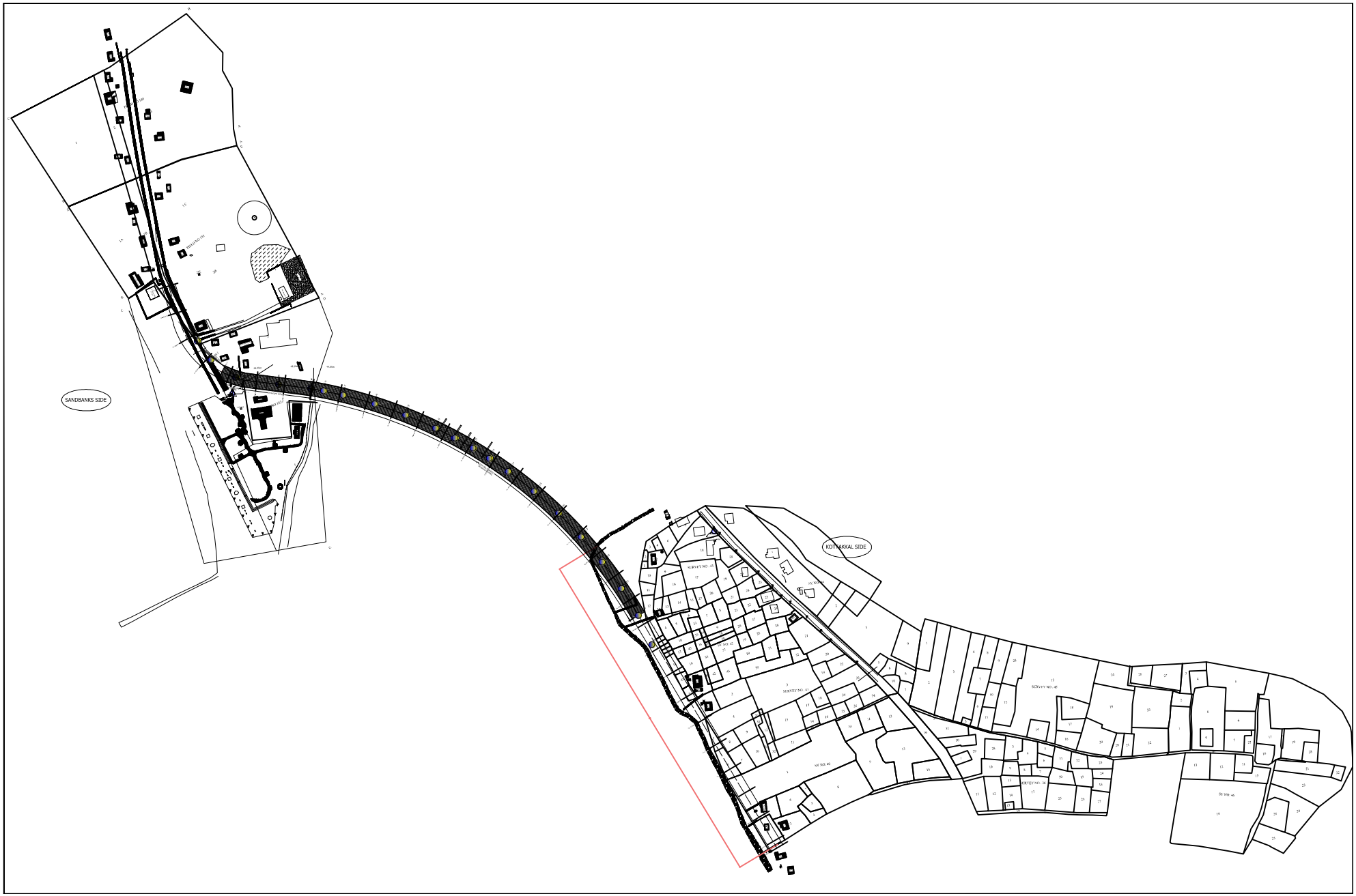
ANNEXURE I

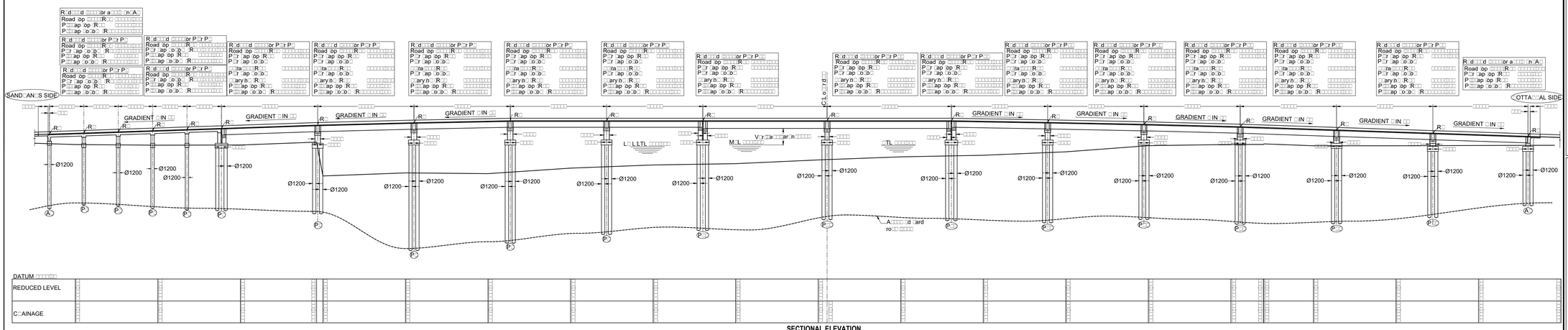
DRAWINGS

ALIGNMENT DRAWING

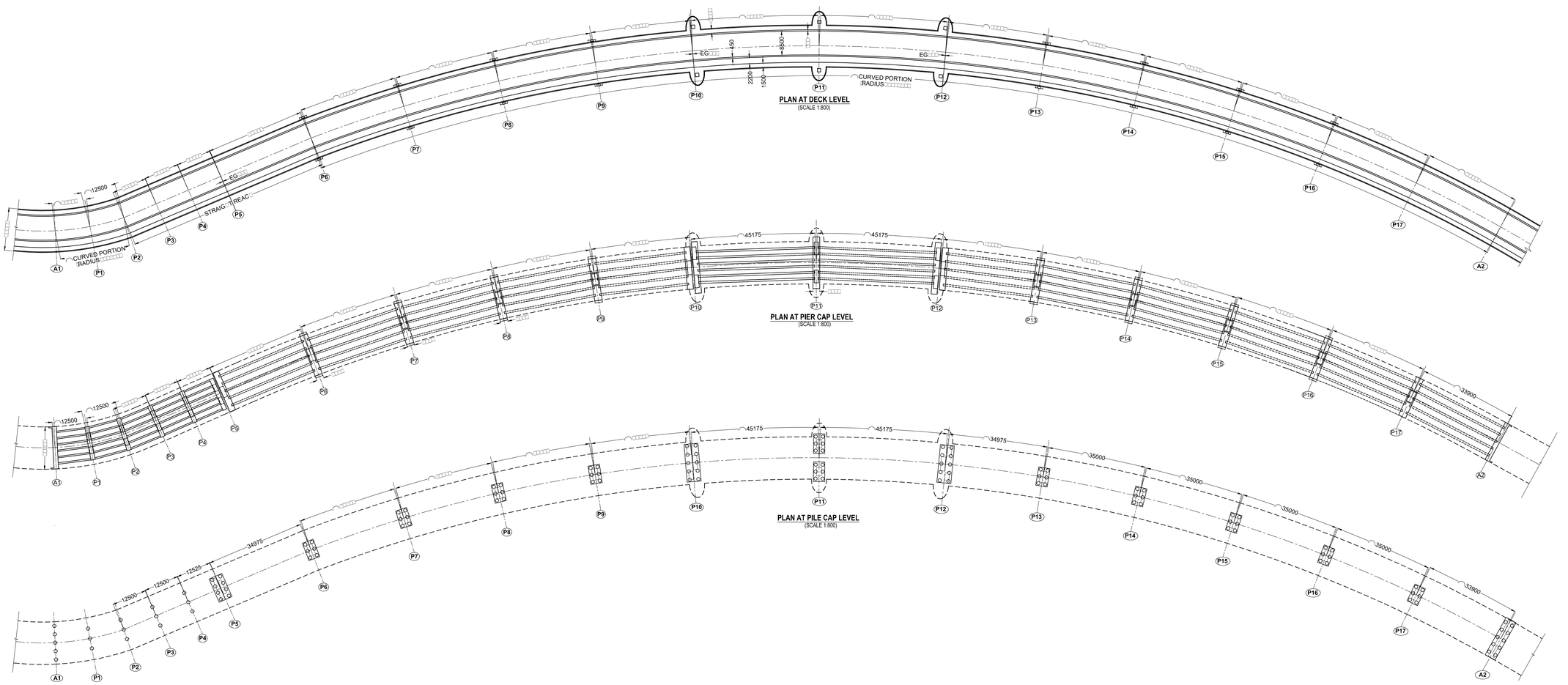
KUNJALIMARAKKAR BRIDGE

FROM KOTTAKKAL TO SANDBANKS


SANDBANKS SIDE
KOTTAKKAL SIDE



SECTIONAL ELEVATION
(SCALE 1:800)



PLAN AT DECK LEVEL
(SCALE 1:800)

PLAN AT PIER CAP LEVEL
(SCALE 1:800)

PLAN AT PILE CAP LEVEL
(SCALE 1:800)

KEY PLAN:

NOTES:

I. GENERAL

1. All dimensions are in millimeters and all levels are in meters unless otherwise mentioned.
2. Only written dimensions are to be followed. No drawing shall be scaled.

No.	Letter No.	Date	Description
2			
1	CE/NH)/Coastal Highway-6966/2015	06/04/2016	Investigation Details

REFERENCE LETTERS

No.	Drawing/Sheet No.	Date	Drawing Title
5			
4	1(d)/6	/10/2019	NOTES ON BRIDGE ELEMENTS
3			
2			
1	1(a)/6	/10/2019	GENERAL NOTES

REFERENCE DRAWINGS

Rev. No.	Designed	Checked	Reviewed	Recommended	Approved	Date	Description
R4							
R3							
R2							
R1							

REVISIONS

NAME OF ROAD: VATAKARA-PAYYOLI

ROAD No.:

NAME OF CROSSING: KUTTIYADI RIVER

ROAD CHAINAGE AT C/L OF CROSSING: CH: 393.225

NAME OF BRIDGE: KOTTAKKAL-SANDBANKS

BRIDGE No.:

DRAWING ISSUED FOR:
- ☑ DPR PREPARATION
- ☐ ADMIN./FINANCIAL SANCTION
- ☐ TECHNICAL SANCTION
- ☐ CONSTRUCTION

EXECUTION WING: -

NAME OF DIVISION: KOZHIKKODE

ROAD CATEGORY:
- ☐ NATIONAL HIGHWAY
- ☐ STATE HIGHWAY
- ☑ MAJOR DISTRICT ROAD
- ☐ OTHER DISTRICT ROAD
- ☐ VILLAGE ROAD

DRAWN BY: SANTHI A., 2ND GRADE DRAFTSMAN

DESIGNED BY: REMIL K., ASSISTANT BRIDGE ENGINEER

BRIDGE CATEGORY:
- ☐ CULVERT
- ☐ MINOR BRIDGE
- ☑ MAJOR BRIDGE
- ☐ FLYOVER BRIDGE
- ☐ UNDER PASS
- ☐ ROAD OVER BRIDGE
- ☐ ROAD UNDER BRIDGE
- ☐ CAUSEWAY

CHECKED BY: ARUN K.S., BRIDGE ENGINEER

CONSTRUCTION NATURE:
- ☑ NEW
- ☐ RECONSTRUCTION
- ☐ REHABILITATION

REVIEWED BY: SAJU S., SENIOR BRIDGE ENGINEER

RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I & QC)

DATE: /10/2019

APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 04712322029 Website: keralapwd.gov.in
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BDU|CDO|PWD

DRAWING TITLE: TENTATIVE GENERAL DESIGN DRAWING

DRAWING SCALE: 1:800

SHEET SIZE: A1

REVISION No.: R0

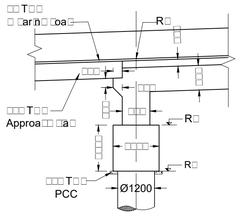
DRAWING No.: CDO/BDU/ /19

SHEET No.: 2a/6

CROSS SECTION

KUNJALIMARAKKAR BRIDGE

FROM KOTTAKKAL TO SANDBANKS



LONGITUDINAL ELEVATION OF ABUTMENT A1
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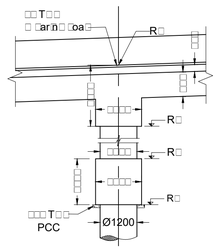

LONGITUDINAL ELEVATION OF PIERS P1, P2, P3 & P4
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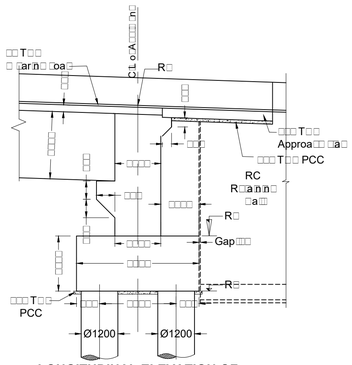

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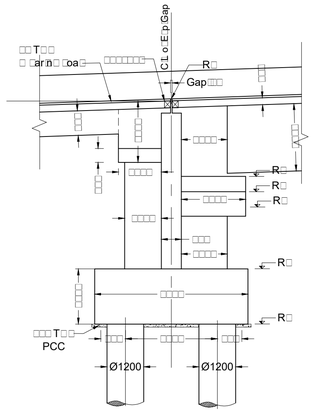

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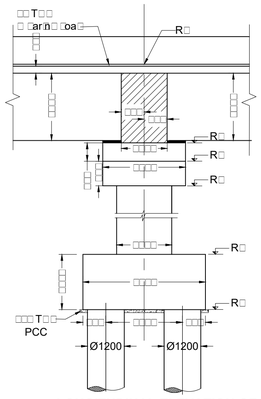

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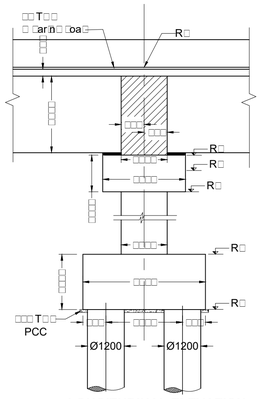

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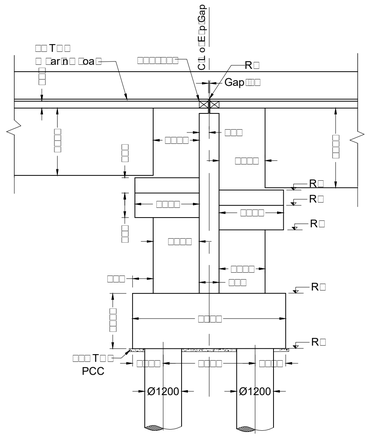

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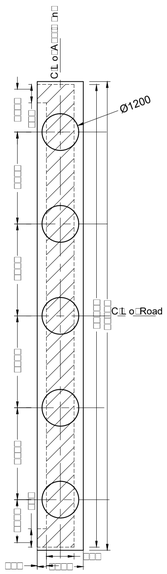

ARRANGEMENT OF PILE UNDER ABUTMENT A1
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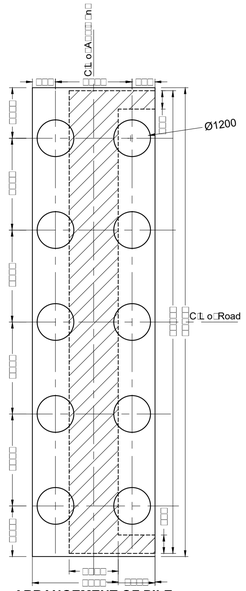

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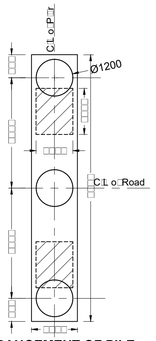

ARRANGEMENT OF PILE UNDER PIERS P1, P2, P3 & P4
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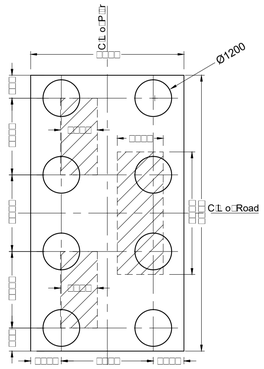

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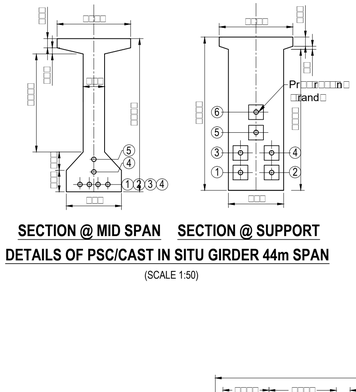

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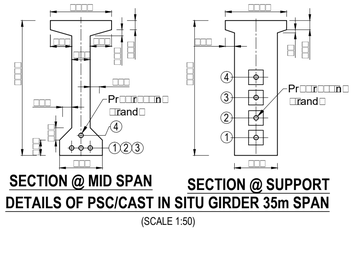
DETAILS OF PSC/CAST IN SITU GIRDER 44m SPAN
(SCALE 1:50)



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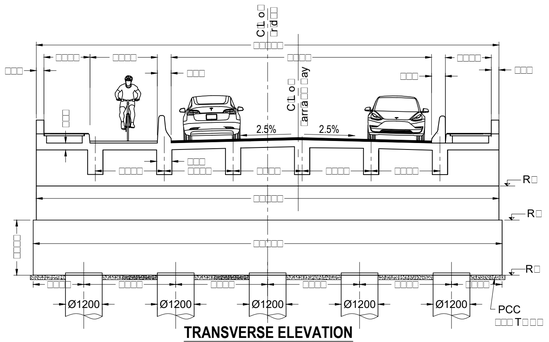

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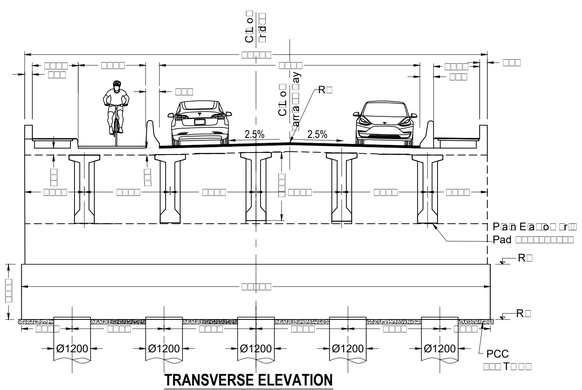

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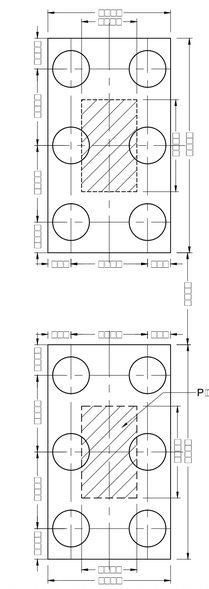

ARRANGEMENT OF PILE UNDER PIER P11
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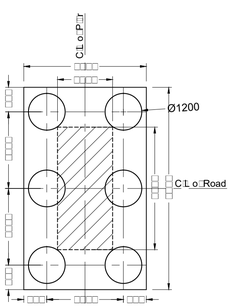

ARRANGEMENT OF PILE UNDER PIERS P6 TO P9 & P13 TO P17
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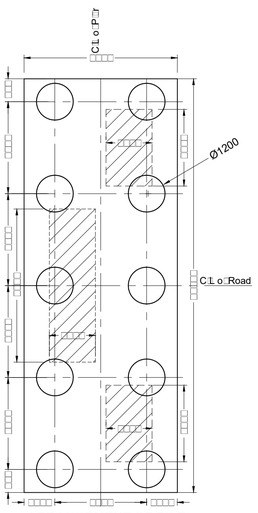

ARRANGEMENT OF PILE UNDER PIER P10 & P12
(SCALE 1:100)

KEY PLAN:

NOTES:

I. GENERAL
1. All dimensions are in millimeters and all levels are in meters unless otherwise mentioned.
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1	CE/NH)/Coastal Highway-6966/2015	06/04/2016	Investigation Details

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5			
4	1(d)/6	/10/2019	NOTES ON BRIDGE ELEMENTS
3			
2			
1	1(a)/6	/10/2019	GENERAL NOTES

REFERENCE DRAWINGS

Rev. No.	Designed	Checked	Reviewed	Recommended	Approved	Date	Description
R4							
R3							
R2							
R1							

REVISIONS

NAME OF ROAD: VATAKARA-PAYYOLI
ROAD No.:

NAME OF CROSSING: KUTTIYADI RIVER
ROAD CHAINAGE AT C/L OF CROSSING: CH: 393.225

NAME OF BRIDGE: KOTTAKKAL-SANDBANKS
BRIDGE No.:

DRAWING ISSUED FOR:
- ☑ DPR PREPARATION
- ☐ ADMIN./FINANCIAL SANCTION
- ☐ TECHNICAL SANCTION
- ☐ CONSTRUCTION

ROAD CATEGORY:
- ☐ NATIONAL HIGHWAY
- ☐ STATE HIGHWAY
- ☑ MAJOR DISTRICT ROAD
- ☐ OTHER DISTRICT ROAD
- ☐ VILLAGE ROAD

BRIDGE CATEGORY:
- ☐ CULVERT
- ☐ MINOR BRIDGE
- ☑ MAJOR BRIDGE
- ☐ FLYOVER BRIDGE
- ☐ UNDER PASS
- ☐ ROAD OVER BRIDGE
- ☐ ROAD UNDER BRIDGE
- ☐ CAUSEWAY

CONSTRUCTION NATURE:
- ☑ NEW
- ☐ RECONSTRUCTION
- ☐ REHABILITATION

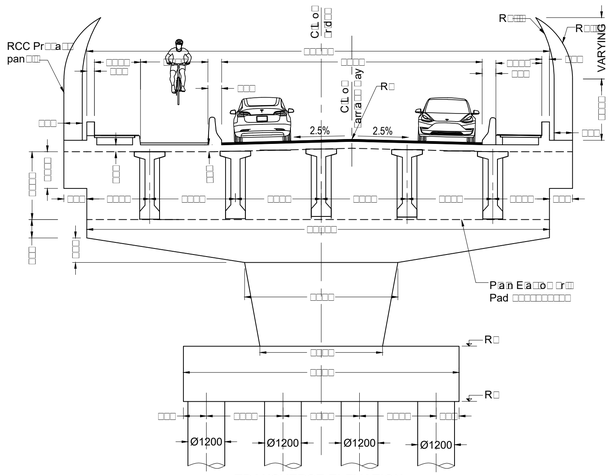
DATE: /10/2019

EXECUTION WING: NATIONAL HIGHWAY
NAME OF DIVISION: KOZHIKKODE
DRAWN BY: SANTHI A., 2ND GRADE DRAFTSMAN
DESIGNED BY: REMIL K., ASSISTANT BRIDGE ENGINEER
CHECKED BY: ARUN K.S., BRIDGE ENGINEER
REVIEWED BY: SAJU S., SENIOR BRIDGE ENGINEER
RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I & QC)
APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

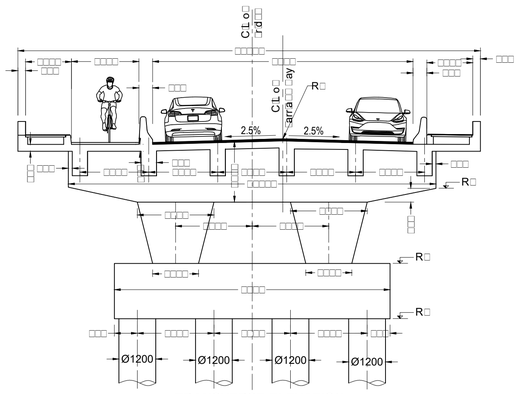
Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 04712322029 Website: keralapwd.gov.in
Fax: Email: bducdo.pwd@gmail.com

BDU|CDO|PWD

DRAWING TITLE: TENTATIVE GENERAL DESIGN DRAWING
DRAWING SCALE: 1:100 & 1:50
SHEET SIZE: A1
REVISION No.: R0
DRAWING No.: CDO/BDU/ /19
SHEET No.: 2b/6



TRANSVERSE ELEVATION
OF PIER P5 (35m span side)



TRANSVERSE ELEVATION
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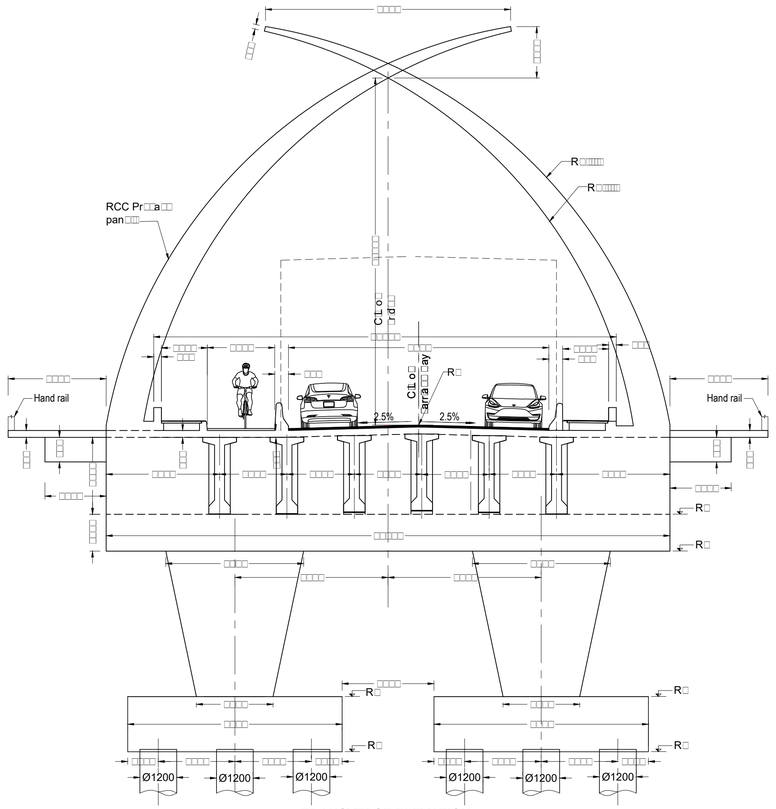
(SCALE 1:100)



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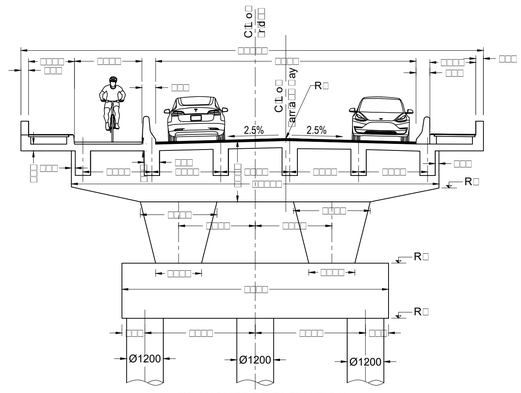

TRANSVERSE ELEVATION
OF PIERS P1, P2, P3 & P4
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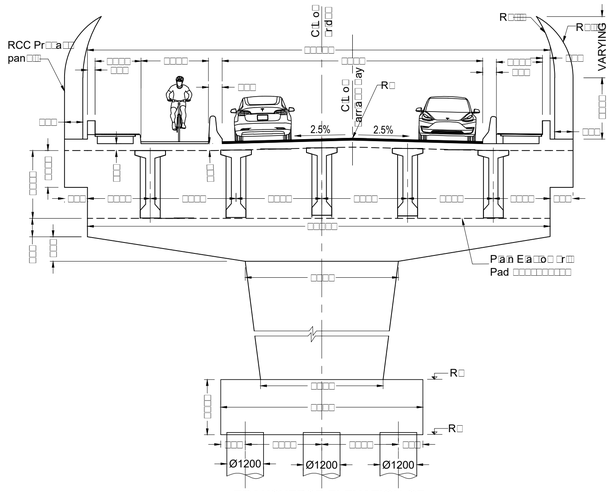

TRANSVERSE ELEVATION OF
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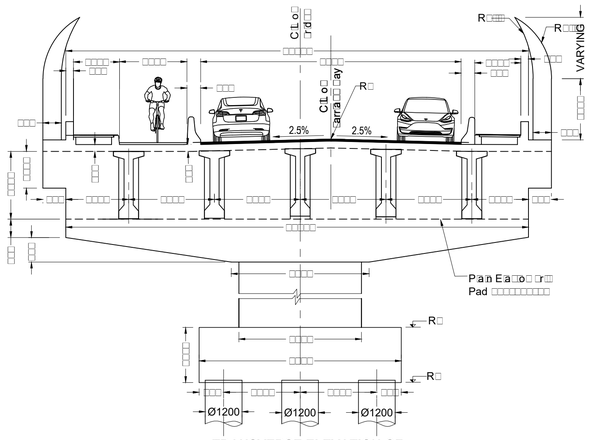

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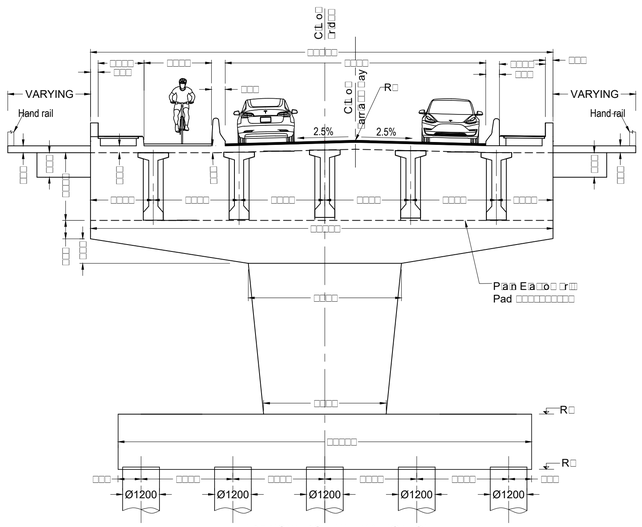
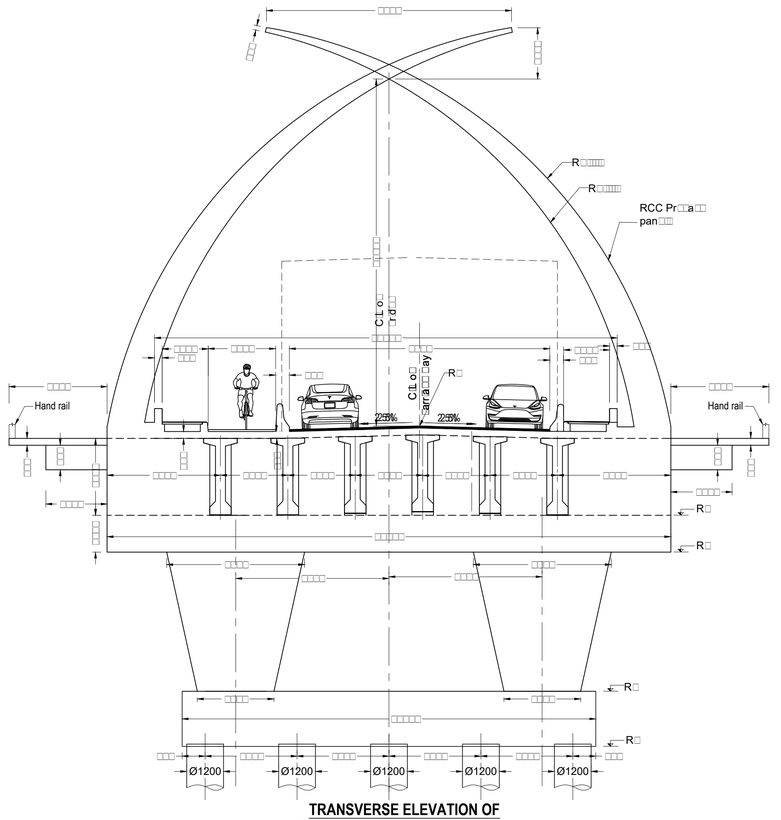


TRANSVERSE ELEVATION OF
PIERS P10 & P12 (35m span side)
(SCALE 1:100)



TRANSVERSE ELEVATION OF
PIERS P10 & P12 (45m span side)
(SCALE 1:100)

KEY PLAN:

NOTES:

I. GENERAL

1. All dimensions are in millimeters and all levels are in meters unless otherwise mentioned.
2. Only written dimensions are to be followed. No drawing shall be scaled.

No.	Letter No.	Date	Description
2			
1	CE/NH)/Coastal Highway-6966/2015	06/04/2016	Investigation Details

REFERENCE LETTERS

No.	Drawing/Sheet No.	Date	Drawing Title
5			
4	1(d)/6	/10/2019	NOTES ON BRIDGE ELEMENTS
3			
2			
1	1(a)/6	/10/2019	GENERAL NOTES

REFERENCE DRAWINGS

Rev. No.	Designed	Checked	Reviewed	Recommended	Approved	Date	Description
R4							
R3							
R2							
R1							

REVISIONS

NAME OF ROAD: VATAKARA-PAYYOLI

ROAD No.:

NAME OF CROSSING: KUTTIYADI RIVER

ROAD CHAINAGE AT C/L OF CROSSING: CH: 393.225

NAME OF BRIDGE: KOTTAKKAL-SANDBANKS

BRIDGE No.:

DRAWING ISSUED FOR:
- ☑ DPR PREPARATION
- ☐ ADMIN./FINANCIAL SANCTION
- ☐ TECHNICAL SANCTION
- ☐ CONSTRUCTION

ROAD CATEGORY:
- ☐ NATIONAL HIGHWAY
- ☐ STATE HIGHWAY
- ☑ MAJOR DISTRICT ROAD
- ☐ OTHER DISTRICT ROAD
- ☐ VILLAGE ROAD

BRIDGE CATEGORY:
- ☐ CULVERT
- ☐ MINOR BRIDGE
- ☑ MAJOR BRIDGE
- ☐ FLYOVER BRIDGE
- ☐ UNDER PASS
- ☐ ROAD OVER BRIDGE
- ☐ ROAD UNDER BRIDGE
- ☐ CAUSEWAY

CONSTRUCTION NATURE:
- ☑ NEW
- ☐ RECONSTRUCTION
- ☐ REHABILITATION

DATE: /10/2019

EXECUTION WING: NATIONAL HIGHWAY

NAME OF DIVISION: KOZHIKKODE

DRAWN BY: SANTHI A., 2ND GRADE DRAFTSMAN

DESIGNED BY: REMIL K., ASSISTANT BRIDGE ENGINEER

CHECKED BY: ARUN K.S., BRIDGE ENGINEER

REVIEWED BY: SAJU S., SENIOR BRIDGE ENGINEER

RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I & QC)

APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 04712322029 Website: keralapwd.gov.in
Fax: Email: bducdo.pwd@gmail.com

BDU|CDO|PWD

DRAWING TITLE: TENTATIVE GENERAL DESIGN DRAWING

DRAWING SCALE: 1:100

SHEET SIZE: A1

REVISION No.: R0

DRAWING No.: CDO/BDU/ /19

SHEET No.: 2c/6

GENERAL NOTES

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14. DESIGN CRITERIA

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15. DESIGN LIVE LOADS

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16. CONSTRUCTION SEQUENCE

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17. CEMENT

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18. COARSE AND FINE AGGREGATES

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19. ADMIXTURES

To □□□a□y □pro□□ □ora□□□y and n□r□a□□ n□a□□□□□n□ □□□ o□□on□r□□□ and □□□ □n□ ro□□□ad□ □□□r□□ □on□or□ □n□ o IS□□□□□□and ASTM C□□□□ Typ□ □ □a□□r□d□n□□ □□□□ ran□□ ad□ □□□r□□□□ □□a□ □□ p□r□□□d in appropr□a□ do□a□□□□□□□□□o □□□r □a□□a□□ory pro□□n □□□□

20. REINFORCEMENT

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21. WATER:

□a□r □or □on□r□□ and □or □□ □r□n□ □□a□□□ o□po□a□□ □□a□y and pr□□n□□ o□any □a□□□□□□ar□ and po□□an□ □□□□ □□□ord□□□□□p□a□□a□a□□□□□□□a□ □□ □ □□□□ □□□n □□□r □□ □□ p□□□□d in C□□□□□□□□ o□IRC□□□□ □□□□□□□

22. CONCRETE

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□□ C□□ □n□on□n□n□ □□□ □on□r□□ □ □□ □a□no□□□ □□□□ □an □□□ r□□p□□□□□ values specified in Table-3 and not more than 450kg/m³.

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23. ACCEPTANCE CRITERIA FOR CONCRETE

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24. DECK DRAINAGE

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25. EXPANSION-CONTRACTION JOINTS

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26. LIGHTING ON DECK:

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27. ROAD MARKINGS

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28. SIGNALS

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29. PAINTING AND PROTECTIVE COATINGS

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30. APPROACH EMBANKMENT

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31. RIVER TRAINING AND PROTECTION WORKS

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KEY PLAN:

NOTES:

No.	Letter No.	Date	Description
3			
2			
1	CE/NHJ/Coastal Highway-6966/2015	06/04/2016	Investigation Details

REFERENCE LETTERS

No.	Drawing/Sheet No.	Date	Drawing Title
4			
3			
2			
1			

REFERENCE DRAWINGS

Rev. No.	Designed	Checked	Reviewed	Recommended	Approved	Date	Description
R4							
R3							
R2							
R1							

REVISIONS

NAME OF ROAD: VATAKARA-PAYYOLI

ROAD No.

NAME OF CROSSING: KUTTIYADI RIVER

ROAD CHAINAGE AT C/L OF CROSSING: CH: 392.225

NAME OF BRIDGE: KOTTAKKAL-SANDBANKS

BRIDGE No.

DRAWING ISSUED FOR:
- ☑DPR PREPARATION
- ☐ADMIN./FINANCIAL SANCTION
- ☐TECHNICAL SANCTION
- ☐CONSTRUCTION

EXECUTION WING: BRIDGES

NAME OF DIVISION: KANNUR

DRAWN BY: SANTHI A., 2ND GRADE DRAFTSMAN

DESIGNED BY: REMIL K., ASSISTANT BRIDGE ENGINEER

CHECKED BY: ARUN K.S., BRIDGE ENGINEER

REVIEWED BY: SAJU S., SENIOR BRIDGE ENGINEER

RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I & QC)

APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

ROAD CATEGORY:
- ☐NATIONAL HIGHWAY
- ☐STATE HIGHWAY
- ☑MAJOR DISTRICT ROAD
- ☐OTHER DISTRICT ROAD
- ☐VILLAGE ROAD

BRIDGE CATEGORY:
- ☐CULVERT
- ☐MINOR BRIDGE
- ☑MAJOR BRIDGE
- ☐FLYOVER BRIDGE
- ☐UNDER PASS
- ☐ROAD OVER BRIDGE
- ☐ROAD UNDER BRIDGE
- ☐CAUSEWAY

CONSTRUCTION NATURE:
- ☑NEW
- ☐RECONSTRUCTION
- ☐REHABILITATION

DATE: /11/2019

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
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DRAWING TITLE: GENERAL NOTES

DRAWING SCALE:

SHEET SIZE: A3

REVISION No. R0

DRAWING No. CDO/BDU/ /19

SHEET No. 1(a)/5

NOTES ON BRIDGE ELEMENTS

1. SUPERSTRUCTURE

a) The superstructure is PSC slab and beam type as shown in Table-3.

b) The Grade of concrete for superstructure is as per Table-3.

c) The prestressing system, anchorages, grouting, etc. shall be as per the approved drawings and specifications.

d) The superstructure is designed as simply supported and continuous structure as shown in the drawings.

e) No construction joint is allowed in the prohibited zones as shown in the drawings. Construction joints, if any, provided at locations other than those shown in the drawings shall be as directed by the Engineer.

f) Provision of construction joints in the span direction shall be as per the approved drawings or as directed by the Engineer.

g) The prestressing of PSC slab and beam shall be as per the following tolerances.

Variation in the cross section of the beam	+10 to -5 mm
Variation in the vertical profile or camber	: ±5mm
Variation in the horizontal alignment of the span	±10mm OR 1/1000 of the span, whichever is less
Shrinkage and temperature stresses	As per IRC:112

2. SUBSTRUCTURE

a) The substructure consists of pier and abutment as shown in the drawings. The foundation shall be designed and constructed as per the approved drawings or as directed by the Engineer.

b) The Grade of concrete for substructure is as per Table-3.

c) Vertical deviation of pier and abutment from the plumb line shall not exceed 1/500 of the height of the pier or abutment, subject to a maximum of 50 mm, provided the deviation is gradual and uniform. The deviation shall be measured at the top of the pier or abutment.

d) In case of piers and abutments constructed in flowing water, adequate protection shall be provided to the foundation and the substructure from scour as per the approved drawings and specifications. The protection measures shall be designed by the Consultant and approved by the Engineer.

e) Additional measures for the protection of bridge foundations against scour, if any, shall be carried out as directed by the Engineer. The foundations shall be designed for the anticipated hydraulic forces, including the forces due to the protection measures.

f) The permissible tolerances for substructure construction shall be as per the following.

Variation in cross sectional dimensions	-5 to +10 mm
Misplacement from the specified position in plan	: ±10mm
Variation of the pier cap	±10mm
Variation of the abutment wall	: ±5mm
Variation from plumb or batter	: ±10mm
Shrinkage and temperature stresses	As per IRC:112

3. FOUNDATIONS

The foundation is designed based on the soil parameters mentioned in the geotechnical investigation report. During construction, if any variation in soil strata is noticed, the Engineer shall be informed and the foundation design shall be modified as directed by the Engineer.

Pile foundation:

a) Pile foundation is designed as per IRC:78 and construction as per IRC:112.

b) Bored cast in situ piles are designed and constructed as per IRC:78 and as per the approved drawings.

c) Drilling and casing operations, concreting and reinforcement in the pile shall be as per the provisions in IRC:112. The casing shall be withdrawn in such a way that the concrete is not damaged.

d) Pile load test shall be carried out as per the approved drawings and specifications. The test piles shall be designed for the maximum load as per the approved drawings. The load test shall be carried out as per the provisions in IRC:78 and as directed by the Engineer. The test piles shall be constructed in the same manner as the working piles. The test piles shall not be used in the permanent bridge foundation.

e) The pile shall be designed for the maximum scour depth as per the approved drawings. The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

f) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

g) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

h) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

i) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

j) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

k) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

l) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

m) The pile shall be designed for the forces due to the protection measures, if any, as per the approved drawings and specifications.

n) Pile cap is designed for the load carrying capacity as per Table-4.

4. HAND RAILS OR CRASH BARRIERS

a) The hand rail or crash barrier is as per the approved type or RCC crash barrier as per the drawings and M30 or raised kerb and M30 or raised kerb and as per the approved drawings.

b) A suitable raised kerb and footpath as per the approved drawings.

Table-1: GEOMETRICAL FEATURES

Span arrangement	As per the approved drawings
Overall length	As per the drawings
Overall width	As per the drawings
Carriageway width	As per the drawings
Footpath	As per the drawings
Cycle track	As per the drawings
Crash barrier type	PSC Type as per the approved drawings / RCC Type as per the approved drawings

Table-2: HYDRAULIC PARAMETERS

Design M.L	As per the drawings
Design H.T.L	As per the drawings
Design L.W.L	As per the drawings
Design Scour Level Pier point	As per the drawings
Design Scour Level Abutment point	As per the drawings
Design mean velocity	As per the drawings
Design discharge	9340 m³/sec

Table-3: DESIGN PARAMETERS FOR CONCRETE

Sl. No.	Component	Grade of concrete	Max. W/C ratio	Min. Cement content kg/m³	Clear cover mm	Exposure condition
1	Superstructure above bearing					
1a	PSC Girder	M40	0.40	360	40	Severe
1b	Slab & Diaphragm	M40	0.40	360	40	Severe
2	Substructure below bearing					
2a	RCC Girder Slab & Diaphragm	M40	0.40	360	40	Severe
3	Pier & Abutment					
3a	Abutment & Pier Cap	M30	0.45	320	50	Very severe
3b	Pier cap	M30	0.45	320	50	Very severe
3c	Pier	M30	0.45	320	50	Very severe
4	Approach slab & foundation	M30	0.45	320	50	Severe

Table-4: DESIGN PARAMETERS FOR FOUNDATION

Abutment/ Pier No.	Foundation type	Size of Foundation OR Dia. of Pile m	Max. Base pressure (kN/m²) OR Working Pile Load kN	Horizontal load on Pile kN	Embedment/ Socket depth into hard rock/strata m	Estimated length of MS liner/Casing pipe for pile m
A1 to A2	Pile	1.200	0	0	3.000	0.000
P1 to P5	Pile	1.200	0	0	3.000	0.000
P6	Pile	1.200	0	0	3.000	0.000
P7 to P8	Pile	1.200	0	0	3.000	0.000
P9	Pile	1.200	0	0	3.000	0.000
P10	Pile	1.200	0	0	3.000	0.000
P11	Pile	1.200	0	0	3.000	0.000
P12 to P13	Pile	1.200	0	0	3.000	0.000
P14	Pile	1.200	0	0	3.000	0.000

Table-5: QUANTITY ESTIMATE OF SUPER STRUCTURE PER SPAN (Approximate)

Sl. No.	Type	Structural Concrete m³	Prestressing steel(kg)	Reinforcing steel(kg)
1	Interior			
1a	PSC Girder	0.00	0.000	0.000
2	Slab	0.00	0	0.000
3	Diaphragm	0.00	0	0.000
4	Interior			
4a	PSC Girder	0.00	0.000	0.000
5	Slab	0.00	0	0.000
6	Diaphragm	0.00	0	0.000

The above quantity does not include the quantity of end diaphragm and cross bracing.

KEY PLAN:

NOTES:

REFERENCE LETTERS

No.	Letter No.	Date	Description
3			
2			
1	CE/NHJ/Coastal Highway-6966/2015	06/04/2016	Investigation Details

REFERENCE DRAWINGS

No.	Drawing/Sheet No.	Date	Drawing Title
4			
3			
2			
1			

REVISIONS

Rev. No.	Designed	Checked	Reviewed	Recommended	Approved	Date	Description
R4							
R3							
R2							
R1							

NAME OF ROAD: VATAKARA-PAYYOLI — ROAD No.:

NAME OF CROSSING: KUTTIYADI RIVER — ROAD CHAINAGE AT C/L OF CROSSING: CH: 392.225

NAME OF BRIDGE: KOTTAKKAL-SANDBANKS — BRIDGE No.:

DRAWING ISSUED FOR:
- ☑ DPR PREPARATION
- ☐ ADMIN./FINANCIAL SANCTION
- ☐ TECHNICAL SANCTION
- ☐ CONSTRUCTION

EXECUTION WING: BRIDGES

NAME OF DIVISION: KANNUR

ROAD CATEGORY:
- ☐ NATIONAL HIGHWAY
- ☐ STATE HIGHWAY
- ☑ MAJOR DISTRICT ROAD
- ☐ OTHER DISTRICT ROAD
- ☐ VILLAGE ROAD

BRIDGE CATEGORY:
- ☐ CULVERT
- ☐ MINOR BRIDGE
- ☑ MAJOR BRIDGE
- ☐ FLYOVER BRIDGE
- ☐ UNDER PASS
- ☐ ROAD OVER BRIDGE
- ☐ ROAD UNDER BRIDGE
- ☐ CAUSEWAY

CONSTRUCTION NATURE:
- ☑ NEW
- ☐ RECONSTRUCTION
- ☐ REHABILITATION

DRAWN BY: SANTHI A., 2ND GRADE DRAFTSMAN

DESIGNED BY: REMIL K., ASSISTANT BRIDGE ENGINEER

CHECKED BY: ARUN K.S., BRIDGE ENGINEER

REVIEWED BY: SAJU S., SENIOR BRIDGE ENGINEER

RECOMMENDED BY: RAJI SIVADAS, DIRECTOR (I & QC)

DATE: /11/2019

APPROVED BY: HUYGHEEN ALBERT, CHIEF ENGINEER (DESIGN)

Bridges Design Unit
CHIEF DESIGN OFFICE
DESIGN WING, KERALA PUBLIC WORKS DEPARTMENT
PUBLIC OFFICE COMPOUND, MUSEUM P.O.
THIRUVANANTHAPURAM, KERALA. PIN: 695 033
Tel: 0471232029 Website: keralapwd.gov.in
Fax: 04712322029 Email:jdhighways.pwd@gov.in

DRAWING TITLE: NOTES ON BRIDGE ELEMENTS

DRAWING SCALE:

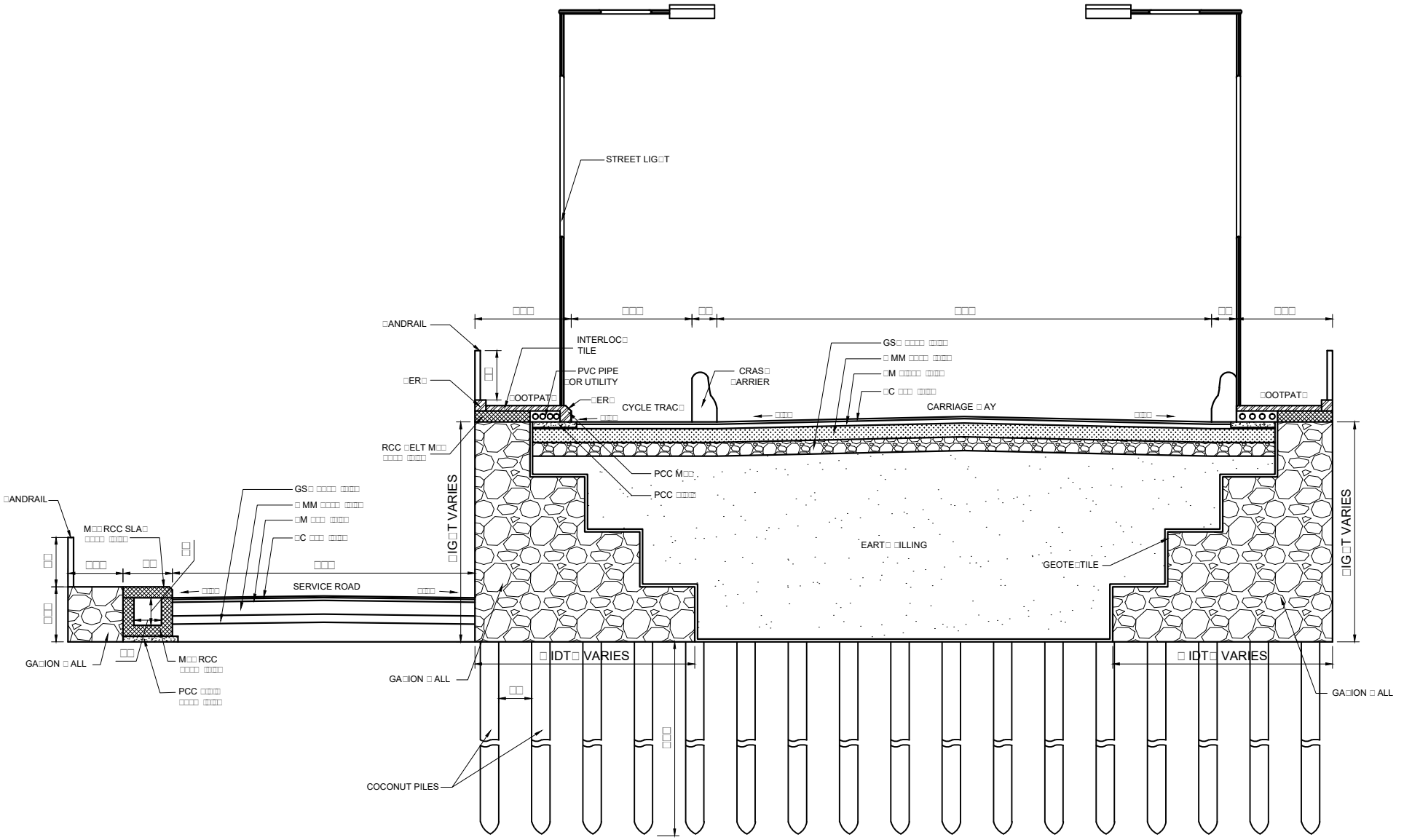
SHEET SIZE: A3

REVISION No.: R0

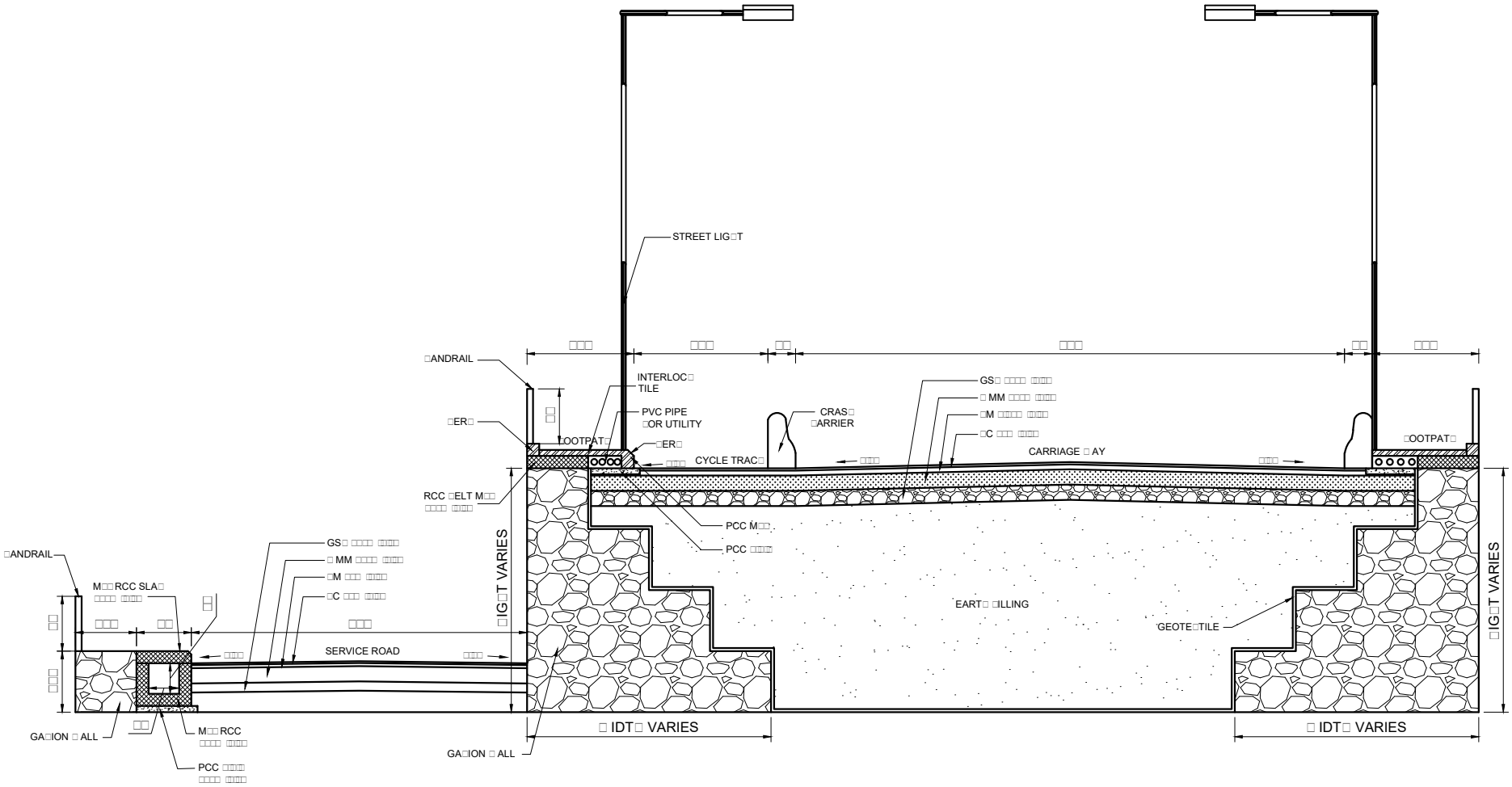
DRAWING No.: CDO/BDU/ /19

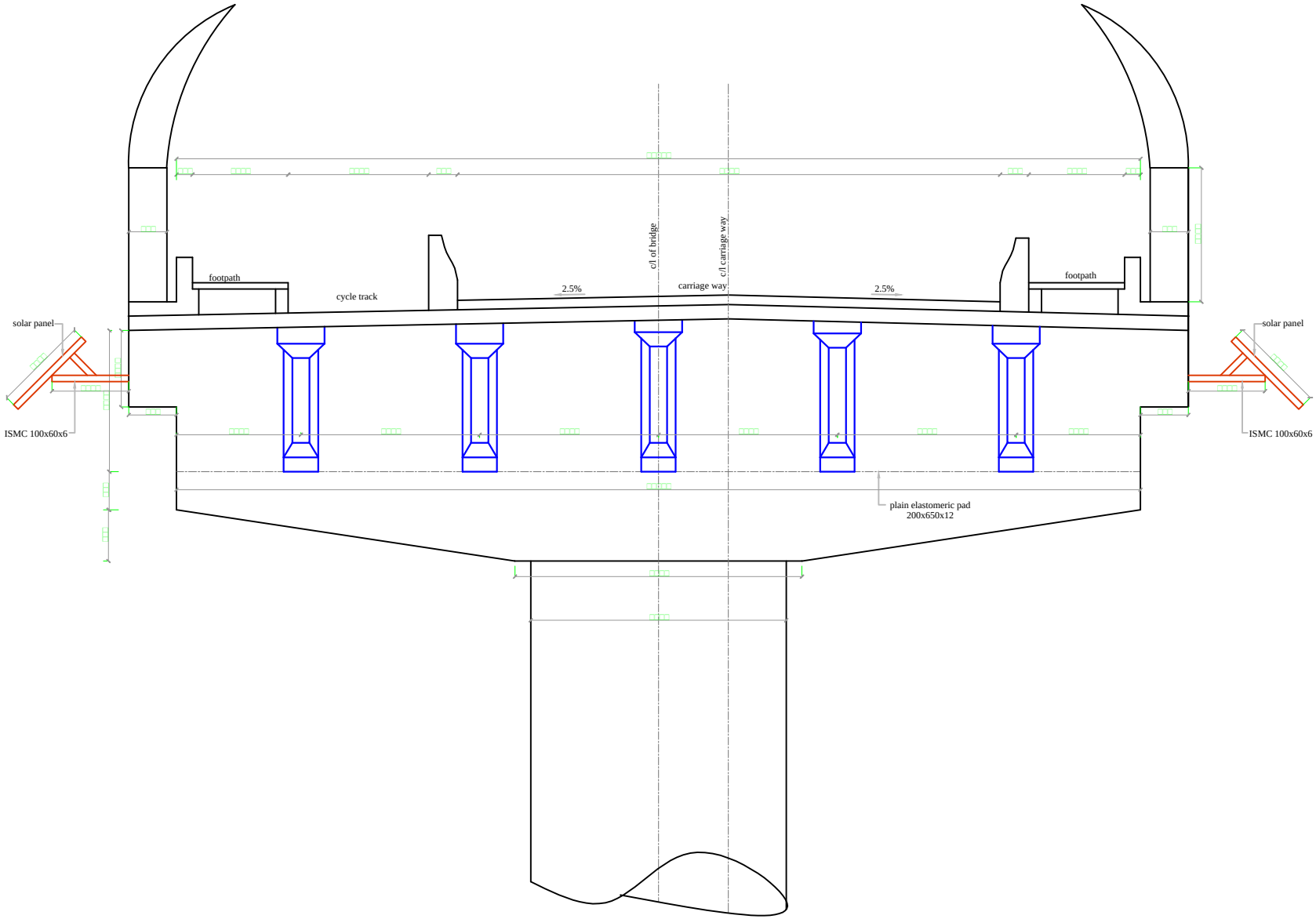
SHEET No.: 1(d)/5

TYPICAL CROSS SECTION OF APPROACH ROAD - KOTTAKKAL SIDE



TYPICAL CROSS SECTION OF APPROACH ROAD - SANDBANKS SIDE




footpath
cycle track
2.5%
carriage way
2.5%
footpath
c/l of bridge
c/l carriage way
solar panel
ISMC 100x60x6
solar panel
ISMC 100x60x6
plain elastomeric pad
200x650x12

DETAILED APPRAISAL REPORT

DETAILED PROJECT REPORT FOR THE CONSTRUCTION OF KUNJALIMRAKKAR BRIDGE SANDBANKS TO KOTTAKKAL KADAVU IN KOZHIKODE DISTRICT.

Rep No. AR-2020-TRANS 18-PWD014-15

October 2020

SALIENT FEATURES

1.1 Project details in brief

Name of Project	Construction of Kunjalimarakkar Bridge across Sand banks to Kottakkal Kadavu sandbanks in Kozhikode Dt.
District	Kozhikode
Constituency	Koyilandy
Project Outlay	Rs 49.77 Cr against the DPR of Rs 59.00 Cr
Report Prepared by	PWD NH Division Kozhikode
SPV/Implementing Agency	KRFB
Administrative Sanction	GO(Rt) No 942/2017/PWD Dtd 10/07/2017
Budget Speech Reference	2015-16
Budget provision	Funded by KIIFB
Bridge Type	PSC- T Beam & Slab/RCC T beam & Slab integrated with sub structure
Total length of Bridge & approach road	Length of bridge 537.25 M Length of approach road: (160m+90m) = 250 M Length of bridge+ approach: 787.25 m.
Span arrangement of Bridge	18 spans: 5x12.50 m +5 x 35.00m+2 x45.18+6 x 35.00 m = 537.25 m
Overall width & Carriageway	15.10 m &8.50 m. Cycle track of 2.20 m on one side and foot path of 1.50 m on either side.
Foundation Details	Pile foundation 1200 mm dia

Land to be acquired	0.7928 H
Gradient of approaches	1 in 30
Structures affected	Nil
Statutory clearances	CRZ clearance under E (P) act 1986

1.3 This bridge is proposed in the alignment of Coastal Highway across Sandbanks to Kottakkal kadavu in Kozhikode District.

1.4 Administrative Sanction was accorded for the work as per GO(Rt) No 942/2017/PWD Dtd 10/07/2017

1.5 The Detailed Project Report is prepared by PWD NH Wing Kozhikode which comprises project description, engineering surveys and investigation details, Geometric design and General Arrangement Drawing (GAD), Project cost estimation and Cost benefit Analysis. The report acknowledge that all activities related to field studies, design and documentation were done as per the prevailing IRC/KIIFB guidelines. The report also states that the on completion of the project, it would improve the connectivity of the area, reduce the traffic congestion along NH 66.

1.6 Total length of Bridge :18 spans- 5 x12.50m +5 x35.00m+2 x 45.18 m+ 6x35.00m = 537.25 m. The DPR comprises all necessary Traffic study data, GAD, Geotechnical data, Cost estimate, Socio-economic analysis etc. in support of the arguments favoring the project.

1.7 The layout of the proposed location of Bridge is as given below:

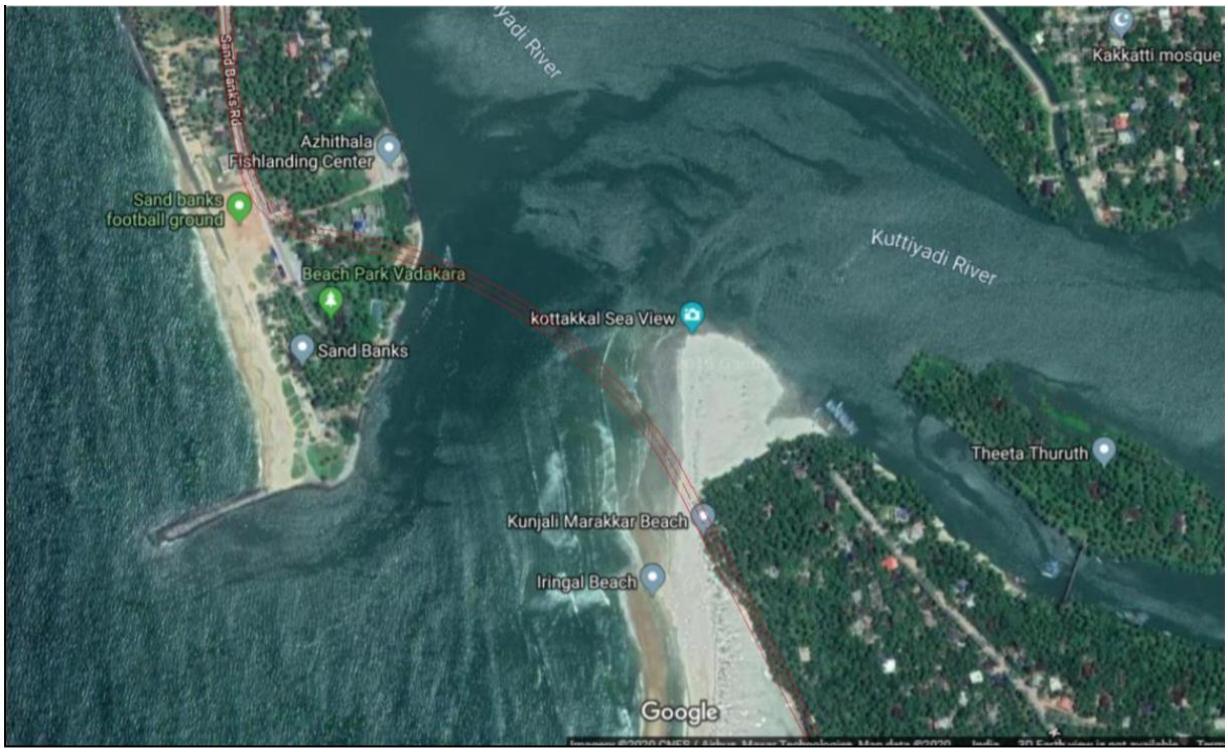


Fig: Proposed location of Kunjalimarakkar bridge

2 REQUIREMENT / DEMAND ANALYSIS

2.1 This is a historical bridge proposed in the alignment of the coastal Highway & it is the policy decision of the Government of Kerala to construct 655.60 Kms of Coastal Highway connecting Poovar & Kunjathoor covering 9 coastal districts.

2.2 Promoting tourism spots, Fisheries Development, Easy Cargo Movement & Reducing

2.3 congestion in NH are the objectives of this highway in addition to providing transport facilities to the coastal areas/ports. The proposed project is implemented through KIIFB funding.

2.4 In addition to the above objectives, on completion of the entire reaches of coastal highway in this district, it would definitely decongest the NH 66 between Kozhikode and Kannur.

2.5 The average daily traffic (ADT) for the base year worked out is 1283. The design traffic with a vehicle damage factor of 3.9 & lane distribution factor of 0.50 comes to 33 msa.

2.6 All the particulars furnished above, establish the necessity of this historical bridge.

3 FUNCTIONAL DESIGN

3.1 The functional design is carried out based on the requirement analysis through field studies and documentation as per IRC & KIIFB guidelines. Designs are strictly as per geometric standards. The alignment drawing has been finalized based on the topographic and geotechnical studies & in consultation with NATPAC.

3.2 Total length of Bridge will be 537.25 M. It comprises 18 spans - 5 x12.50m +5 x35.00m+2 x 45.18 m+ 6x35.00m.

3.3 The alignment is selected in such a way that the land acquisition and rehabilitation is minimum.

3.4 It is reported in the DPR that this alignment is verified and vetted by the NATPAC team also.

4 ENGINEERING DESIGN

4.1 Preliminary Engineering design of this project is carried out as per feasibility studies, establishing all the design requirements and geometric standards.

4.2 Span arrangement of the bridge is: 18 spans: 5 x12.50m + 5 x35.00m +2 x45.18 +6 x 35.00 = 537.25 m (Overall length)

4.3 Overall and Carriage way width: 15.10 m & 8.50 m. Cycle track of 2.50 m on one side and foot path of 1.50 m on either side is also proposed.

4.4 Foundation: 1200 mm dia piles M 40, for a depth varying from 18.70 m to 38.20 m

4.5 Bridge Type: PSC T – Beam& Slab/RCC T – Beam &Slab integrated with Substructure. Traffic Details: PCU: 8655, ADT: 1283, msa: 33

4.6 For the 160 m length approach road on Kottakkal side, sand piles are proposed.

4.7 Structural details of approach road: Subgrade 500 mm, GSB: 200mm, WMM: 250 mm, DBM: 88 mm & BC: 40 mm.

4.8 Provision for Green Power Generation for lighting the bridge is also incorporated in the estimate.

5 O&M STRATEGY

5.1 Construction and maintenance of the coastal Highways in Kerala is under the control of PWD NH. The defects if any during the defect liability period will be done by the original project contractor with the supervision of PWD NH wing. KRFB will stipulate necessary conditions in the agreement for the same.

5.2 The DLP period of the project will be 5 years.

5.3 All the activities in connection with the O&M strategy are explained in the DPR

6 FINANCIAL ESTIMATES & COST PROJECTIONS

5.4 The estimated cost is based on MoRTH specifications and DSR 2016 arrived at as per PRICE with cost index of 31.06 of Kozhikode District.

5.5 As per revised DPR 4.1.1 page 88, it is mentioned - total extent of land to be acquired is 0.991 H. Out of this 0.991 H, nearly 20% of land exists in public road and the remaining 80% is to be acquired. But in the proposal, cost for 0.991 H including 5% contingency is seen accounted. This 5% contingency is excluded and instead of 0.991 H, 0.793 H is only considered by limiting the 20% available land.

5.6 After scrutiny total cost of the project as per DPR comes to **Rs 4977.00 L**

5.7 The summary of cost sought for funding and the recommended cost is provided below:

	Item	Cost as per Revised DPR (lakhs)	Recommended Cost (lakhs)
1	For Land Acquisition	276.14	210.35
2	For the construction of Bridge	3758.65	3758.65
3	Approach road	399.85	399.85
4	For Utility shifting	10.00	10.00
6	Road Safety works	7.14	7.14
7	Sand Piling	79.95	79.95
7	For GST 12%	543.8	510.67
8	Unforeseen & LS	24.47	0.39
9	**Total**	**5100.00**	**4977.00**

Total Recommended Cost – Rs. 49.77 Cr

TS Committee shall evaluate the revised estimate prior to sanction

7 COST BENEFIT ANALYSIS

7.1 Cost Benefit analysis (CBA) are well detailed and documented in the report.

7.2 This route definitely decongests the traffic snarled in NH 66 between Kozhikode & Kannur. Also, reduction in air pollution, noise pollution, travel time savings of passengers, savings in fuel consumption etc. are the benefits documented in the report.

7.3 Development of tourism will be a major benefit of the proposed project.

7.4 Cost benefit ratio worked out comes to 1.229 and EIRR is 32.59%

8. VALUE ENGINEERING OPTIONS

8.1 The alignment is selected in such a way that the land acquisition and rehabilitation will be minimum.

8.2 It is reported in the DPR that this alignment is verified by the NATPAC team.

8.3 The GAD proposed in the DPR is observed to be the one with optimum cost.

9 IMPLEMENTATION SCHEDULE & WBS

9.1 A detailed Work Program Schedule is furnished in Annexure.

9.2 As per DPR, physically the work of the project is proposed to be commenced on 21.12.2020.

9.3 The schedule has to be re-worked as the preparatory work itself has delayed considerably.

10 PROJECT MANAGEMENT ORGANIZATION STRATEGY

10.1 KRFB has been appointed as the Special Purpose vehicle (SPV) for the implementation of the project.

10.2 NH wing of the PWD will be directly involved in the execution and supervision of the project

11 CONTRACT MANAGEMENT STRATEGY

11.1 The strategy has been explained in the DPR

11.2 Tenders will be invited by KRFB as per prevailing practice under two cover and normally the price of the lowest bidder will be accepted.

11.3 The work will be implemented through PWD NH wing.

12 STATUTORY CLEARANCES

12.1 Administrative sanction has already been accorded for the construction coastal road as per GO(Rt) No 942/2017/PWD Dtd 10.07.2017.

12.2 As the project is close to coastal belt, CRZ clearance is also inevitable.

12.3 As the project is deviated from the already approved alignment, Revised alignment approval has also been obtained from Government.

13 ENVIRONMENTAL ASPECTS & SUSTAINABILITY

13.1 Project is not coming under protected areas such as Forest/Sanctuary/National Park etc. prior clearances are not applicable under Conservation Act.

13.2 But the project falls under coastal area and as such CRZ clearance is inevitable implementation of the project

14 QUALITY MANAGEMENT PLAN

14.1 Quality management plan and strategies are also covered in the DPR contemplated in the PWD manual.

14.2 1ST tier quality management will be the responsibility of the contractor and will be done in consultation with the supervising agencies.

14.3 The 2nd tier quality management will be done by the PWD through reputed lab.

14.4 The 3rd tier QC checking shall be arranged by the external agency empaneled for the purpose.

15 RISK ASSESSMENT AND MITIGATION MEASURES

15.1 The DPR has covered and assessed the possible risk associated with this work and suggested measures for the mitigation.

15.2 Detailed work program schedule, statement towards cash flow for mitigating financial risk, construction management strategy, strategy for utility shifting etc. are covered in this report.

16 REMARKS AND INFERENCES

16.1 The project report has satisfied all the basic requirements for consideration for the financial assistance from KIIFB. The revised alignment proposal for the coastal highways in Kozhikode District has also been obtained from Govt.

16.2 The parameters studied as per the demand are in regard to this project itself and the functional design is matching with the actual requirements and are as standards.

16.3 The GAD & design particulars furnished are satisfactory. It is to be noted by the tendering authority that the bidders require a high degree of technical inputs at bidding stage as well as during execution stage to make reliable assessment and to achieve coordination between design and execution. The estimate prepared and submitted is as per the GAD and meets all the basic requirements.

16.4 It is also to be ensured by the client that the estimate for the electrical work shall also be in PRICE mode.

16.5 Rectification of defects and maintenance requirements are to be handled in a unified manner within the DLP and after expiry of DLP and a foolproof strategy to be framed before tendering.

16.6 CBR and EIRR meets the targeted standards.

16.7 As the design proposed is observed to be one with optimum cost, no further value engineering attempts are suggested.

16.8 It should be ensured that no geometry shall be compromised at any stage of design or execution.

16.9 The period of completion targeted is realistic and the WBS is based on the rational sequencing of activities with most likely durations. If re-scheduling is warranted the same shall be submitted to KIIFB as early as possible.

16.10 The contract management plans are acceptable provided the procedures and the documentations shall strictly be as per the prevailing norms.

16.11 The risk factors in obtaining statutory clearances from another department shall strictly be monitored by KRFB and delay avoided.

16.12 need for environmental clearances shall also be verified and confirmed at the time of commencement of work also.

16.13 The risk management plan shall be one which eliminates and mitigates all the risk factors associated with the work. It is the responsibility of KRFB to make available majority of ROW at the beginning of the execution and to obtain the approval of alignment from government prior to commencement and also the timely shifting of utilities, so as to avoid possible chances of time extension.

16.14 As the design, execution and quality control of different items are to ensure by contractor also, all the personnel deployed by the contractor should be well qualified and experienced to achieve desired output.

17 RECOMMENDATIONS AND SUGGESTIONS

17.1 The project may be considered for funding since the revised alignment approval from government has also been obtained.

17.2 The project may be considered for funding by KIIFB provided the tripartite agreement shall be entered after ensuring adequate clarity in the observations 16.4, and 16.8 to 16.13.

17.3 In view of the replies to TAR, furnished by KRFB, the amounts to be considered for sanction comes to **Rs 49.77 Cr.**

17.4 The detailed estimate shall strictly be reviewed and scrutinized by the TS authority. In order to avoid any ambiguity during execution, the TS authority should confirm that all the designs & proposals are technically sound, appropriately engineered and also that the estimates are accurately prepared. Also, it should be ensured that the electrical estimate is under PRICE mode.

17.5 Technical sanction is mandatory before tendering and executing agreement

17.6 The cost provisions earmarked against work alone shall be utilized for execution of work. The savings or anticipated savings from LA, QC, shifting utilities etc. shall not be re- appropriated for meeting expenditure of work proper.

17.7 The identified revenue streams if any shall be communicated while signing tripartite agreement.

17.8 Though LA work can be proceeded, work of bridge should be tendered only after getting Financial Sanction to the proposal of connecting road on either side of the bridge so that the project as a whole should be functional soon on completing the bridge work.

REVISION REPORT

PWD016-04 - Construction of Azhikode - Munambam Bridge in Thrissur District

Report No. RR 2023-PWD016-04-Revision-01

Dated: 12th July 2023

SHORT DETAILS

- Name of Project : Construction of Azhikode - Munambam Bridge in Thrissur District
- Constituency : Kaipamangalam (Thrissur)
  Vypin (Ernakulam)
- District : Thrissur and Ernakulam
- Budget provision : Rs. 160 Crore
- Project outlay : Rs. 141.4 Crore
- Financial Sanction : Rs. 154.626 Crores
- Report Prepared by : Kerala PWD
- SPV/Implementing Agency : Kerala Road Fund Board
- Administrative Sanction : G.O (Rt) No. 942/2017/PWD dated 10/07/2017, Annexure II, Sl. No. 22 (Rs. 160.00 Cr.)
- Budget Speech Reference : Budget speech 2017-18, Para No. 157, Sl. No. 22
- Data reviewed : Detailed Project Report and Revision Proposal

Details of Revision submitted and general findings on the Bridge.

1. The current Revision is mainly due to the variation in the quantities, GST revision from 12 to 18 percent and the inclusion of investigation.
2. The current Revision includes a provision for investigation of the pile to determine the depth of pile. The depth of pile was not ascertained hence the investigation of the pile was not awarded even after tendering for nearly four times and hence investigation for the pile was also included in the Revision submitted.
3. The Revision is demanded for an amount of Rs. 181,55,35,462.58 from Rs. 154,62,67,905
4. A detailed scrutiny was not conducted for this revision hence the pile depth can be confirmed only after the investigation work and the whole estimate including the design may change according to the depth.
5. The proposed bridge has 12 spans have a length of 52.6 meters and pile depth of 84 meters. Normally for a bridge, the middle spans will be of longer spans and the rest of

the spans will be of 35 or 40 meters. But in this case, span of 52.6 meters is maintained on all spans and the reason for providing this span configuration will be probably because of the larger pile depth (which may result in a considerably higher foundation cost). Reconsideration of the span configuration can reduce the overall cost of the bridge and the same can determined only after the result of the investigation.

6. It is also seen that a slope of 1 in 30 is not maintained after the middle span and maintaining a constant slope can reduce the height of pier as well as number of land spans in both sides.
7. Boreholes have not been taken below all the piers as per the codal provisions for the land piers.
8. The pile design currently considers combined end bearing and friction, but a revision may be required based on the detailed investigation and the availability of hard strata at a depth of 40 to 50 meters in Kerala.
9. Staging and fabrication quantities need to be checked during the submission of the revision after obtaining the investigation results.
10. The quantity of steel should be determined based on the detailed drawing in the revision after the investigation.

A major recasting is needed in the Bridge work estimate once the investigation is completed. SPV is directed to submit a Revision/Revised Estimate which address all the comments from 4 to 10 above and commence the pile work only after the approval of the RE. The file even if submitted as a variation file, the approval will be necessary for the commencement of work other than investigation.

The revised demand is as follows:

Sl. No.	Description	Amount as per DAR	Amount as per Revision
1	Land Acquisition	14,61,60,000.00	14,61,60,000.00
2	Bridge proper	1,03,43,93,908.00	1,20,69,99,501.99
3	Approach road, side protection & river protection	5,01,22,079.00	6,80,48,424.39
4	Additional investigation		29,99,600.38
5	Utility shifting for KSEB (Package approved)	2,00,00,000.00	32,73,381.00

6	Utility shifting for Kerala Water Authority (Two estimates)		25,56,000.00
7	Utility shifting for BSNL		
8	LS for High mast light at approach road – 6 nos	30,00,000.00	30,00,000.00
9	Providing arrangements for protection from Lightning (30 x 415000)	1,24,50,000.00	1,24,50,000.00
10	L S for additional land	10,00,00,000.00	10,00,00,000.00
11	LS for Dredging the kayal (for transferring fund to Port Authorities)	4,00,00,000.00	4,00,00,000.00
12	Jankar shifting	25,00,000.00	
13	GST @ 12%	13,76,41,918.00	
14	GST @ 18%		23,00,48,554.82
Total		**1,54,62,67,905.00**	**1,81,55,35,462.58**

Recommendation:

The subproject Revision from Rs. 154,62,67,905 to **Rs. 181,55,35,462.58 (Rupees One Hundred and Eighty-one Crore Fifty-five Lakh Thirty-five Thousand Four Hundred and Sixty-two only)** which is 17.41 % above the current FS may be considered for KIIFB funding ***subject to the following conditions:***

1. *SPV should submit a Revision/Revised Estimate which address all the comments from 4 to 10 mentioned above.*
2. *Works other than investigation can only be executed after getting the approval by KIIFB for the Revision/ Revised Estimate based on the outcomes of the investigation.*
3. *The amount required for additional investigation work (Rs. 29,99,600.38+GST @ 18%) will be recovered from the centage charges payable to the SPV.*

REVISION REPORT

Construction of Coastal Highway in Malappuram District Reach I - Padinjarekkara to Unniyal Junction Km 0/000 to 15/000

Rep No. Revision Report 2022- PWD0014-01 – Revision - 02

Project details in brief

- Name of Project: Construction of Coastal Highway in Malappuram District Reach I - Padinjarekkara to Unniyal Junction Km 0/000 to 15/000
- District : Malappuram
- Approved

  Project outlay : Rs. 52,77,72,295/-
- SPV : KRFB
- AS : G.O(Rt)No.942/2017/PWD dated 10/07/2017, Sl No 2 for Rs 6500 Cr
- Budget Speech : Kerala Budget 2017-18.

1. Padinjarekkara to Unniyal Junction Km 0/000 to 15/000 is a part of Coastal Highway. This stretch starts from Padinjarekkara Park which is in the bank of Ponnani Estuary and continue till Unniyal.
2. The road act as a connection for the proposed Ponnani Bridge and Kootayi.
3. The existing road is single carriage way with an tar width of 3.80 to 5.5 meter and RoW of 7 to 22 meters up to 8/170 km chainage, tar width of 10 meter and RoW of 12 to 15 meter upto 12/640 (developed by RBDCK) and tar width of 5.5 m and RoW of 10 to 15 m till 15/000.
4. The existing road surface consists of Chipping carpet till 8/170 and BM- BC in the rest of the portions
5. The existing road need to be upgraded to the Coastal Highway standard.
6. The proposed road is a BM & BC road with a RoW of 15.6 meter which includes 2.5-meter cycle track.
7. The proposal includes widening of road, construction of 1550m CC drain on both sides, 1.5 m shoulder on both sides and 2.5 m cycle track in the west side.

The 9th EC has approved the project for a total outlay of **Rs. 52,77,72,295/-**.

P□□□□□□□	S□□□□□□□d □□ □□□□□□ □□r FS □R□□	S□□ Pr□□□□□ R□□□□□□□ □ O□□□□□ □I□ R□□	R□□□□ □ □□d□d R□□□□□□□ □ O□□□□□ □I□ R□□
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Land A□□□□□□□on	□	□	□□□□□□□□□□
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- Earlier Sub project revision-1 was sanctioned by CEO from Rs. 52,78,00,000/- to Rs. 53,45,97,100/- for the project due to the increase in the amount for KSEB Utility shifting from Rs 31, 72,525/- to Rs 1,06,04,203/-.
- Now SPV has proposed subproject revision-2 for widening of the road for a length of 4.1 km for upgrading the existing road which is having an average RoW of 8 meters to Coastal Highway KIIFB standards of 14 meters, which cost an amount of Rs. 4.30 Crores

Recommendation

Sub project Revision for the project Construction of Coastal Highway in Malappuram District Reach I - Padinjarekkara to Unniyal Junction Km 0/000 to 15/000 from an amount of Rs. 52,78,00,000 /- to **57,75,97,101/-** may be approved.

Detailed Project Report

KIIFB 2017-18

DETAILED PROJECT REPORT ON COASTAL HIGHWAY

Construction of Coastal Highway in Malappuram District

Reach- I :

Padinjarekkara to Unniyal Junction

Km (0/000 – 15/000)

Estimate Amount : ₹4650 Lakhs

Submitted by

NH DIVISION MALAPPURAM

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SALIENT FEATURES OF THE PROJECT

1.	Title of the project	KIIFB – Budget speech 2017-18 Construction of Coastal Highway in Malappuram Disitrict: Reach- I : Padinjarekkara to Unniyal Junction
2.	Department	Public Works Department
3.	Details of project location	
	i. District	Malappuram
	ii. Taluk	Tirur
	iii. Corporation/Municipality/Panchayath	Purathur/ Mangalam, Vettom / Niramaruthur /Tanalur
	iv. Assembly Constituency	Thavannur, Tirur &Tanur
4.	Implementing agency/SPV	KRFB
5.	DPR prepared by	PWD, NH Division, Malappuram.
6.	Project outlay	Imprvmnt of carriage way: 31.93 Cr Road safety appurtenances: 6.51 Cr Drainage, Foot path & Ducts: 7.53 Cr Shifting of utilities : 0.35Cr Compensation for afforestation : 0.12 Cr Cr TOTAL AMOUNT 46.50 Cr
7.	Budget provision	650000 Lakhs
8.	Budget speech reference	Budget Speech 2017-18, Page No:62,Sl No:152
9.	Administrative sanction	Order No:- GO(Rt)No-942/2017/PWD Dated - 10-07-2017 Sl No : 2
10.	Nature of the project (New formation/ widening/ strengthening/ widening and strengthening/ new formation, widening and strengthening)	Strengthening of the carriageway, Road safety measures, drainage works
11.	Present status of roads, if any	Heavily damaged and not adequate to accommodate heavy traffic

12.	Need for the project	Improvement and widening of the road to accommodate the high traffic density after the opening of Chamravattom regulator cum bridge through which the distance between Ernakulum and Calicut has been reduced about 30 KMS.
13.	Details of proposed roads	
	i. Length of road	15 KM (0/000 – 15/000)
	ii. Carriage way width	12 m
	iii. Thickness of layers	GSB 260 mm WMM 250 mm DBM 65 mm BC 40mm
	iv. Details of cross drainage works	Utility ducts
	v. Other details	Drains
14.	Details of investigations/surveys conducted	
	i. Traffic	Traffic Analysis for 7 days. Present Traffic count Traffic Volume study Projected Traffic for 10years (Reports attached)
	ii. Geotechnical	CBR tests Benkelman Beam Deflection Studies (Reports attached)
15.	Whether Land Acquisition involved?	No
	If yes, furnish details	
16.	Total estimated cost and item wise cost break up and details of Schedule of Rates	4650 Lakhs
	Whether detailed estimate attached?	Yes
17.	Details of revenue streams	KIIFB
18.	Details of Cost Benefit Analysis (CBR value)	Details attached with DPR
19.	Details of project risks	Completion of Land acquisition and Shifting of utilities in time.
20.	Details of project management organisation strategy	Work will be executed under the proper supervision of PWD (NH) Engineers

21.	Details of contract management strategy	Through approved contracting agencies by inviting competitive bids
22.	Details of Project Implementation Schedule (PIS) & Work Breakdown Schedule(WBS) Proposed duration to complete the project	Expected that the work can commence during 2017-18 and completed by 2018-19 Proposed duration is 18 months from the date of commencement
23.	Details of statutory clearances	Statutory approval will be obtained from concerned departments before commencement of the work.
24.	Quality control infrastructure and mechanism	Contractor will be responsible for Setting up of QC lab and first tier QC tests. Second and third tire QC tests will be conducted/monitored by quality control wing of PWD.
25.	Operations & Maintenance (O&M) arrangements of the project after completion	36 months DLP period for rectifying damages. No separate claim for the contractor within DLP period.
26.	Details of attached drawings	Road alignment drawings, Cross section of road, drain, culvert and Irish drain
27.	Other attachments	Investigation report, Photos of existing road , Bar chart, Levels drawings

PROFORMA

NAME OF WORK	:	**Construction of Coastal Highway in Malappuram Disitrict: Reach- I : Padinjarekkara to Unniyal Junction**
ASSAMBLY CONSTITUENCY	:	**THAVANNUR,TIRUR &TANUR**
DIVISION UNDER THE WORK	:	**PWD NH - MALAPPURAM**
CHAINAGE(STARTING&ENDING IN WHICH THE WORK IS PROPOSED TO BE TAKEN UP	:	**0/000 TO 15/000**
LENGTH TO BE COVERED IN CASE OF ROAD WORK	:	**15.000 KM**
CATOGORY OF ROAD WHETHER NH,SH,MDR	:	**MDR**
ESTIMATED COST OF WORK	:	**4650.00 Lakhs**
BUDGET PROVISION	:	**650000.00 Lakhs**
PAGE NO AND ITEM NO IN THE BUDGET	:	**Budget Speech 2017-18, Page No:62,Sl No:152**
HEAD OF ACCOUNT	:	**5054-04-337-99-00-16-V**
DETAILS OF AS (IN THE CASE OF PROPOSAL OF SPECIAL SANCTION)	:	**DPR Sanction Order No:- GO(Rt)No-942/2017/PWD Dated Thiruvanathapuram - 10-07-2017**

EXE. ENGINEER **ASST. EXE. ENGINEER** **ASSISTANT ENGINEER**

15075-
11/7/17

GOVERNMENT OF KERALA

Abstract

Public Works Department – Budget Speech 2017-18 – Implementation of Projects to be taken up by availing funds under Kerala Infrastructure Investment Fund Board (KIIFB) – In Principle Administrative Sanction - Accorded - Orders issued.

PUBLIC WORKS (G) DEPARTMENT

G.O.(Rt) No. 942/2017/PWD. Dated, Thiruvananthapuram, 10.07.2017

Read:- 1) G.O. (Rt) No. 596/2017/PWD dated 04.05.2017.

2) G.O(Rt) No. 616/2017/PWD dated 10.05.2017.

3) Letter Nos. CE/R&B/GL-KIIFB/2017-18 dated 06.06.2017 & 14.06.2017 from the Chief Engineer(Roads & Bridges), Thiruvananthapuram.

ORDER

It has been announced in the Budget Speech 2017-18 as detailed below that KIIFB will invest an amount of Rs. 18,185 Crore for the development of Hill Highway, Coastal Highway, various Road Corridors, Bridges, Flyovers etc. under Public Works Department.

Sl. No.	Name of Work	Estimate Amount (Rs. In Crore)
1	Hill Highway	3500
2	Coastal Highway	6500
3	182 roads	5628
4	69 Bridges & Flyovers	2557
	TOTAL	18185

(2) In the Reply Speech 2017-18, certain corrections / substitution / deletion

were made in the list of works under PWD referred in Para 156 & 157 of Budget Speech 2017-18. Among the Road works in Para 156, Sl. No. 162 & 175 are repeated twice and hence Sl. No. 162 was removed from the list. The work "Karettu-Kallambalam road" in Sl. No. 113 of Para 156 of Budget Speech 2017-18, has been replaced with Drinking Water Projects in Pulimathu, Nagaroor and Karavaram Villages. As per Government Order read as 1st paper above Administrative Sanction was accorded for the work "Kundannur Flyover" (Sl. No. 34, Para 157 of Budget Speech 2017-18) & as per Government Order read as 2nd paper above in-principle sanction was accorded for the work "Vyttila flyover" (Sl. No. 48, Para 157 of Budget Speech 2017-18) and the amount for the work "Bridge connecting Kurunkotta Island with Cochin Corporation" (Sl no. 69, Para 157 of Budget Speech 2017-18) amount has been cut short by Rs. 10 Crore. Hence the total number of Bridges/ROBs/Flyovers decreases from 69 to 67 and the total amount falls from Rs. 2557 Crore to Rs. 2345 Crore. In case of road works, Sl No. 162 has been deleted and the work in Sl. No. 113 of Para 156 has been substituted and the total number of Road works decreases from 182 to 180 and the total amount falls from Rs. 5628 Crore to Rs. 5583 Crore.

(3) As per letters read above, the Chief Engineer, PWD (Roads & Bridges) has requested to accord in principle sanction for the works to be taken up under KIIFB funding.

(4) Government have examined the matter in detail and are pleased to accord in-principle Sanction for the development of Hill Highway, Coastal Highway, Improvements of 180 Road works and 67 Bridges & Flyovers as detailed below under Public Works Department for an amount of Rs. 17,928 Crore (Rupees Seventeen Thousand Nine Hundred and Twenty Eight Crore only) to be taken up under Kerala Infrastructure Investment Fund Board (KIIFB) funding.

(5) The Kerala Road Fund Board (KRFB) will be the Special Purpose Vehicle (SPV) for arranging the Roads & Bridges works and Roads and Bridges Development

Corporation of Kerala Ltd. (RBDCK) will be the Special Purpose Vehicle for executing ROB's and Flyovers. Hill highway and Coastal Highway will also be implemented by Kerala Road Fund Board and will be executed through Roads & Bridges and National Highway wings of Kerala Public Works Department respectively.

Sl. No.	Name of Work	Estimate Amount (Rs. In Crore)
1	Hill Highway	3500
2	Coastal Highway	6500
3	180 roads (List appended as Annexure I)	5583
4	67 Bridges & Flyovers (List appended as Annexure II)	2345
	TOTAL	17928

(By Order of the Governor),
R. SREEKALADEVI
SPECIAL SECRETARY TO GOVERNMENT

To

The Chief Engineer, PWD (Roads & Bridges), Thiruvananthapuram.
The Chief Executive Officer, Kerala Road Fund Board, TC 4/1654, Mayooram, Belhaven Gardens, Kowdiar Post, Thiruvananthapuram – 695003.
The Managing Director, Roads & Bridges Development Corporation of Kerala, Preethy Buildings, 2nd Floor, Palarivattom, Kochi.
The Joint Fund Manager, Kerala Infrastructure Investment Fund Board, 4th Floor, India Heights, Govt Women's College Road, Vazhuthacaud, Thycaud P.O, Thiruvananthapuram - 695014.
The Accountant General (A&E)/(Audit), Kerala, Thiruvananthapuram.
The Finance Department.
The Public Works (D/H/PS) Department
Stock File/Office Copy/Website.

Forwarded / By Order

Section Officer.

KIIFB-Budget Speech 2017-18 Construction Of Coastal Highway In Malappuram District: Reach- I : Padinjarekkara To Unniyal Junction

CERTIFICATE

Certified that I have personally inspected the site of the proposed work **KIIFB-Budget Speech 2017-18 Construction Of Coastal Highway In Malappuram District: Reach- I : Padinjarekkara To Unniyal Junction** and the estimate is corrected incorporating the observation issued by the Chief Technical examiner vide observation note file No 376172/I&PW-B1/2017/Fin Dt. 27.01.2017

Name of Work:- **KIIFB-Budget Speech 2017-18 Construction Of Coastal Highway In Malappuram District: Reach- I : Padinjarekkara To Unniyal Junction**

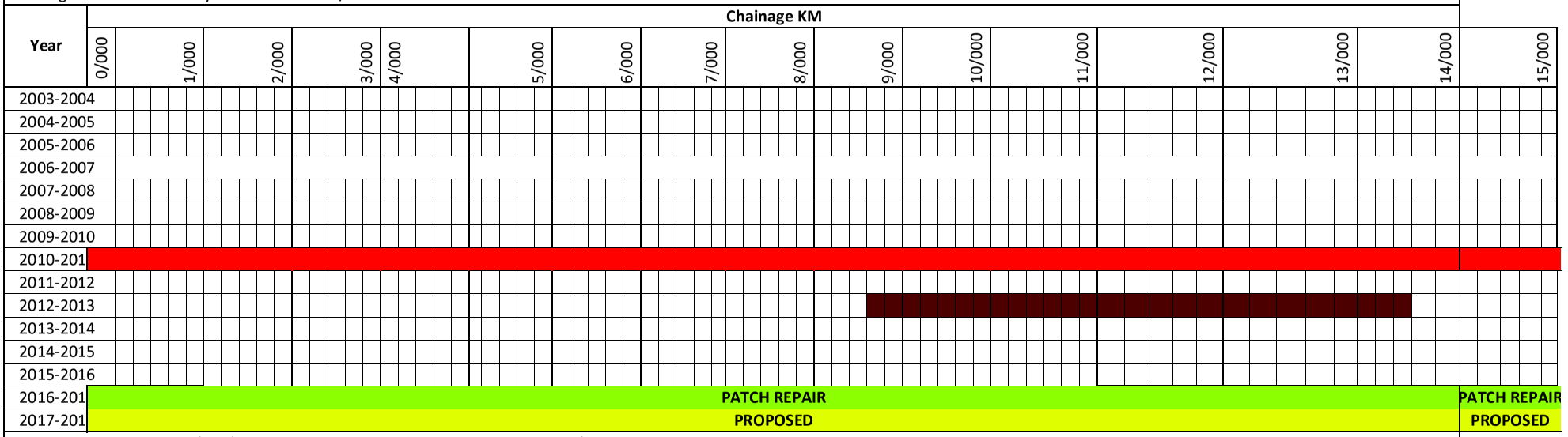
LAND AVAILABILITY CERTIFICATE

Certified that the Land is available for the work **KIIFB-Budget Speech 2017-18 Construction Of Coastal Highway In Malappuram District: Reach- I : Padinjarekkara To Unniyal Junction**

KERALA PUBLIC WORKS DEPARTMENT

BAR CHART FOR THE YEAR 2016-17

Name Of Road	Tippusulthan Road	Division	Malappuram
Category	MDR	Sub-Division	Kuttippuram
Starting Place	Padinjarekkara 0/000	Section	Kuttippuram
Ending Place	Unniyal Junction Km 15/000		



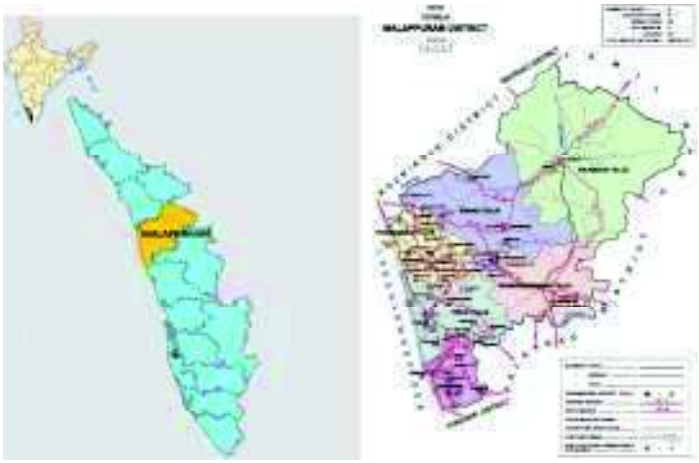
	Completed	Ripe	Ongoing	Proposal
BT				
OR				
BMBC				
SR				

Chief Engineer Sup. Engineer

Exe. Engineer Asst Exe. Engineer Asst. Engineer

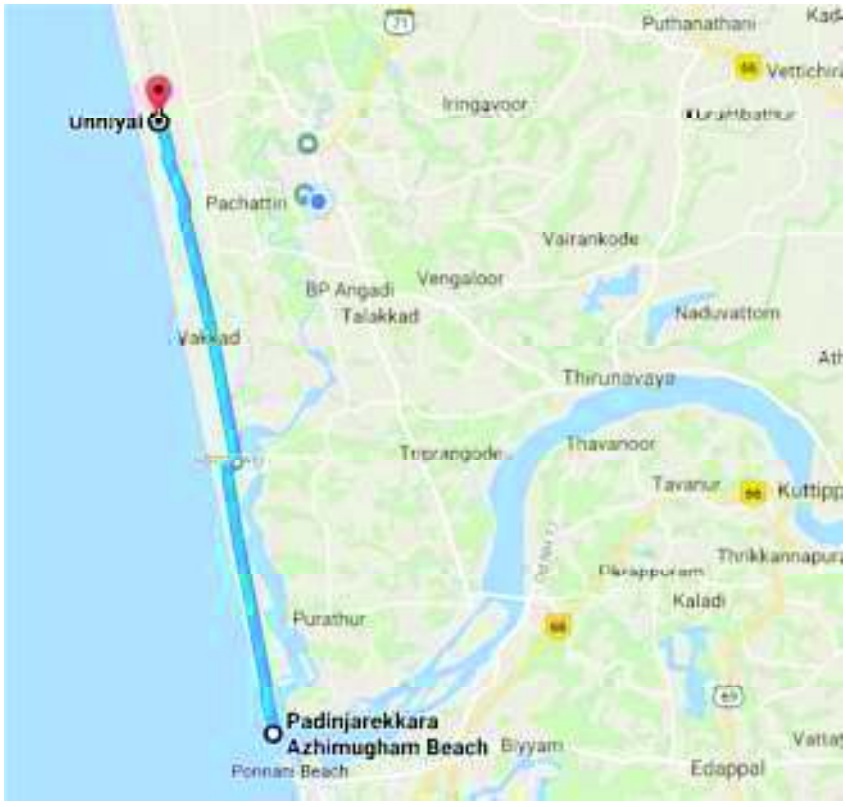
PROJECT LOCATION

The project is located in Malappuram district as shown below



PROJECT ROAD

The project road starts from Padinjarekara to Kadalundi via Kootayi,Unniyal ,Tanur, Parappanangadi and ends at Kadalundi Bridge in Tirur - Kadalundi road. Blue line shows the project under consideration which is from Padinjarekkara to Unniyal (Km 0/0000 to 15/000).



EXISTING PHOTOS OF ROAD

COASTAL HIGHWAY - MALAPPURAM

916
KDM

Koottayi Junction & Alinchuvadu

ROAD NEARBY ATTRACTIONS

ROAD NEAR BY ATTRACTIONS

THUNJAN PARAMBU

Thunjan Parambu is situated 17.00Km from Kottakkal Changuvetty. Thunjan Parambu in Tirur in Malappuram is the birthplace of Thunchath Ezhuthachan, the father of the Malayalam language. A memorial (Thunjan Smarakom) for the great poet has been built at Thunjan Parambu in 1964. Ezhuthachan is considered as the Father of the Malayalam language, because of his devotion to the language, his influence on the acceptance of the Malayalam alphabet, and his extremely popular poetic works in Malayalam. The kilippaattu style in Malayalam was introduced by Ezhuthachan. A week-long literary festival is organized annually in last week of December. The famous “Thunchan Utsavam” is held here every year in the first week of February. On Vijayadasami day hundreds of people throng to Thunjan Parambu with their children, to initiate them into the world of letters. Poets and teachers help children to write on the white sands of Thunjan parambu with their fingers.

Even budding poets and writers come here to offer their first works. There is a research centre, cottages for writers, an auditorium, and a literary museum here. It is also a Manuscript Resource centre of the National Manuscript Mission.

Kadalundi Bird Sanctuary

Spread over a cluster of islands, the Kadalundi Bird Sanctuary is a virgin land, which houses a large number of beautiful migratory birds and hundreds of native birds and offers a splendid view of the Kadalundi River. This phenomenal destination is surrounded by hillocks where the Kadalundi River meets the Arabian Sea. Nature lovers and wildlife enthusiast, visits this stunning location to spot exotic birds and capture their movements in cameras.

The Kadalundi River, which flows inside the sanctuary meets the Arabian Sea at a particular point and that point is locally known as Kadalundi Nagaram. The sanctuary is managed by the Gram Panchayat of Kadalundi and Vallikunnu, as appointed by the government to take care of the exotic reserve, which houses so many beautiful birds and water animals. The tourists can take a ride on the boats operated by the Forest Department and experience the endless beauty

of the lush green forest and bird population. Other activities that keep tourists engaged are trekking, photography, boating, etc. The best time to visit this sanctuary is between December and April, as the forest looks its best during winter with surrounding covered in a green blanket of nature. There is no option to stay in the sanctuary, so, the tourists can stay in Kozhikode, which is around 19 km from the sanctuary.

VAKKAD BEACH

Thunchan Memorial Government College

Thunchan Memorial Government College holds a unique position of pride in the education history of the district of Malappuram and is known for providing quality education both in pure science, social science and languages. This historic institution, established in memory of the father of Malayalam language, tried its best to combine academic excellence with value based education and facilitated a conducive environment for overall development of students.

THUNCHATH EZHUTHACHAN MALAYALAM UNIVERSITY

Thunchath Ezhuthachan Malayalam University, was established by the Government of Kerala on 1 November 2012 in a function held in the premises of Thunchanparamba, the home of Thunchath Ezhuthachan in Tirur, Malappuram, Kerala. K Jayakumar, a civil servant of the Indian Administrative Service cadre, who retired as the Chief Secretary of Kerala, is the first Vice-Chancellor of Malayalam University.

The university is named after Thunchaththu Ramanujan Ezhuthachan, a 16th-century CE Malayalam litterateur whose writings helped develop Malayalam as a language with a script of 51 letters, vocabulary, and literature. Thunchath Ezhuthachan — often described as "the Father of Malayalam language" was born at Trikkantiyur in Thunchan Parambu in Tirur, in the state of Kerala.

COASTAL HIGHWAY - MALAPPURAM

DETAILED PROJECT REPORT

COASTAL HIGHWAY - MALAPPURAM

1. INTRODUCTION

Tirur-Kadalundi road is an Important MDR traversing through the coastal belt of Malappuram district connecting Ponnani and Kozhikode. This DPR is prepared for the improvements of the road for the high traffic density stretch of the road between Thazhepalam in Tirur LAC and Poorapuzha in Tanur LAC, having 14.000 km length with a BT width of 7.00m.

After opening of Chamravattom- Regulator cum bridge, the road distance between Ernakulam- Kozhikode has been reduced about 30 kms through chamravattom-Tirur-Kadalundi route. This road traverses through a plain terrain through coastal areas without sharp curves. Also, the route devoid of tolls and speed interceptors. Due to easement of driving, commuters choose this route including container trucks, tankers etc. Consequently, the traffic density has increased enormously through this route.

The present crust and width of road is not adequate to accommodate the high intensity of heavy traffic. Hence strengthening the surface and widening the road at town areas are essential and proposed in this project. Due to the low elevation of the road and higher water table of the locality, the rain water flowing through the road surface/stagnated at road side during the rainy season. In order to drain out rain water properly, construction of drains with culverts at the required chainages are very essential and proposed in the estimate. Raising of road at required locations to maintain proper slope for draining out the rain water is also proposed in this project.

This estimate of the project is classified as three Appendixes, 1) Appendix - A- Strengthening the Carriage way, 2) Appendix-B - Road safety Measures, 3) Appendix-C - Cross Drainage works. Total cost for the proposal comes to Rs-4800 Lakhs

2. PROJECT DEFINITION, CONCEPT AND SCOPE

(a) Land availability:- This road have an average 15.00metre right of way with a 7.00m carriage way from 0/000 to 14/000.There is no hindrance for the implementation of this project.

(b) Design: - The existing carriage way surface with BM and BC are damaged severely due to the heavy vehicular traffic after opening of Chamravattom regulator cum bridge. This road traverses through coastal belt having sandy soil and level terrain and it requires sufficient drainage system. Due to the lack proper improvement and upgradation works to the road and lack of sufficient drainage system, this road damage rapidly during the monsoon.

A detailed investigation was conducted over this road by M/s Esteem Developers (P) Ltd, Cochin. Asper the investigation studies the road improvement with 200mm Granular sub base (GSB), 250mm Wet Mix Macadam (WMM), 100mm thick Dense Bitumen Macadam (DBM) and 50mm thick Bituminous Concrete (BC) are essential for the surface improvement. Widening of the road at town portions are proposed for a width of 9.00m from the existing 7.00m carriage way and also widening carriage way at curved portions. For the widening works base and sub base are proposed with 200 mm GSB and 250mm WMM as per the investigation. Drainage work with cement concrete, Extension of existing cross drainages, Traffic safety items are included in this project.

A traffic study was conducted on the road for seven days and PCU comes to 57228.

(c) If this road is improved to the standards with side drains and extension of culvert, then the journey through this road will increase the riding comfort. Travel time and operation cost will be reduced which will be beneficial to the public and Government.

3. PROJECT BACKGROUND

The Proposed road improvement works starts from Thazhepalam Bridge at chainage 0/100 and end at Poorapuzha Bridge at chainage Km 14/000. A new bridge at Thazhepalam is constructed recently and the approach road works are in progress under bridges section Tirur. A flyover bridge at Thazhepalam junction at chainage 0/000 of this road is also evolving, as it received in Principle AS under KIIFB scheme.

4. PROJECT DETAILS

The road improvement works are proposed for the Padinjarekkara-Unniyal section of Padinjarekkara –Unniyal -Tanur-Ariyallur-Kadalundi road which connects Cochin and Calicut through the shortest route through Ponnani and Tirur.

Tirur is a Revenue Division/Taluk Headquarter and A class municipality in Malappuram district. It is one of the business centers of Malappuram district. It is on the Shoranur–Mangalore section of the railway line. Tirur is also a major regional trading centre for fish and betel leaf and has an average elevation of 2 metres from MSL.

Tirur was part of the Kingdom of Vettattnad in medieval times. The 16th-century poet Thunchaththu Ezhuthachan, who is considered to be the father of the Malayalam language literature, lived in the town. Thunchan Parambu in Tirur is highly venerated and its sand is believed to be sacred. The sand is used in Vidyāraṃbhaṃ, especially on Vijayadashami. Historically many famous scholars like Melpathur Narayana Bhattathiri who composed the Narayaneeyam in Sanskrit and Thunchathu Ramanujan Ezhuthachan came from Tirur. Thirunavaya, the classic medieval centre of Vedic learning; Kottakkal, home of Ayurveda medicine are located near to the Tirur. Ponnani, one of the oldest centres of Islamic education and important fishing harbour is located on the Chamravattom – Kadalundi route.

Thunjath Ezhuthachan Malayalam University, Thunchanparambu a memorial for the great poet Thunjath Ramanujan, Wagon tragedy hall in memorial of the wagon tragedy during British rule are located in Tirur.

Garudan Kavu, Alathiyur Hanuman Kavu Temple, Chamravattom Sastha Temple, Triprangode Kalasamharamurthy temple, Vyrankodu Bhagavathi Temple, Trikkandiyoor Maha-Siva Temple, Bhayankavu Bhagavathi Temple Puthiyangadi Masjid etc. are some of the important worship and pilgrimage centre in are in and around this route.

This project is not a newly alignment road. In this project improvements of existing roads with drainage systems are proposed. Present condition of existing cross drainage structures are poor. Shifting charges of utilities and water lines include in this project.

5. OBJECTIVE AND SCOPE OF THE WORK

If this road is improved to the standards and executing side drains and, then the journey through this road will be very pleasant and the travel time and operation cost be reduced which will be much beneficial to the public. Construction of proper drainage system, reducing the obstruction of vision at curves, providing GSB, WMM, DBM & BC and traffic safety measures are mainly includes in this project.

6. FEASIBILITY STUDIES

A detailed investigation conducted over this road by M/s Esteem Developers (P) Ltd, Cochin. Traffic analysis, Present traffic count, projected traffic for 10 years, CBR tests, Benkelman Beam Deflection studies etc. are conducted as part of the investigation studies. Investigation studies and Pavement design Proposes surface improvement with 65mm thick Dense

Bitumen Macadam and 40mm thick Bituminous Concrete are essential for the surface improvement.

7. REQUIREMENT / DEMAND ANALYSIS

(a) After opening of Chamravattom- Regulator cum bridge, the road distance between Ernakulam- Kozhikode will be reduced about 40 kms through proposed coastal route. This road traverses through a plain terrain through coastal areas without sharp curves. Also, the route devoid of tolls and speed interceptors. Due to easement of driving, commuters will choose this route including container trucks, tankers etc. Consequently, the traffic density has increased enormously through this route and hence improvements to the road including the sub base is essential to accommodate high intensity of heavy traffic.

(b) The proposed work will be benefited to the natives of the locality and farmers and is very essential to the overall development of the Municipality and nearby Panchayaths in particular.

(c) Most of the people living in this area are low income group or middle income group whose main income is from agriculture. The major crops are coconut, areacanut, Betal leaf, vegetables etc. Now they have to carry these agricultural products to reach the marketing centres such as Malappuram, Kottakkal, Ponnani, Calicut etc. by travelling through this badly damaged road which cause heavy expenditure. If this road is improved including the subbase and by DBM & BC road and providing proper drainage and culverts, the farmers can easily fetch the marketing centres with less expenditure and reduce travelling time and fuel.

(d) A traffic study was conducted for seven days and PCU comes to 57684. Which is separately attached with this DPR. Both side of this stretch highly populated area.

8. FUNCTIONAL DESIGN

(a) This road is one of the important MDR in Malappuram district, starts from Padinjarekara to Kadalundi which leads to Calicut. The existing carriage way surface with BT are damaged due to the heavy vehicular traffic and the non-maintenance of road except the ordinary repairs, hence this project is proposed.

(b) Detailed investigation studies are conducted accordingly the pavement designs are prepared.The detailed estimate prepared for the improvement of the work of this road is as per the current Delhi schedule of rates for 2016 and MoRTH specifications.

(c) This project is improvements to existing road. If this road is improved to the standards and executing side drains and extension of culvert, then the journey through this road will be very pleasant and the travel time and operation cost be reduced which will be much beneficial to the public.

(d) The operation of this work will be entrusted to the Kerala Public Works Department. Due to the fulfilment of this project the expenditures and benefit of transportation expenditure due to the fuel savings. The government have a huge savings of approximately Rs. 50.00 Lakhs per year from the yearly maintenance of this road.

(e) This road traverses through coastal belt having sandy soil and level terrain and it requires sufficient drainage system. Due to the lack proper improvement and upgradation works to the road and lack of sufficient drainage system, this road damage rapidly during the monsoon. Construction of proper drainage system, traffic safety measures are includes in this project.

(f) A traffic study was conducted for three days and PCU comes to 8112. The detailed project report prepared for the improvement of the

work of this road is as per the current Delhi schedule of rates for 2016 and MoRTH specifications.

(g) A detailed investigation conducted over this road by M/s Esteem Developers (P) Ltd, Cochin. As per the pavement design the road surface improvement with 65mm thick Dense Bitumen Macadam and 40mm thick Bituminous Concrete are essential for the surface improvement. For improving the foundation/sub base of the road are constructing with 260 mm GSB and 250mm WMM are also proposed asper the investigation and test results.

9. ENGINEERING SURVEYS AND INVESTIGATIONS

Detailed investigation and surveying conducted over this road by M/s Esteem Developers (P) Ltd, Cochin. Details are mentioned in investigation report, which is attached with this DPR.

10. ENGINEERING DESIGN

(a) A detailed topographical and geotechnical investigation conducted over this road by M/s Esteem Developers (P) Ltd, Cochin. Details are mentioned in investigation report. Design and cross section of road which is separately attached with this DPR.

(b) <u>Existing ROW Details</u>

i. This road have an average 15.00metre right of way with a 5.50m carriage Way from 00/000 to 15/000

ii. The height of existing embankment is average 0.50 in many stretches and the present condition is very bad in some stretches. Raising is proposed in the estimate as per the investigation studies and topographical map.

iii. Location of drainage details clearly mentioned in the detailed estimate. Present condition of existing drainage is not good.

iv. The present condition of existing side drain is bad. As the road traverse through level terrain, it is difficult to connect the Outlet of existing side drain with natural streams and culverts. Hence raising

of existing road levels are proposed at required locations in the estimate.

v. There are large number of deferent types of trees and utilities like underground cable and KWA pipe lines along and across within the boundary.

vi. There is no existing bus bay locations in this stretch. Present condition of existing road safety measures are nil or completely damaged.

vii. These items are mainly included in bridge work.

viii. It is observed that the large parts of the road are in a pathetic condition with total ruts, ravelling and alligator crack. Water stagnation on major parts of the road are observed during rainy season. Many cross roads are present in this road. Since the existing road is not a designed one proper camber is not available for drainage of storm water.

(c) A detailed investigation is conducted over this road by M/s Esteem Developers (P) Ltd, Cochin. Pavement design and surface improvements are done based on the investigation results and as per IRC specification and MoRTH specifications.

(d) In this work 36 month DLP period is implemented for rectifying damages. No separate claim for contractor within DLP period.

(e) Drawings of extension of existing cross drainage, side drain and retaining wall are separately attached with DPR.

11. FINANCIAL ESTIMATES & COST PROJECTIONS

(a) Estimate amount comes to Rs 46.50 Crores, An amount of Rs 6500.00 Crores included in the Budget Speech 2017-18, Page No:62,Sl No:152

(b) The detailed estimate prepared for the improvement of the work of this road is as per the current Delhi schedule of rates for 2017 and MoRTH specifications through PRICE.

(c) Cost of investigation is including in this DPR.

(d) Provision for land acquisition charge not included in this DPR.

12. REVENUE STREAMS

(a) Roadway costs include public expenditures to build and maintain roadway facilities, including land, road construction, maintenance, and operations. Cost recovery refers to the portion of roadway costs that are borne by users through special user fees and taxes, such as road tolls, special fuel taxes, and vehicle registration fees.

(b) Government organizations today generate revenue through the sale of goods—through existing retail operations, the sale of government assets and the sale of seized or forfeited assets. This strategy is particularly appropriate for agencies with existing retail operations or a large base of underutilized assets. Agencies that do already sell goods could generate additional non-appropriated revenue by developing innovative products and improving go-to-market strategies.

i. Advertising Agencies can also generate non-appropriated revenue through advertising. With the constraints associated with the traditional advertising model of selling space loosening, organizations can think more broadly about where and how they can sell advertising. An agency with publicly visible assets or an ongoing marketing campaign can find creative ways of providing value for the agency, the public and its private sector partners.

ii. Using four strategies—sale of goods, value-based fees, collection of rents and advertising—public sector organizations are testing the waters and discovering the potential for generating no appropriated revenue. By exploring examples of federal agencies that have already taken steps to generate non-appropriated revenue, we can highlight when these strategies can be applied and uncover opportunities for further innovation.

13. COST BENEFIT ANALYSIS & INVESTMENT CRITERIA

Cost benefit analysis details of the projects are attached with this Detailed Project Report.

14. ENVIRONMENTAL AND SUSTAINABILITY ASPECTS

Environmental issues are not anticipated during this project as this Project is for the improvements to existing road. The trees cut for the widening of the carriageway will be compensated by planting trees. Provision for the same has been incorporated in the estimate.

15. RISK ASSESSMENT AND MITIGATION MEASURES

The work will be implemented by the Public Works Department with all responsibilities. During the defect liability period of this works, the contractor is responsible for all the rectification of defects.

16. PROJECT MANAGEMENT ORGANISATION

Monitoring committee organized for asses this project. The project will be arranged by the Kerala Public Works Department (NH) and will be carried out through approved contracting agencies by inviting competitive bids. Work execute under the proper supervision of PWD (NH) Engineers.

17. CONTRACT MANAGEMENT STRATEGY

(a) The project will be arranged by the Kerala Public Works Department (NH) and will be carried out through approved contracting agencies by inviting competitive bids.

(b) The detailed project report for the improvement of the work of this road is as per the current Delhi schedule of rates for 2016 and MoRTH specifications.

(c) No arbitration clauses will existing in public works department inforce.

(d) Additional financial commitments will be met from lump sum amount provided in the DPR.

18. IMPLEMENTATION SCHEDULE & WBS

(a) Time bound work schedule will be prepared for this project before executing agreement, which is an important part of this project, which helps in better handling of project in planning, implementation of all works.

(b) Date of commencement of work will be implemented after executing agreement. Bar chart and project schedule will be prepared before executing agreement.

(c) Proposed work scheduled as per agreement schedule, in each phase work is monitoring by monitoring committee. Work execute under the proper supervision of PWD (NH) Engineers.

(d) It is expected that the work has to be completed within 18 months from the date of commencement and the work can commence during 2017-18 and completed by 2018-19.

(e) Detailed project report should provide a time bound action plan including tendering, appointment of contractors, construction schedule, quality assurance and separate quality wing (PWD) for monitoring the project in each stage. Work execute under the proper supervision of PWD (NH) Engineers. Work will be implemented by the Public Works Department with all responsibilities. . During the defect liability period of this works contractor is responsible for all the rectification of defects.

19. STATUTORY CLEARANCES

(a) Statutory clearance will be obtained from KSEB, KWA and BSNL before the commencement of work. Shifting charges for utility items provided in the Detailed Project Report.

(b) Statutory approval will be obtained from concerned departments before the commencement of work.

20. QUALITY MANAGEMENT PLAN

(a) Quality assurance and separate quality wing (PWD) for monitoring the project in each stage.

(b) Three type of method adopted to ensure quality checking in PWD wing.

a. First tier quality checking (contractor)
b. Second tier quality checking
c. Third tier quality checking.

(c) As per the direction of PWD officials, contractor has to setup first tier quality testing lab at site. All materials quality checked before commencement of work.

(d) As per clause 2406 of the revised PWD Manual 2012, Technical audit shall be done by an external agency/expert empanelled for the purpose after the construction of a project is completed. This will form the third tier of QC system. Technical audit shall be done for projects, estimated cost of which is above Rs 5 crores. All tests carried out in the first-tier and second-tier QC testing shall be reviewed during technical audit.

(e) Technical Audit shall be completed within six months from the date of completion of construction. Non-destructive testing techniques shall be adopted if conventional testing techniques cannot be applied.

21. OPERATIONS & MAINTENANCE PLAN

(a) In this project operation and maintenance will be implemented by the Public Works Department (National Highway Division) with all responsibilities.

(b) In this project 36 month DLP period for rectifying crack or damages. No separate claim for contractor within DLP period.

(c) Operation and maintenance amount included in this project.

DETAILED APPRAISAL REPORT

DETAILED PROJECT REPORT FOR THE PROPOSED CONSTRUCTION OF COASTAL HIGHWAY: PALAKODE - KUNNARU CITY STRETCH (KM 0/000 TO 4/665) IN KANNUR DISTRICT

Rep No. AR-2020-TRAN 17-PWD014-16

Date: 29 September 2020

1 SALIENT FEATURES

1.1 Project details in brief

Name of Project	Proposed Construction of Coastal Highway: Palakode – Kunnaru City Stretch (Km 0/000 to 4/665) in Kannur District.
District	Kannur
Constituency	Payyanur
Project Outlay	**Rs 34.7132 Cr** against the DPR cost of **Rs 79.60 Cr**
Report Prepared by	PWD NH Division Kannur
SPV/Implementing Agency	KRFB
Administrative Sanction	GO(Rt) No 942/2017/PWD Dtd 10/07/2017
Budget Speech Reference	Budget Speech 2017-18 (6500 Cr for Coastal Highway)
Budget provision	Funded by KIIFB
Length of road	4.665 Km
RoW & Carriage way	14.00 m & 7.00m.
Details of other components	0.75 m paved shoulders on either side, 1.50 m drain cum foot path on either side & 2.50 m cycle track on left side
Structural components of pavement	GSB 150mm, WMM 250 mm, DBM 50 mm, & BC 40 mm.
Number of Culverts	11 Nos
Land to be acquired	856 Cents
Structures affected	**2786.877 m2**

1.2 Administrative Sanction was accorded for the work as per GO(Rt) No 942/2017/PWD Dtd 10/07/2017.

1.3 The Alignment of the stretch starts (Ch 0+000 Km) near from Palakkode Bridge nearly 4.5 km west of NH-66 and continues till Kunnaru City (Ch 4+665 km) where KIIFB Road (Ramanthali – Kunnaru) starts. After Ch. 4+665 km, the alignment will continue through KIIFB road as proposed by NATPAC.

1.4 The Detailed Project Report is prepared by PWD NH Wing Kannur which comprises project description, engineering surveys and investigation details, Geometric design Project cost estimation and Cost benefit Analysis. The report acknowledge that all activities related to field studies, design and documentation were done as per the prevailing IRC/KIIFB guidelines. The report also states that on completion of the project, It would improve the connectivity of the area, reduce the traffic congestion along NH 66.

1.5 Total length of the road will be 4.665 Km. The DPR comprises all necessary Traffic study data, alignment drawing, Cost estimate, Socio-economic analysis etc. in support of the arguments favoring the project.

1.6 The layout of the proposed road is as given below:

Fig: Project Influence Corridor

2 REQUIREMENT / DEMAND ANALYSIS

2.1 It is the policy decision of the Government of Kerala to construct Coastal Highway connecting Poovar & Kunjathoor covering 9 coastal districts.

2.2 Promoting tourism spots, Fisheries Development, Easy Cargo Movement & Reducing congestion in NH are the objectives of this highway in addition to providing transport facilities to the coastal areas/ports. The proposed project is implemented through KIIFB funding.

2.3 In addition to the above objectives, on completion of the entire reaches of coastal highway in this district, it would definitely decongest the NH 66 in the district. The Alignment of the stretch starts (Ch 0+000 Km) near Palakkode Bridge nearly 4.5 km west of NH-66 and continues till Kunnaru City (Ch 4+665 km) where the KIIFB Road (Ramanthali – Kunnaru) starts.

3 FUNCTIONAL DESIGN

3.1 The functional design is carried out based on the requirement analysis through field studies and documentation as per IRC & KIIFB guidelines. Designs are strictly as per geometric standards. The alignment drawing has been finalized based on the topographic and geotechnical studies.

3.2 Total length of road will be 4.665 Km with RoW of 14m and Carriage way of 7m.

3.3 The alignment is selected in such a way that the land acquisition and rehabilitation is minimum.

4 ENGINEERING DESIGN

4.1 Preliminary Engineering design of this project is carried out as per feasibility studies, establishing all the design requirements and geometric standards.

4.2 RoW and Carriage way width: 14 m & 7 m respectively

4.3 Structural details of pavement: GSB 150mm, WMM 250 mm, DBM 50 mm, & BC 40 mm.

5 O&M STRATEGY

5.1 Construction and maintenance of the coastal Highways in Kerala is under the control of PWD NH.The work will be carried out by KRFB through PWD NH Wing.

5.2 The defects if any during the defect liability period will be done by the original project contractor with the supervision of PWD NH wing. KRFB will stipulate necessary conditions in the agreement for the same.

5.3 The DLP period of the project will be 3 years.

5.4 All the activities in connection with the O&M strategy are explained in the DPR

6 FINANCIAL ESTIMATES & COST PROJECTIONS

6.1 The estimated cost is based on MoRTH specifications and DSR 2016 arrived at as per PRICE with cost index of 32.04 of Kannur District.

6.2 Total cost of the project as per revised estimate comes to Rs 36.5 Cr.

6.3 The summary of cost sought for funding and the recommended cost is provided below:

	Item	Cost as per Revised DPR (lakhs) Rs	Recommended
1	For the formation &pavement construction	**10,98,54,978.44**	**10,98,54,978.44**
2	For side protection and CD works	**8,94,30,362.08**	**8,94,30,362.08**
3	For road safety & Beautification works	**2,42,56,717.65**	**2,42,56,717.65**
4	For Bus shelter	**25,49,383.67**	**25,49,383.67**
6	Street Lighting	**32,97,613.00**	**32,97,613.00**
7	Utility shifting KWA	**1,10,00,000.00**	**1,00,00,000.00**
8	KSEB Pole shifting	**1,50,00,000.00**	**1,00,00,000.00**
9	Shifting of water line of Ramanthali-Panchayath, Telephone cables and other utilities	**10,00,000.00**	**10,00,000.00**
10	For Land Acquisition	**1,90,52,550.00**	**1,90,52,550.00**
11	For compensation of structures	**5,01,99,786.00**	**5,01,63,786.00**
	Total	**32,56,41,390.84**	**31,96,05,390.84**
12	For GST Payment	**3,90,76,966.90**	**2,75,26,686.58**
13	For Unforeseen & LS	**2,81,642.26**	
	Total	**36,50,00,000.00**	**34,71,32,077.42**

Total Recommended Cost – Rs. 34,71,32,077 Cr

TS Committee shall evaluate the revised estimate prior to sanction

7 COST BENEFIT ANALYSIS

7.1 Cost Benefit analysis (CBA) are not detailed and documented in the report. This shall be furnished.

7.2 This route definitely decongests the traffic snarled in NH 66 between Kozhikode & Kannur. Also, reduction in air pollution, noise pollution, travel time savings of passengers, savings in fuel consumption etc. are the benefits documented in the report.

7.3 Development of tourism will be a major benefit of the proposed project.

8 VALUE ENGINEERING OPTIONS

8.1 The alignment is selected in such a way that the land acquisition and rehabilitation will be minimum.

8.2 It is reported in the DPR that this alignment is verified by the NATPAC team.

8.3 The GAD proposed in the DPR is observed to be the one with optimum cost.

9 IMPLEMENTATION SCHEDULE & WBS

9.1 A detailed Work Program Schedule is furnished in Annexure.

9.2 As per DPR, physically the work of the project is proposed to be commenced on 21.12.2020.

9.3 The schedule have to be re-worked as the preparatory work itself has delayed considerably.

10 PROJECT MANAGEMENT ORGANIZATION STRATEGY

10.1 KRFB has been appointed as the Special Purpose vehicle (SPV) for the implementation of the project.

10.2 NH wing of the PWD will be directly involved in the execution and supervision of the project

11 CONTRACT MANAGEMENT STRATEGY

11.1 The strategy has been explained in the DPR.

11.2 Tenders will be invited by KRFB as per prevailing practice under two cover and normally the price of the lowest bidder will be accepted.

11.3 The work will be implemented through PWD NH wing.

12 STATUTORY CLEARANCES

12.1 Administrative sanction has already been accorded for the construction coastal road as per GO(Rt) No 942/2017/PWD Dtd 10.07.2017.

13 ENVIRONMENTAL ASPECTS & SUSTAINABILITY

13.1 Project is not coming under protected areas such as Forest/Sanctuary/National Park etc. prior clearances are not applicable under Conservation Act.

14 QUALITY MANAGEMENT PLAN

14.1 Quality management plan and strategies are also covered in the DPR as contemplated in the PWD manual.

14.2 1ST tier quality management will be the responsibility of the contractor and will be done in consultation with the supervising agencies.

14.3 The 2nd tier quality management will be done by the PWD through reputed lab.

14.4 The 3rd tier QC checking shall be arranged by the external agency empaneled for the purpose.

15 RISK ASSESSMENT AND MITIGATION MEASURES

15.1 The DPR has not covered and assessed the possible risk associated with this work and suggested measures for the mitigation.

15.2 Detailed work program schedule, statement towards cash flow for mitigating financial risk, construction management strategy, strategy for utility shifting etc. are to be furnished .

16 REMARKS AND INFERENCES

16.1 The project report has satisfied all the basic requirements for consideration for the financial assistance from KIIFB.

16.2 The parameters studied as per the demand are in regard to this project itself and the functional design is matching with the actual requirements and are as per standards.

16.3 The alignment & design particulars furnished are satisfactory.

16.4 The nomenclature given in the DPR shall be corrected as " Palakode- Kunnaru city stretch " instead of Palakode – Randuthengu stretch.

16.5 The estimate prepared and submitted is as per the KIIFB/MORTH standards and meets all the basic requirements. Anyhow the TS committee should verify and confirm the provisions of side protection and CD works before according sanction.

16.6 Rectification of defects and maintenance requirements are to be handled in a unified manner within the DLP and after expiry of DLP and a foolproof strategy to be framed before tendering.

16.7 CBR and EIRR are to be furnished by SPV.

16.8 It should be ensured that no geometry shall be compromised at any stage of design or execution.

16.9 The period of completion and the WBS are to be furnished as per norms as early as possible.

16.10 The contract management plans are acceptable provided the procedures and the documentations shall strictly be as per the prevailing norms.

16.11 The risk factors in obtaining statutory clearances from other department shall strictly be monitored by KRFB and delay avoided.

16.12 Need for environmental clearances shall also be verified and confirmed at the time of commencement of work also.

16.13 The risk management plan shall be one which eliminates and mitigates all the risk factors associated with the work.

16.14 It is the responsibility of KRFB to make available majority of ROW at the beginning of the execution and to obtain the approval of alignment from government prior

to commencement and also the timely shifting of utilities, so as to avoid possible chances of time extension.

16.15 As the design, execution and quality control of different items are to ensure by contractor also, all the personnel deployed by the contractor should be well qualified and experienced to achieve desired output.

17 RECOMMENDATIONS AND SUGGESTIONS

17.1 The project may be considered for funding by KIIFB provided the tripartite agreement shall be entered after ensuring adequate clarity in the observations 16.5 to 16.14.

17.2 In view of the replies to TAR, furnished by KRFB the amounts to be considered for sanction comes to **Rs. 34,71,32,077 Cr**

17.3 The detailed estimate shall strictly be reviewed and scrutinized by the TS authority. In order to avoid any ambiguity during execution, the TS authority should confirm that all the designs & proposals are technically sound, appropriately engineered and also that the estimates are accurately prepared.

17.4 Technical sanction is mandatory before tendering and executing agreement.

17.5 The cost provisions earmarked against work alone shall be utilized for execution of work. The savings or anticipated savings from LA, QC, shifting utilities etc. shall not be re- appropriated for meeting expenditure of work proper.

17.6 The identified revenue streams if any shall be communicated while signing tripartite agreement.

Detailed Project Report

Coastal Highway Palakkode - Randuthengu Stretch in Kannur district.

TECHNICAL REPORT

NOVEMBER 2019

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1.0 INTRODUCTION

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2.0 PROJECT DEFINITION CONCEPT AND SCOPE

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3.0 REQUIREMENT/DEMAND ANALYSIS

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4.0 FUNCTIONAL DESIGN

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5.0 ENGINEERING SURVEYS AND INVESTIGATIONS

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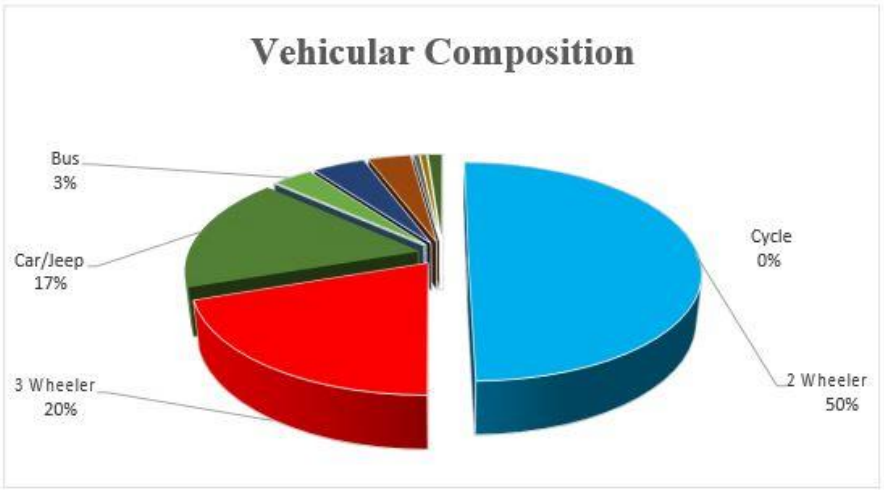

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Figure 12.5 Catalogue for pavement with bituminous surface course with granular base and sub-base - Effective CBR 9% (Plate-5)

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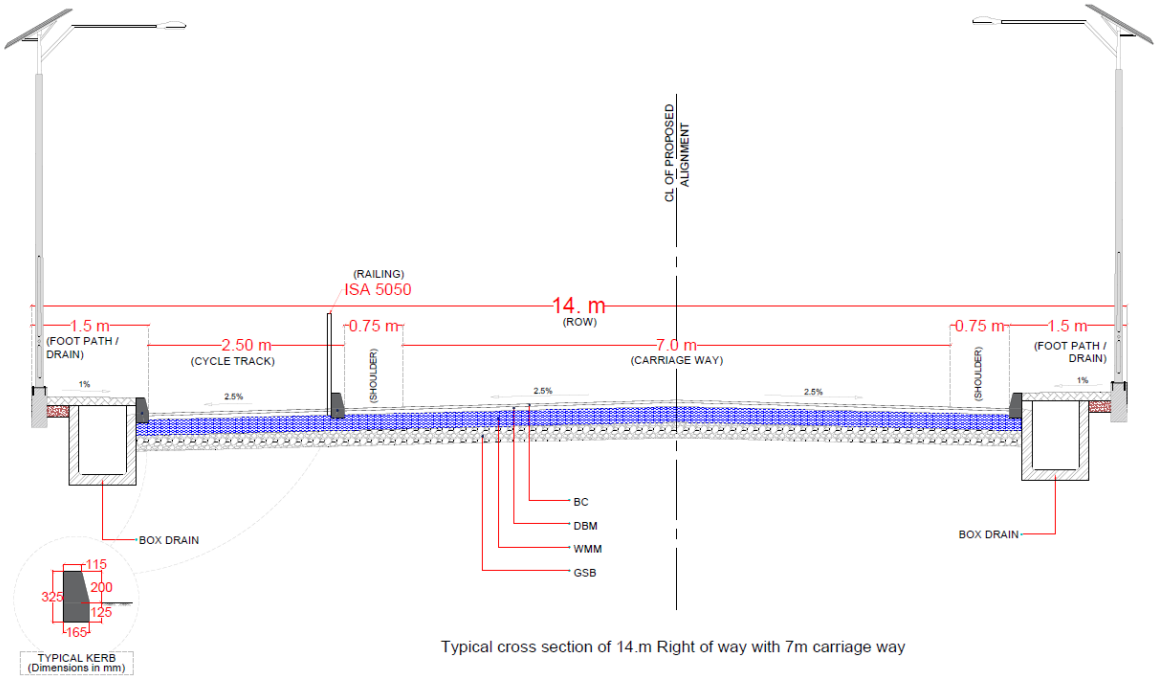

Typical cross section of 14.m Right of way with 7m carriage way

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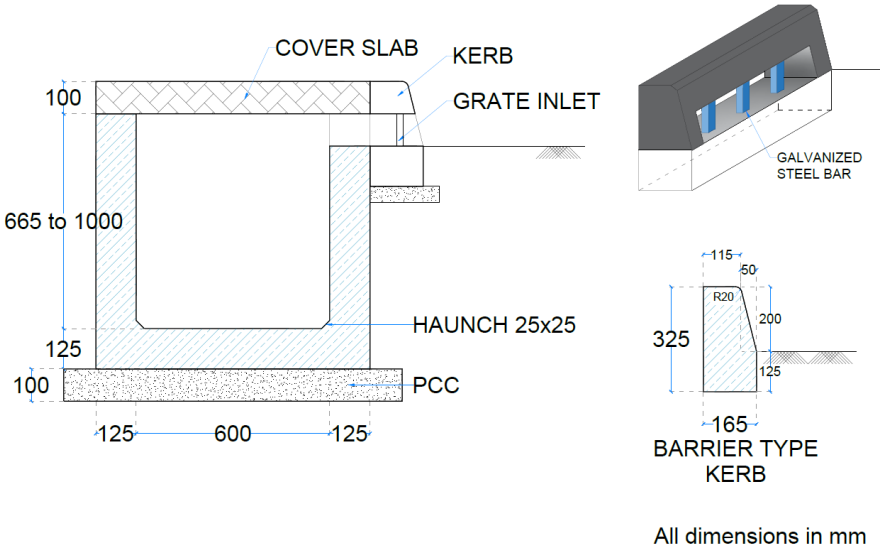

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Roads and Bridges Development Corporation of Kerala Limited (RBDCK)

Kerala Infrastructure Investment Fund Board (KIIFB)

Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches

Detailed Project Report
(Volume-I: Main Report)

March 2020

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CERTIFICATE

This is to certify that, the DPR for **"Construction of Cable stayed Bridge across Ponnani Estuary in Costal Highway"** has been verified by us and the provisions included are essentially required and adequate for the proper completion of work. Also certify that, the estimates and rates have been prepared using PRICE software based on DSR 2016 and cost index applicable to the projects in Malappuram District, i.e. 31.06%.

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DOCUMENT CONTROL

Title	**Construction of Cable stayed Bridge across Ponnani Estuary in Costal Highway"**			
Document Type	Detailed Project Report			
Reference to related documents	GO. (Rt) No. 942/2017/PWD dt. 10.07.2017			
Approval Agency	Kerala Infrastructure Investment Fund Board			
Prepared by	L&T Infrastructure Engineering Ltd			
Verified and Submitted by	Roads and Bridges Development Corporation Kerala Ltd.			
	Checked	Verified	Recommended	Approved
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				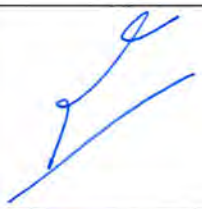

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

Client: **Roads and Bridges Development Corporation of Kerala Limited (RBDCK)**
(A Government of Kerala Undertaking)

Project:	**Project No.:**
Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches	C1193601

Title:	**Document No.:**	**Rev.:**
Detailed Project Report Volume-I: Main Report	RP010	0

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Notes:

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Revision Details:

Rev.	Date	Details	Prepared Init.	Prepared Sign.	Checked Init.	Checked Sign.	Approved Init.	Approved Sign.
0	12/03/2020	First Submission	VVD		PML		KGN	

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ANNEXURE-5: WBS FOR CONSTRUCTION ACTIVITIES OF THE PROJECT

1 SALIENT FEATURES

1.	TITLE OF THE PROJECT	DESIGN AND CONSTRUCTION OF CABLE STAYED BRIDGE ACROSS PONNANI ESTUARY WITH APPROACHES UNDER EPC MODE IN MALAPPURAM DISTRICT OF KERALA STATE, INDIA.
2.	DISTRICT	MALAPPURAM
	THALUK	PONNANI, TIRUR
	CORPORATION/MUNICIPALITY /PANCHAYAT	PONNANI, PURATHUR
	ASSEMBLY CONSTITUENCY	PONNANI, TIRUR
3.	IMPLEMENTING AGENCY/SPV	ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LIMITED (RBDCK)
4.	DPR PREPARED BY	L&T INFRASTRUCTURE ENGINEERING LIMITED (L&T-IEL)
5.	PROJECT OUTLAY	Rs.309.442 CRORES
6.	BUDGET PROVISION	Rs.100 CRORES
7.	BUDGET SPEECH REFERENCE	SECTION VI, PARAGRAPH 157, ITEM 44 OF BUDGET SPEECH 2017-18.
8.	ADMINISTRATIVE SANCTION	REVISED ADMINISTRATIVE SANCTION FOR Rs. 236 CRORES VIDE G.O (Rt) No.942/2017/PWD DATED 10-07-2017.
9.	NATURE OF THE PROJECT	NEW BRIDGE
10.	PRESENT STATUS OF EXISTING BRIDGES/ROADS	NOT EXISTING
11.	NEED FOR THE PROJECT	CONNECTING PONNANI TO TIRUR (PADINJAREKKARA) - MISSING LINK IN COASTAL HIGHWAY
12.	TYPE OF BRIDGE	CABLE STAYED BRIDGE WITH VIADUCT

	TOTAL SPAN LENGTH OF BRIDGE	***A) FOR MAIN BRIDGE (CABLE STAYED PORTION)*** 100 + 200 + 100 = 400m. ***B) FOR VIADUCT PORTION*** 17 x 30m + 2 x 50m + 16 x 30m = 1090m.
	OVERALL AND CARRIAGEWAY WIDTH'S	***A) FOR MAIN BRIDGE (CABLE STAYED PORTION)*** DECK WIDTH = 23m. CARRIAGEWAY WIDTH = 9.5m (with shy) FOOTPATH CUM CYCLE TRACK WITH TOURISM AMENITIES = 9.5m MEDIAN WIDTH = 2.0m ***B) FOR VIADUCT PORTION*** DECK WIDTH = 13m. CARRIAGEWAY WIDTH = 9.5m (with shy) FOOTPATH = 2.0m
	PROVISION OF FOOTPATH	YES
	IRC LOADING CLASS	CLASS 70R, CLASS A AND SPECIAL VEHICLE (AS PER IRC-6:2017)
	OTHER DETAILS OF PROPOSED BRIDGE	TOURISM AMENITIES SHALL BE PROPOSED OVER MAIN BRIDGE AT FOOTPATH CUM CYCLE TRACK LOCATIONS. AFTER AUGMENTATION TO 4 LANE'S THE PEDESTRIAN PATH SHALL BE SHIFTED TO UNDERNEATH THE BRIDGE WHICH SHALL BE HANGING FROM THE BRIDGE CANTILEVER.
13.	LENGTH OF APPROACH ROADS	3.310 km.
	OTHER DETAILS	**A) PACKAGE-I (FROM CH:0+000 to CH:2+550)** LENGTH OF APPROACH ROADS = 2.550 km.

		B) PACKAGE-II (FROM CH:2+550 to CH:4+800) LENGTH OF APPROACH ROADS = 0.760 km. LENGTH OF VIADUCT = 1.09 km. LENGTH OF MAIN BRIDGE = 0.4 km.
14.	DETAILS OF INVESTIGATIONS/SURVEYS CONDUCTED	
	i. TOPOGRAPHICAL	YES
	ii. BATHYMMETRY	YES
	iii. GEOTECHNICAL	YES
	iv. TRAFFIC	YES
	v. PAVEMENT CONDITION SURVEY	YES
	vi. MATERIAL INVESTIGATIONS	YES
	vii. SOCIAL SURVEY	YES
	viii. MARINE ENVIRONAMENTAL SURVEY	UNDER PROGRESS
	ix. CRZ MAPPING	UNDER PROGRESS
15	WHETHER LAND ACQUSISTION INVOLVED?	YES
	IF YES, FURNISH DETAILS	DETAILS WILL BE SUBMITTED SEPARATELY.
16.	TOTAL ESTIMATED COST AND ITEM WISE COST BREAK UP AND DETAILS OF SCHEDULE OF RATES	DONE
	WHETHER DETAILED ESTIMATE ATTACHED?	YES
17.	DETAILS OF REVENUE STREAMS	1. BRIDGE CAFÉ AT PYLON LOCATIONS. 2. TOURISM AMENITIES AT BRIDGE

		DECK.
18.	DETAILS OF COST BENEFIT ANALYSIS (CBR VALUE)	EIRR 21.15%
19.	DETAILS OF PROJECT RISKS	AS PER SECTION 3.11
20.	DETAILS OF PROJECT MANAGEMENT STRATEGY	AS PER SECTION 3.12
21.	DETAILS OF CONTRACT MANAGEMENT STRATEGY	AS PER SECTION 3.13
22.	DETAILS OF PROJECT IMPLEMENTATION SCHEDULE (PIS) & WORK BREAK DOWN SCHEDULE (WBS) -PROPOSED DURATION TO COMPLETE THE PROJECT	AS PER SECTION 3.14 PROPOSED DURATION TO COMPLETE THE PROJECT IS TWO (2) YEARS
23.	DETAILS OF STAUTUORY CLEARANCES	AS PER SECTION 3.15 CRZ CLEARANCE-UNDER PROGRESS FOREST CLEARANCE/TREE FELLING PERMISSIONS – UNDER PROGRESS
24.	QUALITY CONTROL INFRASTRUCTURE AND MECHANISM	AS PER SECTION 3.16
25.	OPERATIONS & MAINTENANACE (O&M) ARRANGEMENTS OF THE PROJECT AFTER COMPLETION	AS PER SECTION 3.17
26.	DETAILS OF ATTACHED DRAWINGS	VOLUME-IX: DRAWING VOLUME VOLUME-X: STRIP PLANS
27.	OTHER ATTACHMENTS	VOLUME-II: DESIGN REPORT VOLUME-III: MATERIALS REPORT VOLUME-IV: EIA REPORT INCLUDING EMP&RAP VOLUME-V: TECHNICAL SPECIFICATIONS VOLUME-VI: RATE ANALYSIS VOLUME-VII: COST ESTIMATES VOLUME-VIII: BILL OF QUANTITIES

2 EXECUTIVE SUMMARY

2.1 General

Roads and Bridges Development Corporation of Kerala Limited (RBDCK) (the "Client/Authority") has been entrusted with the assignment of ***"Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala".*** In this context, the Client has appointed **L&T Infrastructure Engineering Limited (L&TIEL) (the "Consultant")** for carrying out Feasibility Study, to establish the technical, economic and financial viability of the aforesaid project and to prepare Detailed Project Report.

The project road comprises of construction of new Road connecting Ponnani Junction (NH66 Bypass) with Padinjarekkara-Kuttayi Road. This includes construction of cable stayed bridge connecting these two locations. This is also a part of proposed coastal highway and also acts as an alternative route for National Highway 66.

2.2 Background

The Work Order of the project is accepted on 8th July 2019 and the key persons in the Consultant Project Team is visited the project site on 10th July 2019. The Kick-off meeting of the project was held on 11th July 2019 in the presence of the General Manager RBDCK at Kochi and all stake holders meeting held at Speakers Chamber on 26th July 2019. The various activities to be involved in the project and the way forward were discussed on the same day.

The project has been commenced from 8th July 2019 and Inception Report was submitted on 31th July 2019.The key persons from Dept. of Ports, Harbour, PWD, Tourism, KIIFB and General Manager RBDCK, team members proposed for the project by Consultants has attended this meeting. The meeting requested consultants to expedient the project activities and ensure completion of feasibility report and schedules in 120 days. It was advised during the meeting to commence the field activities (especially traffic and topographic surveys) immediately.

As per the instruction from the Speaker's office the consultants consulted Dr. E. Sreedharan, 18th August 2019 to discuss and get advice on the project, particularly on the alignment and the iconic Bridge. He generally agreed on Consultant's proposal and proceeded further.

The concept report as part of the Feasibility Study is submitted to RBDCK on 13th August 2019 and proceeded on Survey/Investigations to complete Feasibility Study. A Stake holder's meeting held on 1st October at Speaker's Chamber to discuss on the Concept and Feasibility Study. The key aspects of the project like alignment, Iconic Bridge Theme and Type have been concluded and proceeded further for Feasibility Report preparation.

The Draft Feasibility Report is submitted on 17th October 2019 and a Public Consultation meeting held at Project site at Ponnani on 24th October. The approval on the Concept report was received from RBDCK on 28th October 2019, Feasibility report is submitted on 17th October 2019 and Draft Detailed Project Report preparation is started.

Draft Detailed Project Report is prepared based on the RBDCK approval of Feasibility Study and submitted on 30th November 2019. The Draft DPR is modified incorporating RBDCK remarks and submitted in KIIFB format on 15-02-2020.

This report **RP009 Volume-I: Main Report** presents Final Detailed Project Report of Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala.

The various stages leading to the submission of the report are as listed below:

- Signing of Contract
- Inception Report
- Concept Report
- Draft Feasibility Report
- Final Feasibility Report
- Draft Detailed Project Report
- **Final Detailed Project Report**

2.3 Project Corridor

The Salient features of the project corridor are given in **Table 2-1.**

Table 2-1: Salient Features of Project Corridor

Salient Features	Description
Length of Project Road (Km)	4.8 Km (Project starts from Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) and follows the existing PWD road up to Ponnani Harbour afterwards crossing the Bharathupuzha River through a cable stayed bridge meeting at the government tourist park location and ends at PWD road at the distance of 700 m from the situated park.
Right of way (m)	Existing Right of Way – 7m to 11m varies
Terrain	Plain
Land Use	Port area and Encroachments / Settlements near bank of Bharathupuzha River. Built up Area (Ponnani junction to Harbor)
Level Crossing	Nil

2.3.1 Summary of Traffic Survey

Consultants have carried out the following traffic surveys in August 2019.

- Classified Traffic volume Count survey (7 Day CVC) 3 location
- 1 day O-D Survey 1 locations
- 2 day Axle load survey 2 locations
- 1 Day Turning Movement Surveys (24 hrs) 4 locations
- Ferry Terminal Survey (12hrs) 1 location
- Speed and delay survey is conducted Along existing road network in Project Influence Area

Average Daily Traffic (ADT) arrived at various survey locations which are listed in **Table 2-2**.

Table 2-2 Average Daily Traffic (ADT) at Other Locations

Vehicle Type	Location NH-66 (Near Urban Bank)		
	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)	SH-62 (Near Kundukadav Bridge)
Two Wheeler	7,538	10,372	11,407
Three Wheeler	1,290	1,664	1,325
Car	5,669	5,401	3,997
Mini Bus	112	63	84
Bus	268	240	437
Goods Auto	179	191	180
Tata Ace / Mahindra	423	546	343
LCV	711	361	448
2-Axle Truck	491	365	462
3-Axle Truck	263	200	130
MAV	218	137	187
Agriculture Tractor-Trailer	2	4	3
Bi-Cycle	253	61	234

Vehicle Type	Location NH-66 (Near Urban Bank)		
	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)	SH-62 (Near Kundukadav Bridge)
Others*	11	9	3
Total Vehicles	**17,429**	**19,615**	**19,238**
Total PCUs	**17,115**	**17,134**	**16,652**

2.4 Road Geometry Improvement Proposal

2.4.1 Cross sectional Elements

As per the Project scenario, it is proposed as a two lane road till 2045 as per KIIFB standards and by considering the future development and predicted traffic, it shall be proposed as a 4-lane configuration thereon. Hence, the deck width proposed for two lanes in the approach viaduct portion to the Iconic Bridge is considered in such a way that new structure which will be constructed shall accommodate future traffic lanes. The Iconic Bridge deck width is proposed to accommodate two lanes traffic on one side of the central median with other side for pedestrians and tourism amenities. It is proposed to move these pedestrian movements to the bottom of the deck once the traffic is augmented to 4 lanes. The proposed carriageway for the project road is presented in ***Table 2-3***.

Table 2-3: Cross-sectional requirement

S.No	TCS Type	Location	Width (m)		
			Carriageway	Paved Shoulder	Footpath cum drain
1	TCS - 2	Chainage 0.000 to 2.750	7	1.5	1.8
2	TCS - 1	Chainage 4.660 to 4.800	7	1.5	1.8
3	TCS – 3*	Chainage 0.000 to 2.750	7	0	1.8

Note * for the existing road before complying to KIIFB standard.

2.4.2 Design Speed

Alignment approved by RBDCK with reference to letter No. RBDCK/ T228/Vol.III /1918 dated 28th October 2019 in feasibility report is considered. Design speed considered for Geometric design is 80 KMPH except some stretch follows 40 KMPH **to avoid land acquisition** in built-up areas. The Design speeds along the stretch are shown in ***Table 2-4.***

Table 2-4: Design Speed

Sl.No	Chainage	Road Type	Design speed Km/hr.	Remarks
1	0.000 to 2.200	At-grade	80	-
2	2.200 to 2.500	At-grade	40 (Can be improved to 80 Km/hr with additional LA)	Built-up area.
3	2.500 to 4.800	At-grade and Elevated	65	Restricted to 65 kmph, since the location of merging with junction and further LA is a constraint

2.4.3 Geometry

The Project section primarily is a Plain terrain. The Project section passes through settlements and Port area. Ruling design speed will be the guiding criteria for correlating the various design features as far as possible. However, minimum design speed will be adopted in constrained sections. The design speed shall be the minimum design speed of 40 to 65kmph.

General principles followed for designing the horizontal alignment are

i) Alignment shall be designed in line with the Existing alignment and proposed within the available ROW.

ii) All horizontal curves requiring super elevation shall consist of circular portion flanked by spiral transitions at both ends.

iii) Reverse curves may be needed in difficult terrain. Sufficient length between two curves shall be provided for introduction of requisite transition curves and required super elevation.

iv) The curves in the same direction separated by short tangents known as broken back curves shall be avoided to the extent possible within the available ROW.

v) Radius of Horizontal Curves:

The radius of horizontal curves shall not be less than ruling minimum values as given in Table-2.5 of IRC: SP: 73-2018 for the specified design speed. Wherever possible higher radii shall be adopted, subject to the availability of PROW

vi) Transition Curves:

As per IRC 73:1980, the length of transition curves will be the maximum value of the following three cases,

Case I: Length calculated as per "Rate of Centrifugal Acceleration", $L=(0.0215V^3)/CR$

Case II: Length Calculated as per "rate of Change of Super elevation", L= Super elevation (%)/100*150*Width of the carriageway.

Case III: As per Table - 17 of IRC 73-1980.

General principles followed for designing the vertical alignment are:

i) The vertical alignment shall be designed as per IRC SP 23: 1993 and IRC 73:2018.

ii) Gradients up to the value corresponding to ruling gradient shall be provided in accordance with IRC: SP: 73-2018.

iii) Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile. Desirably, there should be no change in grade within a distance of 150m in case of new carriageway and bypass.

iv) The aspect of efficient drainage shall be taken into consideration while designing vertical profile and cross sections of the highway in accordance with IRC SP 42: 2014 and IRC SP 50: 2013.

v) There shall be coordination between horizontal alignment and vertical profile of the project highway and guidelines in accordance with IRC 73: 2018.

vi) The level of minor bridge shall be worked out with respect to High Flood level and the proposed soffit level shall be cross verified with existing soffit level.

vii) The vertical alignment of the widening carriageway, bypass and realignment locations shall be designed as per IRC SP 73:2018.

viii) Sight distance shall be in accordance with provision of IRC SP: 73-2018.

ix) The project road is located in Plain terrain. Thus, the vertical alignment of the project road is substantially designed to satisfy design speeds of 40 kmph to 65 kmph

x) The vertical alignment design of the project road in built up areas i.e. from chainage 0.000 to 2.750 (towns and villages) has followed the existing grade. This is preferred to provide easy road side access to the abutting property and at grade intersections/junctions. While designing the vertical alignment, efforts were made to satisfy the Intermediate Sight Distance.

2.4.4 Pavement Design

Pavement Investigation is an important aspect of any highway improvement project, since the performance of highway directly depends on the performance of its pavement and the cost of improvement of pavement is equally important to arrive at the cost of project. The data collected in the survey is an important factor and is utilised to identify the stretches of reconstruction and rehabilitation.

The consultant has carried out visual pavement condition survey on the project road to examine the functional efficiency of the existing pavement. Condition survey data was collected at every 100 m interval with the help of straight edge and measurement scale for main carriageway and paved shoulder.

The general characteristics of pavement distresses observed during the survey of the project road corridor are presented below. Poor workmanship is also a key factor contributing to the pavement failure at many sections of the project road.

- Alligator Cracking
- Longitudinal & Transverse Cracking
- Rutting

- Block Cracking
- Potholes
- Patching
- Raveling
- Edge Crack

Section no.	Overlay Thickness (mm)
0.000 to 2.785	40
4.450 to 5.000	40

2.4.5 Structures

Considering various aspects and discussions with the relevant stakeholders during the DPR stage of the project, Cable Stayed Bridge (main bridge) is proposed across Ponnani Estuary. The span arrangement of the main bridge shall be 100m+200m+100m with a deck width of 23m. The approach viaduct shall be of 30m spans with a deck width of 13m. However at the varying deck transition zone portion, the span shall be restricted to 50m.

The main bridge portion is aesthetically shaped as per the local heritage of the project area. A minimum vertical clearance of 16m shall be maintained as per the requirement of Harbour Engineering Department.

Existing structure condition in the stretch was studied extensively and the improvement recommended will be of the following nature:

- Reconstruction or widening of existing structures (culverts)

2.4.6 Project Facilities

- Tourist viewing facility at bridge.
- Rest areas for tourists.
- Parking and other amenities on both sides.

2.4.7 Road Furniture

- Traffic Signs and Pavement Markings
- Traffic Signs and pavement markings shall include roadside signs, overhead signs; kerb mounted signs and road markings along the project highway. Overhead signs shall be installed ahead of major intersections. Road studs shall be provided throughout the length of the project highway. Chevron sign boards shall be provided at all Horizontal curves on either side of the carriageway. The sign boards shall be designed as per IRC-67-2012. The pavement markings shall be designed as per IRC 35-2015.
- Concrete Crash Barriers / Safety Barriers

- Concrete Crash barriers shall be provided on either side of elevated road and approaches/ramps.
- Hectometre / Kilometre Stones / Boundary Stones
- Hectometre / Kilometre Stones shall be provided as per IRC 26, IRC-8, and IRC-25 and also as per MORT&H specifications.

2.4.8 Environmental and Social Impact Assessment

Developmental projects are likely to trigger set of environmental and social impacts which forms a critical part in decision making. There are various significant benefits which occur due to such development projects while adverse impacts may arise in terms of environment and social aspects. The adverse impacts can be minimized with the help of appropriate mitigation measures. Environmental and Social planning is very crucial to minimize/mitigate such impacts. The design of the road must adhere to the desired standards which meets the requirement of sustainable environment, social acceptability and economic viability. To understand & address various issues which may arise as direct and indirect impacts, Environment & Social Screening is carried out. It helps to prepare Environmental and Social Management Plans (ESMP). They are means to develop appropriate mitigation plans so as to identify and overcome potential negative impacts without aggravating prevailing environmental and social issues on people and environment due to infrastructure development projects.

The EIA has been included in project preparation to streamline environmental issues in project design, constructional and operational stages. The scope of the Environmental Impact Assessment (EIA) as envisaged in the Terms of Reference (ToR) includes Environmental Impact Assessment along with preparation of an Environmental Management Plan (EMP). This report presents EIA of the project and the EMP for the anticipated impacts. Various components covered in the EIA report are briefly discussed in volume IV.

2.5 Project Implementation

The project is proposed to be implemented in **Two Packages** considering the Land Acquisition and R&R. The **First Package** shall be from the start of the project road at Ponnani Junction (Ch.: 0+000) to the Court Junction (Ch.: 2+550) which contains complete road stretch wherein the alignment shall follow the existing PWD road with widening to comply with the KIIFB guidelines. The widening to comply with KIIFB standard shall be taken up at later stage with due LA and R&R. The **Second Package** is from the Court Junction (Ch.: 2+550) to the end of the project road (Ch.: 4+800) which contains road as well as Iconic Bridge with approach viaduct. The LA and R&R shall be done as per the proposed road cross section. The Package 1 shall be taken up separately after completion of Package 2. Since both the packages are mutually independent, the works of Package-1 can be taken up at a convenient time, while the bridge portion, and works on Northern side can be taken up on priority.

2.6 Capital Cost of the Project

S. No.	Bill of Items	Total Amount (In Crore Rupees)
A	**Total Civil Work Cost (Rs. In Cr) as per PRICE (including GST)**	**265.577**
i	Add physical contingency @ 2.8% of total civil work cost	7.436
B	**Total including Physical Contingency of 2.8% (Rs. In Cr) B = A + i**	**273.013**
ii	Add Agency Charges 3% on A	7.967
iii	Add Quality Control 0.25% on A	0.664
iv	Add Road Safety 0.25% on A	0.019
v	5% Maintenance of A	13.279
C	**CENTAGES C = ii+iii+iv+v**	**21.929**
D	**Total project cost (Including Cengage's) D = B + C**	**294.942**
vi	Cost of Utility shifting (Rs. In Cr)	0.500
vii	Cost of Rehabilitation and Resettlement R&R (Rs. In Cr)	2.500
viii	Cost of Land Acquisition LA (Rs. In Cr)	11.500
E	**Total Capital Cost for the Project (Rs. In Cr), E = D + vi+vii+viii**	**309.442**

S.No.	Description	Land/Structure affected	Unit Cost (Rupees)	Cost (in Crore Rupees)
1.	Land to be Acquired	~7.48 acres (748 cents)	i.e. ~100,000/ cent	7.48
2.	Structures Affected	~148 buildings/ structures (~2400 sq.mt)	~16,500/ sq.mt	3.96
3.	R&R	per Household (i.e. 148 HH)	150,000/-	2.22
Estimated LA and R&R cost				**13.66**

IMPORTANT NOTES

1. **Estimation of LA is based on Topo survey results; exact LA details will be based on ROW as per revenue records/village maps.**
2. **R&R Cost takes into account the R&R components as per the LARR Act.**
3. **Any structure which appears to be impacted by over 25%, the entire structure is considered as to be impacted.**

3 CHAPTERS

3.1 INTRODUCTION

Roads and Bridges Development Corporation of Kerala Limited (RBDCK) (the "Client/Authority") has been entrusted with the assignment of ***'Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala'***. In this context, the Client has appointed **L&T Infrastructure Engineering (L&TIEL) (the "Consultant")** for carrying out Feasibility Study, to establish the technical, economic and financial viability of the aforesaid project and to prepare Detailed Project Report.

The project is a part of Coastal Highway for which the alignment on southern and northern side is already finalised. The proposed alignment will be linking these two points; on southern side the Ponnani Junction (NH66 Bypass) and Northern side Padinjarekkara-Kuttayi Road. At present the two sides of the river is connected by Jenkar services in the day time. The road connectivity between the two banks is via Chamravattom Bridge which takes around 20Km. This road will act as a parallel road to NH 66 and reduces the travelling distance from Ernakulam to Kozhikode around 30 Km. Hence the proposed Bridge will be the life line of the Ponnani Beach and its surrounding area.

In addition to the road connectivity between Ponnani and Padinjarekkara, this project has high tourism potential. The Ponnani Beach is mainly fishing beach and as per the Master Plan for Ponnani a lot of tourism amenities have been proposed at this location. The proposal of new Port and Karma roads will enhance the traffic and tourism potential here. In the Northern side Padinjarekkara Beach is already a tourism spot with Park and other amenities.

The project location got its own geographic beauty due to the natural estuary. Hence the construction of high level bridge across the estuary will give a panoramic view of the sea/river at an elevated level. Hence the Bridge is proposed as an Iconic Bridge blended with local heritage.

The Final Detailed Project Report is formulated in the following structure:

Volume I: Main Report.

Volume II: Design Report.

Volume III: Materials Report.

Volume IV: Environmental Assessment Report including Environmental Management Plan (EMP) & Resettlement Action Plan (RAP).

Volume V: Technical Specifications.

Volume VI: Rate Analysis.

Volume VII: Cost Estimates.

Volume VIII: Bill of Quantities.

Volume IX: Drawings.

Volume X: Strip plans and clearances.

Volume XI: EPC work contract Agreement.

3.1.1 Project Definition, Concept and Scope

The proposed bridge structure is planned across the mouth of Bharathapuzha River where the river meets the Arabian Sea in Ponnani. The area along the coast where the approaches to the bridge is proposed is partly intertidal land, partly land without scrub, some Casuarina (north of the River mouth) and sloping towards the coast. The bridge is proposed as the shortest connectivity between Ponnani and Padinjarekkara/Kuttayi as well as an Iconic structure resembling the local heritage considering the high tourism potential. A detailed study is done from various aspects like Highway geometrics, Bridge Structure, Traffic dispersion, Environmental and Social Impacts, Tourism aspects etc.

Land Acquisition, to the extent possible is minimized however where inevitable land schedule will be prepared as per applicable laws and guidelines and shall follow the scope as discussed in the TOR/RFP. The consultant has collected the revenue maps from Revenue Authorities and superimposed the same for preparation of land plan.

Design guidelines for new structures are evolved, and generally in accordance with the IRC/MORT&H standards and codes. Data available from the flood control department regarding the width of waterway and required clearance of existing bridges is considered for fixing the span arrangements and for devising the construction method.

Various alignment options are studied considering the take-off and landing points from the Coastal Highway alignment. The merits and demerits in terms of road geometry, Bridge construction, traffic dispersal, Environment and Social impacts, Rehabilitation and Resettlement, Socio Economic aspects etc. is investigated.

The Environmental Impact Assessment (EIA) study is carried out in accordance with the latest guidelines/norms and amendments of the Ministry of Environment and Forests & Climate Change (MoEF&CC)/Central Pollution Control Board (CPCB). The EIA report is prepared as per the MoEF&CC prescribed EIA Guidance Manual for Highways. **Table 3-1** lists some of the Environmental regulations to be looked into for the degree of applicability for conducting the EIA study:

Table 3-1 Environmental Regulations

Likely Applicable GoI Policies & Regulations	Year	Objective
Environmental (Protection) Act	1986	To protect and improve overall environment
Environmental Impact Assessment Notification (as amended)	2006	Re-engineered EIA notification for Environmental protection and Sustainable Development
Coastal Regulation Zone (CRZ) Notification	2011, 2019	To restrict development activities and act as the primary regulation for conservation and protection of India's coastline and protection of coastal livelihoods
Forest Conservation Act (as amended)	1980	Act to provide for the conservation of forests, felling of trees
Air (Prevention and Control of Pollution) Act	1981	To control air pollution by controlling emission and air pollutants according to prescribed standards
Noise Pollution (Regulation and Control)	2001	Noise pollution regulation and controls

Likely Applicable GoI Policies & Regulations	Year	Objective
Rules 2000 Noise Pollution (Regulation and Control) (Amendment) Rules 2010	& 2010	
Water (Prevention and Control of Pollution) Act	1974	To control water pollution by controlling discharge of water pollutants as per the prescribed standards
The Hazardous Wastes (Management and Handling) Rules	1989 (as amended)	Hazardous wastes management

The General Arrangement of the Cable stayed bridge and its components, Alignment, Plan and Profile, Typical Cross sections, Running cross sections & Junction Improvements shall be referred from **Volume-IX: Drawing volume**. The strip plans shall be referred from **Volume-X: Strip Plans**.

3.1.2 Project Back ground

3.1.2.1 General

Ponnani is a municipality in Ponnani Taluk, Malappuram District, in the state of Kerala, India. It serves as the administrative centre of the Taluk and Block Panchayat of the same name. It is situated at the estuary of Bharathapuzha (River Ponnani) which is the second largest river in Kerala, on its southern bank, and is bounded by the Arabian Sea on the west and a series of brackish lagoons in the south. Ponnani is the only port in Malappuram district. National Highway 66 from Panvel to Kanyakumari passes through Ponnani Municipality. River Tirur joins River Ponnani at its mouth at Padinjarekkara Beach from the north bank, opposite to Ponnani. Our current stretch connects these two banks by constructing a cable stayed bridge which is an iconic bridge of Kerala.

Currently traffic from Ponnani moves to Padinjarekkara beach side either by Ferry Service or has to travel via.., Chamravattom Bridge which is the shortest connectivity between Ponnani and other nearby areas such as Kuttayi, Tirur, Tanur, Parappanangadi etc. These ferry services are operational only from 7:00 am to 7:00 pm. Because of this, road bound traffic to-and-from Ponnani to Padinjarekkara or any other locations is forced to take a circuitous route, thereby resulting in additional time and longer distance travel.

NATPAC has done preliminary alignment surveys and has proposed an alignment for the Coastal Highway. The alignment traverses majorly through existing roads and proposes construction of new bridges and flyovers and missing links. One such bridge/missing link is the current proposed Suspension / Cable Stayed Bridge across Ponnani Estuary in Malappuram District.

The project envisages provision of provision of a cable stayed bridge on Bharathapuzha River and connects Padinjarekkara so as to provide all time road connectivity between these two banks and so as to reduce travel time. This cable stayed bridge is constructed as iconic bridge at the mouth of Bharathapuzha River.

3.1.2.2 The Project Corridor

This section gives the details of alignment which is approved by RBDCK and its stake holders. The project road starts from the Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66. Then follows the existing PWD road up to the cross junction of Ponnani main road and then turns towards the ferry terminal, afterwards follows the proposed structure and crossing the Bharathapuzha River through an Iconic bridge of 200 m obligatory span and then parallel path to existing road up to proposed km 4.660 and then merge with existing PWD road. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock shown in

Figure 3-1.

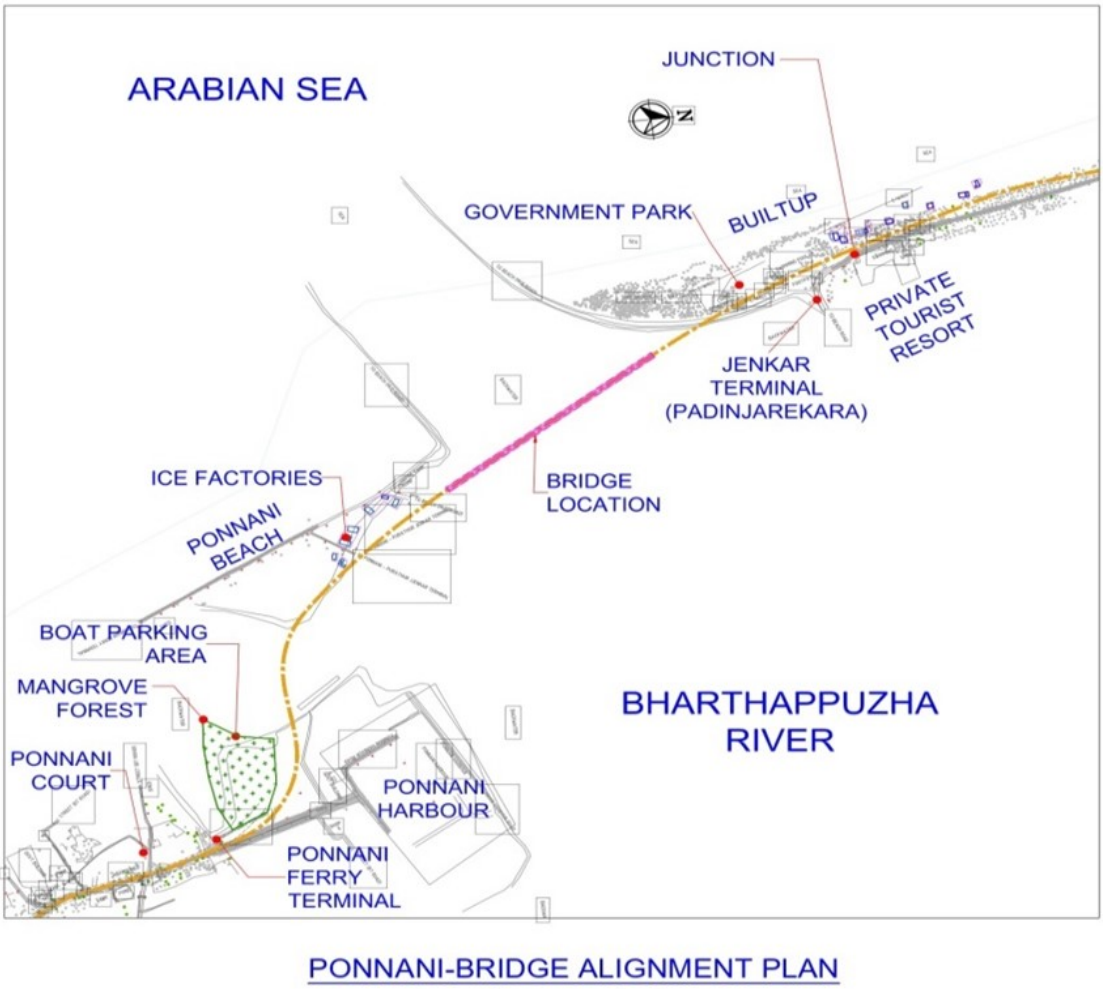


Figure 3-1: Project Alignment

3.1.3 Project Details

The Project Starts at the Ponnani Junction (between Palakkad - Ponnani Road and Panvel – Kochi - Kanyakumari Highway of NH-66) and ends at Padinjarekara beach. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock.

The project is a part of Coastal Highway and the proposed alignment will be linking the two points; on southern side the Ponnani Junction (NH66 Bypass) and Northern side Padinjarekkara-Kuttayi Road. At present the two sides of the river is connected by Jenkar services in the day time. The road connectivity between the two banks is via Chamravattom Bridge which takes around 20Km. Hence the proposed Bridge will be the life line of the Ponnani Beach and its surrounding area. This road will act as a parallel road to NH 66 and reduces the travelling distance from Ernakulam to Kozhikode around 30 Km.

3.1.3.1 Road Connectivity

Ponnani Town is located along the National Highway, NH-66 that connects Kanyakumari in Tamil Nadu and Panvel in Maharashtra. NH-66 connects Ponnani with major places like Ernakulam, Alappuzha, Thiruvananthapuram etc. in the south and Kozhikode, Kannur, Mangalore etc. in the North. NH-66 is predominantly two lane road within the project influence area. Considerable passenger vehicle and goods vehicle movements are observed along this road.

SH-62 connects Guruvayur with Ponnani at Kundukadav Junction. Along with passenger vehicle traffic, the road is observed to carry goods vehicle to / from areas like Guruvayur, Kunnamkulam, and Thrissur etc. The road is of predominantly two lane configuration.

Palakkad- Ponnani Road connects Ponnani with areas such as Edappal, Pattambi, Palakkad etc. The road meets SH-69 at Edappal. The road width is predominantly intermediate and varies between single lane and two lanes at various sections.

Ponnani- Tirur road connects Ponnani with north side of Bharathapuzha River along the Chamravattom Bridge. The road is predominantly of intermediate lane configuration. At present, Chamravattom Bridge is the shortest connectivity between Ponnani and other nearby areas such as Kuttayi, Tirur, Tanur, Parappanangadi etc.

Figure 3-2 and **Figure 3-3** shows the regional setting and major roads that connects Ponnani with other parts of the state.

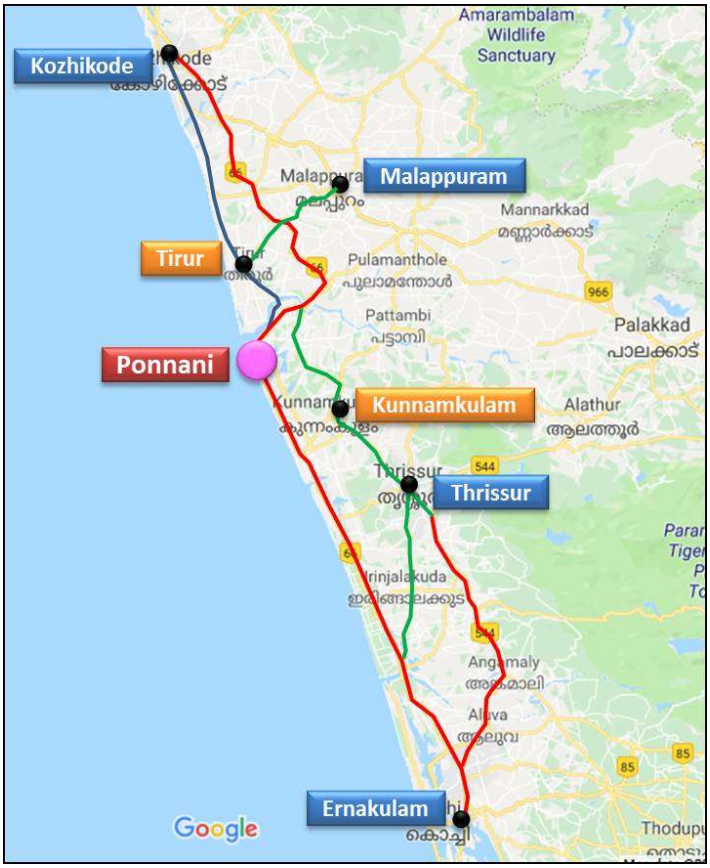


Figure 3-2: Regional Setting of Ponnani Town

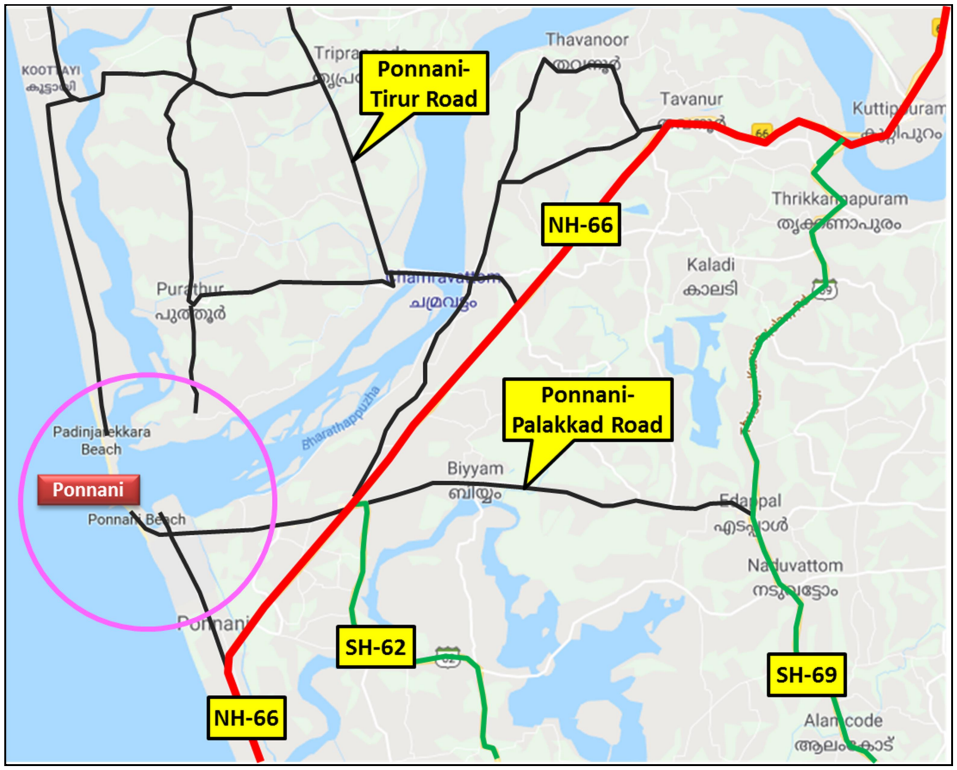


Figure 3-3: Major Roads in Project Influence Area

NH-66 near CV Junction

NH-66 near Anappadi

SH-62 near Valavu Junction

Palakkad-Ponnani Road near KK Junction

Ponnani-Tirur Road near Chamravattom

Chamravattom Bridge

3.1.3.2 Road Characteristics in the project influence area

The major roads and their carriageway width details within the project influence area are presented in **Table 3-2**.

Table 3-2: Carriageway Width of Major Roads in Project Influence Area

S. No.	Name of the Road	Carriageway Details *
1	National Highway (NH-66)	2L-2W-UD

S. No.	Name of the Road	Carriageway Details *
2	Palakkad- Ponnani Road	1.5L-2W-UD
3	Ponnani- Tirur Road	1.5L-2W-UD
4	SH-62 (Guruvayur- Althara- Ponnani Road)	2L-2W-UD
5	Koottayi- Padinjarekkara Road	1.5L-2W-UD
6	Mangalam- Koottayi Road	1.5L-2W-UD
7	Alathiyur- Purathur Road	1.5L-2W-UD
8	Purathur- Chamravattom Road	1.5L-2W-UD
9	Ponnani Beach Road	1L-2W-UD
10	Chanthappadi- NH Link	1.5L-2W-UD

* *L – Lanes, W – Way, UD- Undivided, D- Divided (Eg: 1.5L-2W-UD means Intermediate lane, two-way, undivided road)*

Apart from NH-66 and SH-62, all road sections in the project influence area are predominantly of intermediate lane configuration. However, it is to be noted that there are various sections where the road sections shrink to single lane width.

The Palakkad-Ponnani Road is very narrow near Kodathippadi Junction. Further the bridge on Palakkad- Ponnani Road across Canoli Canal is of single lane configuration. The Koottayi Regulator cum Bridge along Mangalam-Koottayi road is also of single lane configuration.

Koottayi- Padinjarekkara Road

Mangalam- Koottayi Road

Alathiyur- Purathur Road

Purathur- Chamravattom Road

Koottayi Regulator cum Bridge

Bridge across Canoli Canal

Ponnani Beach Road

Chanthappadi- NH Link

3.1.3.3 Ponnani Harbour

Ponnani is one of the major fishing harbours in Kerala. High fishing activities with mechanised boats are centred in Ponnani. The wholesale fish trading and auctioning activities occur near the Ponnani Beach and from there it is transported to various other parts of the state in goods, autos, LCVs and LMVs predominantly. These goods traffic ply through the Ponnani Beach Road to reach their respective destinations. Minimal movement of two axle trucks that carry ice cubes to fish market from ice plants are observed along this road. Ponnani Harbour is the major traffic generator in the Project Influence Area.

Wholesale Market Area

Newly Developed Harbour

The new fishing harbour developed by the Government of Kerala is underutilised since all the market activities occur at the Beach area. Further, from discussion with local people it is understood that the Government has sanctioned a cargo port to be developed at Ponnani.

3.1.3.4 Ponnani Ferry Services

Ponnani Municipality operates a ferry service between Ponnani Harbour and Padinjarekkara. The service is operational from 7:00 am to 7:00 pm. The fare details of the ferry service are presented in ***Table 3-3***.

Table 3-3: Fare Details in Ferry Service

S. No.	Particular	Amount (Rs.)
1	One Person	10
2	Two Wheeler with Driver	20
3	Auto-rickshaw with Driver	30
4	Car/ Jeep/ Van with Driver	65

Ferry Service in Ponnani

3.1.4 Objective and Scope

The main objective is to study in detail on various options of Alignment, Bridge Types in terms of Structure and Aesthetics, Road and Bridge Cross sections to cater the present and projected Traffic, connectivity of the proposed alignment with adjoining road networks keeping in view of Environmentally and Socially viable and sustainable, enhancement of Tourism potential by conducting detailed analysis / investigation / survey. The consultant will present the most feasible options for Alignment, Bridge location and Type, Road and Bridge cross section and various amenities to enhance Tourism potential to RBDCK.

3.1.4.1 SCOPE OF SERVICES

The scope of services includes the following tasks:

1. Review of all available reports and published information about the proposed coastal road, existing and proposed project within the project influence area.
2. Detailed Reconnaissance Survey with Google Maps / GPS.
3. Inventory and condition surveys of existing approach roads.
4. Inventory and detailed condition surveys of sea wall and cross drainage structures in the approaches of Proposed Bridge and Drainage Provisions.
5. Topographic surveys using Total Stations as per the guidelines of latest IRC: SP-19. Fixing of TBM and all reference point on ground during survey; and this should be shown on detailed survey drawings.
6. Shoreline survey and sounding of shipping channel to map shore line/ break waters/ structures and to explore the underwater features using suitable hydrographical survey method. Information shall also be collected on sea waves, river flow, high tide/ low tide levels, volume and seasonal change.
7. Detailed Traffic Study at relevant locations, bringing out the present traffic scenario including study of impact on the traffic scenario during the construction work and after commissioning of the bridge including preparation of proposal and design for development of the road network at both sides to be connected with the proposed bridge for smooth flow of projected traffic at post commissioning stage and preparation of necessary documents for obtaining approval from the competent authority.

8. Geo technical investigation works for the proposed bridge as per guidelines of IRC SP 19-2001 and IRC 78-2014 or any other relevant standard suitable for the structure proposed. Detailed sub soil investigation for proposed bridge, approaches, cross drainage works and etc. shall confirm to the following

   a) The consultant shall carry out geo technical investigations and sub-surface explorations for the proposed bridge/ land spans/viaducts/road. High embankments sea wall etc. as necessary for proper design of works and conduct all relevant laboratory and field tests on soil and rock samples. The minimum scope of geo technical investigation for bridge structures shall be as under

S.No	Description	Location of boring
1	Pylons	One each at both pylon locations
2	Viaduct portion	Total 10 locations spread along the viaduct
3	For road portion	As per IRC

   b) The scheme for boring location and boring depth shall be prepared by the consultant and submitted to RBDCK for approval. These may be finalised in consultation with RBDCK

   c) The sub soil exploration and testing should be carried out through Geo technical consultants who have done Geo technical investigation in similar projects. In case of outsourcing Geo technical investigation the firm selected by the consultant for this purpose should also be approved by RBDCK before start of such works. The soil testing reports shall be in the format prescribed in relevant IRC codes.

   d) For the road pavement if any, bore holes at each major change in pavement condition or at 2 km interval whichever is less shall be carried out to a depth of at least 2.0m below embankment base or to rock level and are fully logged. Additional bore holes shall be taken at locations of retaining structures in the approaches to bridges and viaducts and at locations with venerable sub soil conditions identified through above investigations. Appropriate tests to be carried out on samples collected from these bore holes to determine the suitability of various materials for use in proposed work.

9. Preparation of (minimum 3 no's) suitable bridge proposals from aesthetic view point

10. Preparation of proposal and cost appraisal for 2 lane bridge with 2 lane approach with provision for future expansion to 4 lane

11. Preparation of proposal and cost appraisal for 2 lane bridge with 2 lane approach with provision for future expansion to 4 lane

12. Finalisation of GAD of proposed Bridge and submission to Employer for Approval of GAD. The consultant will interact with harbour engineering department, port authorities and other local authorities on technical issue during approval of GAD.

13. The consultant has to complete discharge calculations and determination of waterway as per IRC 5 and IRC SP 13. Maximum water level of river is also required to be obtained.

14. Providing protection work/ sea wall including preparation of necessary documents for obtaining approval from designated authority like port department, harbour engineering, CRZ authority, MOEF etc.
15. Proposal of electrification of proposed bridge and approaches with special emphasis towards maximum utilisation of solar energy
16. Detail study of behaviour of the bridge structure and preparation of necessary documents for getting approval from designated authority.
17. Social impact assessment.
18. Environmental impact assessment including preparation of necessary documents for obtaining environmental clearance and other statutory clearances from concerned authority.
19. Design of Bridges, structures, roads etc.
20. Preparation of BOQ and cost estimates and obtaining approval from KIIFB/GOK
21. Preparing necessary reports / documents for obtaining all types of clearances required for implementation of project on the ground from concerned agencies like state government, KIIFB etc.
22. Approval of all drawings including GAD and engineering drawings from concerned authorities wherever required
23. Preparation of land plans and utility relocation plan of the project showing existing ROW (along with all the existing assets within ROW e.g. structures, drains, service roads, trees, utilities and safety devices) and proposed additional land required in various stretches for improvement of geometrics, construction of new structures, service roads, project facilities etc. will be considered for LA.
24. Economic and financial viability report
25. Preparation of EPC bid documents including required schedules as per EPC document.

3.2 STATUS OF FEASIBILITY REPORT

As mentioned in section 2.2, Feasibility study has been done and the report is approved by RBDCK. Consultant had carried out a systematic study on various alignment options and different structural systems. Inputs from the various stake holders were collected and their opinions were accommodated. Constructability & Aesthetics were given due weightage while the facilities are uncompromised. Various systems are evolved in such a manner that it is sustainable and can cater for future developments. After analysing the comparative scale of advantages of various options, and after extensive discussions with stake holders, following recommendations are made.

1. Considering various factors described in the Section 3 of Feasibility Report, the alignment proposed in Option 1C is preferred from the Consultant's purview.
2. As per the Traffic analysis described in Section 7 of Feasibility Report, the project road will cater 2 Lane traffic upto 2040 beyond which augmentation may be proposed. And this project is economically viable.
3. The existing road from Ponnani Junction to Court junction shall be widened as per KIIFB cross section to achieve 80 Kmph from the present average speed of 40 Kmph. However the project may be operational with the existing road having geometric deficiencies in terms of design speed.
4. To minimize the land acquisition the design speed is restrained as 40kmph from Ch.: 2+300 to Ch.: 2+500 along the existing PWD whereas this can be improved with due land acquisition.
5. The Iconic Bridge theme shall be given in Option 2 (Snake Boat) as mentioned in the Section 5 of Feasibility Report.
6. The LA and R&R details shall be as per Table 10.5 of Feasibility Report.
7. The Tourism amenities shall be as per Section 5.4 of Feasibility Report.
8. The Iconic Bridge shall be structurally Cable Stayed Bridge.
9. The Stay Cable shall be of single plane centrally placed.
10. The Obligatory span shall be 200m with vertical clearance of 16m.
11. The Deck width for the Iconic Bridge shall be 23m with vehicular traffic on one side of the central median and pedestrian and tourism amenities on other side as given in Sec 11.4 of Feasibility Report.
12. The approach deck width shall be 13m accommodating 2 lanes traffic with footpath.
13. The structure arrangement will accommodate eccentric widening during the 4 lane augmentation with new structure in the approach.
14. Even though the project is proposed in EPC mode, the project is financially viable for regular maintenance activities.

3.3 REQUIREMENT/DEMAND ANALYSIS

The proposed development is for Construction of a Cable Stayed Bridge across Ponnani Estuary with Approaches to the Coastal Highway in Malappuram District of Kerala State. Proposed development corridor is a bridge project with approach roads with total length of about 5.0 km all of which is in Malappuram District. The corridor falls within Ponnani Municipality and Purathur Village of Tirur taluk of the district. Socio-Economic profile of this area (study area) has been primarily drawn from Census of India, 2011 data.

3.3.1 Population of Project Region

Total population in Malappuram district is 41, 12,920 and in the project area of Ponnani Municipality is 90,491 and in Purathur Village area is 31,915. In Malappuram district males constitute 47.66% and females 52.34% of total population in Malappuram district, 47.11% and 52.89% in Ponnani Municipality and 47.19% and 52.81% in Purathur Village. Sex ratio of total population in Malappuram district is 911 females over 1000 males; in Ponnani Municipality 891 females over 1000 males and 894 females over 1000 males in Purathur village. Numbers of households in Malappuram district is 793,999, in Ponnani Municipality is 15,816 and 5,787 in Purathur village.

Total population of 0-6 years in Malappuram district is 574,041, in Ponnani Municipality is 11,917 and Purathur village is 4,290. This constitutes to 13.96%, 13.17% and 13.44% of the total population in Malappuram district, Ponnani Municipality and Purathur village, respectively. The Male Child 0-6 constitutes of 14.90%, 14.21% and 14.18% of the total male population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Similarly, the Female Child 0-6 constitute of 13.10%, 12.24% and 12.78% of the total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively. The sex ratio of the 0-6 Population in Malappuram district is 1,036 females over 1000 males, in Ponnani Municipality is 1,034 females over 1000 males and 992 females over 1000 males in Purathur village.

Total population of Schedule Caste in Malappuram district is 308,266, in Ponnani Municipality is 5,202 and in Purathur village is 3,794. This constitutes to 7.50%, 5.75% and 11.89% of the total population in Malappuram district, Ponnani Municipality and Purathur village, respectively. SC male population constitute of 7.73%, 5.83% and 12.30% of the total male population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Similarly, the SC female population constitute of 7.28%, 5.68% and 11.52% of the total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively. The sex ratio of the SC population in Malappuram district is 967 females over 1000 males, in Ponnani Municipality is 915 females over 1000 males and in case of Purathur village is 955 females over 1000 males.

Total population of Schedule Tribe in Malappuram district is 22,990, in Ponnani Municipality is 196 and in Purathur is 65. This constitutes to 0.56%, 0.22% and 0.20% of total population in Malappuram district, Ponnani Municipality and Purathur village, respectively. The ST male population is 0.58%, 0.24% and 0.21% of total male population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Similarly, ST female population constitutes 0.54%, 0.19% and 0.20% of total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively. The sex ratio of ST population in Malappuram district is 962 females over 1000 males, in Ponnani Municipality is 1,108

females over 1000 males and 912 females over 1000 males in Purathur village. **Table 3-4** and **Table 3-5** present study area population & sex ratio.

Table 3-4: Population Census

Area	Malappuram District	Ponnani Municipality	Purathur Village	Total
HH	7,93,999	15,816	5,787	**8,15,602**
TOT_P	41,12,920	90,491	31,915	**42,35,326**
TOT_M	19,60,328	42,627	15,062	**20,18,017**
TOT_F	21,52,592	47,864	16,853	**22,17,309**
M_06	2,92,132	6,057	2,136	**3,00,325**
F_06	2,81,909	5,860	2,154	**2,89,923**
M_SC	1,51,557	2,485	1,853	**1,55,895**
F_SC	1,56,709	2,717	1,941	**1,61,367**
M_ST	11,272	103	31	**11,406**
F_ST	11,718	93	34	**11,845**

**Source: Census of India, 2011*

HH: Number of House Holds; TOT_P: Total Population; TOT_M: Total Males; TOT_F: Total Females; M_06: Male Child 0- 6 years of age; F_06: Female Child 0-6 years of age; M_SC: Male Schedule Caste C; F_SC: Female Schedule Caste: M_ST: Male Schedule Tribe; F_ST: Female Schedule Tribe

Table 3-5: Sex Ratio

Area	Total Population	0-6 Population	Schedule Caste	Schedule Tribe
Malappuram District	911	1,036	967	962
Ponnani Municipality	891	1,034	915	1,108
Purathur Village	894	992	955	912

**Source: Census of India 2011*

3.3.2 Literacy & Illiteracy Standards

Literacy standards highlights that people have basic reading & writing skills of any one language or more. Literacy population in Malappuram district is 80.51%, Ponnani Municipality is 78.14% and in Purathur village is 78.48% of the total population. The male literacy rate in Malappuram district is 81.49%, in Ponnani Municipality is 80.09% and in Purathur village is 79.96% of the total male population. Similarly, the female literacy rate is 79.62%, 76.41% and 77.16% of the total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively.

Illiterate population of Malappuram district is 19.49%, in Ponnani Municipality is 21.86% and in Purathur village is 21.52% of the total population. This includes the 0-6 population. The male illiteracy rate in Malappuram district is 18.51%, in Ponnani Municipality is 19.91% and in Purathur village is 20.04% of the total male population. Similarly, the female illiteracy rate is 20.38%, 23.59% and 22.84% of the total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively. **Table 3-6** shows the literacy & illiteracy status of the study area.

Table 3-6: Literacy & Illiteracy Standards

S. No	Area	HH	TOT_P	TOT_M Lit	TOT_F Lit	TOT_MI lit	TOT_FI lit
1	Malappuram District	7,93,999	41,12,920	15,97,404	17,13,911	3,62,924	4,38,681
2	Ponnani Municipality	15,816	90,491	34,140	36,574	8,487	11,290
3	Purathur Village	5,787	31,915	12,043	13,004	3,019	3,849

S. No	Area	HH	TOT_P	TOT_M Lit	TOT_F Lit	TOT_Ml lit	TOT_Fl lit
Total		8,15,602	42,35,326	16,43,587	17,63,489	3,74,430	4,53,820

**Source: Census of India, 2011*

TOT_P: Total Population; TOT_M Lit: Male Literate; TOT_F Lit: Female Literate; TOT_Ml lit: Male Illiterate; TOT_Fl lit: Female Illiterate

3.3.3 Economic Profile

Based on the last 10 years data by Census of India, the economic profile of the impacted wards are discussed. The work population is 10,62,424 in Malappuram district, 22,813 in Ponnani Municipality and 8,854 in Purathur village. This constitutes to 25.83%, 25.21% and 27.74% of the total population in Malappuram district, Ponnani Municipality and Purathur village, respectively. The work population with respect to males is 898,157 in Malappuram district, 20,270 in Ponnani Municipality and 7,483 in Purathur village. This constitutes to 45.82%, 47.55% and 49.68% of the total male population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Similarly, the work population with respect to females is 164,267 in Malappuram district, 2,543 in Ponnani Municipality and 1,371 in Purathur village. This constitutes to 7.63%, 5.31% and 8.14% of the total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively.

Total work population is divided into Main Work Participation which means that for whole year round, individual is working. Main Work Participation in Malappuram district is 852,047, in Ponnani Municipality is 19,407 and in Purathur village is 7,232. This is 80.20%, 85.07% and 81.68% of total work population in Malappuram district, Ponnani Municipality and Purathur village, respectively. It is positive sign as people are working regularly and saving & expenditure power is continuous. Marginal Work Participation means an individual is working for 6 months or less in a year. Marginal work population is 19.80%, 14.93% and 18.32% of total work population in Malappuram district, Ponnani Municipality and Purathur village, respectively.

Non work participation population in Malappuram district is 30,50,496, in Ponnani Municipality is 67,678 and 23,061 in Purathur village. This constitutes to 74.17%, 74.79% and 72.26% of total population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Non work population of male is 54.18%, 52.45% and 50.32% of total male population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Similarly, Non work Population of females is 92.37%, 94.69% and 91.86% of total female population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Non-work population includes 0-6 population. **Table 3-7** shows Work Participation status of study area

Table 3-7: Work Population

Area	ToT Work	ToT Work M	ToT Work F	Main Work P	Marg Work P	ToT Non Work	Non Work M	Non Work F
Malappuram District	10,62,424	8,98,157	1,64,267	8,52,047	2,10,377	10,62,171	19,88,325	10,62,424
Ponnani Municipality	22,813	20,270	2,543	19,407	3,406	22,357	45,321	22,813
Purathur Village	8,854	7,483	1,371	7,232	1,622	7,579	15,482	8,854
Total	**10,94,091**	**9,25,910**	**1,68,181**	**8,78,686**	**2,15,405**	**10,92,107**	**20,49,128**	**10,94,091**

Source: Census of India, 2011;
ToT Work: Total Work Population; ToT Work M: Total Work Population Males; ToT Work F: Total Work Population Females; Main Work P: Main work Population; Marg Work P: Marginal work Population; Non Work M: Non Work Males; Non Work F: Non Work Females

3.3.3.1 Classification of Economic Profile

As per Census of India data, Main Work Participation is 10,62,424 in Malappuram district, 22,813 in Ponnani Municipality and 8,854 in Purathur village. These are classified into four categories. Main work participation of Cultivators in Malappuram district is 45,710, Agricultural Labourers is 81,841, Household Workers is 13,450 and Other Works is 711,046 which constitutes to 4.30%, 7.70%, 1.27% and 66.93% of main Work Population, respectively. Similarly, Main work participation of Cultivators in Ponnani Municipality is 68, Agricultural Labourers is 331, Household Workers is 359 and Other Works is 18,649 which constitutes to 0.30%, 1.45%, 1.57% and 81.75% of main Work Population, respectively. Main work participation of Cultivators in Purathur village is 241, Agricultural Labourers is 245, Household Workers is 116 and Other Works is 6,630 which constitutes to 2.72%, 2.77%, 1.31% and 74.88% of the main Work Population, respectively.

Work participation is mostly engaged in other works of secondary/tertiary sectors which includes private/government jobs, business etc. Main Work Participation of Males in Malappuram district is 748,431, Ponnani Municipality is 17,527 and 6,562 in Purathur village. This is 70.45%, 76.83% and 74.11% of total main work population in Malappuram district, Ponnani Municipality and Purathur village, respectively. Similarly, Main Work Participation of Females in Malappuram district is 103,616, Ponnani Municipality is 1,880 and 670 in Purathur village. This is 9.75%, 8.24% and 7.57% of total main work population in Malappuram district, Ponnani Municipality and Purathur village, respectively. **Table 3-8** represents Work Population Classification.

Table 3-8: Work Population Classification

Area	ToT Main Work	MAIN_CL_P		MAIN_AL_P		MAIN_HH_P		MAIN_OT_P	
		Males	Females	Males	Females	Males	Females	Males	Females
Malappuram District	10,62,424	42,693	3,017	69,919	11,922	11,295	2,155	6,24,524	86,522
Ponnani Municipality	22,813	58	10	307	24	303	56	16,859	1,790
Purathur Village	8,854	218	23	223	22	91	25	6,030	600
Total	**10,94,091**	**42,969**	**3,050**	**70,449**	**11,968**	**11,689**	**2,236**	**6,47,413**	**88,912**

Source: Census of India, 2011, Main Work Population
Main CL_P: Main Cultivators Population; MAIN_AL_P: Main Agricultural Labourer; MAIN_HH_P: Main Household Industry Population; Main _OT_P: Main Other Working Population such as private, government Job, business etc.

3.3.3.2 Women Status

As per the Census of India 2011, the total women population is **22,17,309** of which 0-6 child population is 13.075%, Schedule Caste Population is 7.3% and Schedule Tribe Population is 0.53% with respect to the total female population of the study area. The literate population is 74.12% and illiterate population is 20.47% with regards to the total female population. **Table 3-9** represents the Women population of the study area.

Table 3-9: Women Population

Total Female Population	0-6 Females %	Schedule Caste Population %	Schedule Tribe Population %	Literate Population %	Illiterate Population %
2217309	13.075	7.3%	0.53%	74.12	20.47

**Source: Census of India, 2011*

The work participation rate is 58% and non-work participation is 49.34% of the total female population.

The Classification of Women Work Participation are very less as cultivates which is about 1.81%, agricultural labourers are 7.11%, household works incudes women working in household industries which are 1.33% and other works constitutes of 52.86% of the total women work participation classification. The tertiary & secondary jobs, business sector the participation of the work populations among women is much more. Being an urban and centre for many developmental industries, and various sectors the participation is bound to increase more. **Table 3-10** shows the work participation classification among women.

Table 3-10: Classification of Women Work Participation

Cultivates	Agricultural Labourers	Household Works	Other Works
1.81	7.11	1.33	52.86

*Source: Census of India, 2011

3.3.4 Social Assessment

Infrastructure projects not only bring prosperity to the region but also have adverse impacts. Such adverse impacts include loss of land and structure, loss of livelihood, loss of community properties along with fragmentation of society. If such negative impacts are not addressed properly, it may happen that the outcome of the project will have negative impacts and would outweigh the projects' positive impacts, thus leaving question mark on project sustainability. The issues are to be addressed for minimizing the negative impacts by exploring all feasible options without compromising the safety aspects.

Based on social assessments carried out, the following observations/assessments are made:

- The approach road passes through areas with dense to very little population along the corridor and also passes through narrow lanes; however it appears that adequate RoW is likely available at most locations along the alignment
- Land Acquisition and need for Resettlement & Rehabilitation (R&R) is envisaged to be minimal
- Project is located in a very active fishing activity area; proposed development has been assessed to see if it will have adverse impacts on the fishing activities in the area
- Along the approach road there are various commercial activities. Detailed analysis in regards with land acquisition needs, R&R, etc. is being carried out.
- Proposed project is envisaged to have minimal physical and economical displacement
- Proposed development will not have impacts on cultural/heritage property

The baseline social conditions are as presented **Table 3-11**.

Table 3-11 Site Notes, Baseline Social Conditions

S. No	Features	Comments/Remarks
1.	Land Acquisition – Type of land affected (Govt, Pvt, etc.)	The proposed development corridor passes though urban/built-up area. As per the social assessment it appears LA will be minimal. As such proposed development is not likely to have significant impacts due to land acquisition. Based on the final designed alignment, the extent of land to be acquired is being worked out. The affected persons/structures will be identified and appropriate compensation packages as per applicable rules will be worked out.
2.	Type of House Permanent, Semi-Permanent, Temporary	Mostly the structures are permanent. Significant impacts to structures/houses are not envisaged. Some impacts are envisaged along the corridor of the approach road where widening will be required. The structures which will be affected by the proposed development works will be compensated appropriately.
3.	Affected Families/People Permanent Residents, Tenants, Squatters, Encroachers, Pvt Land holders, Agriculture holders, others.	As per reconnaissance survey, significant impacts to structures/ squatters/livelihood of people are not envisaged. However, as the approach road passes through commercial area, there are likely encroachers/squatters settled along the road corridor and impacts to them are being looked into (will be detailed out in the RAP). Such impacts will be identified and compensated appropriately.
4.	Loss of Livelihood	Loss of Livelihood is not envisaged; however, as the approach road passes through commercial area, there are likely encroachers/ squatters settled along the road corridor and impacts to them are being looked into (will be detailed out in the RAP). Such losses will be identified and compensated appropriately.
5.	Cultural/Religious properties	There are few religious structures (mosques, temples) along/in immediate vicinity of the alignment. No common property resources will be impacted due to proposed development. Also, proposed development will not impact any archaeological/ cultural structures.

3.3.5 Stakeholder Consultation

Stakeholder consultations forms an important part of the EIA process. This consultation process is a major tool for information dissemination to the direct and indirect impacted due to the project. The stakeholder consultation process helps in reducing the public resistance to change and enable the participation of the local people in the decision making process. These meetings help to acknowledge the PAPs about the project, relevant information is exchanged, remarks, suggestions given by the people are noted. Such discussions benefit the overall design prospective as well. Stakeholder consultations are continuous process which should be conducted throughout the project lifecycle. Stakeholder consultations can involve any direct or indirect impacted persons associated or affected. It includes local people, local institutions, government officials, NGOs', migrants, vulnerable, women & child, daily wage workers, agriculture labours, etc.

For proposed corridor development project, informal stakeholder consultations have been conducted. Informal stakeholder consultations have been carried out at random locations along the project corridor along with interaction with Stakeholders like local people on the road and shops, Fishermen in the Harbour area, Passengers in the Jungar, Jungar

service operators, Commercial Squatters, Park officials at Purathur side, etc. consultations were also held at the Ponnani Municipality office with municipality officials.

In general, the participants were enthusiastic and appreciated the proposed project and gave valuable inputs over the development aspect, localized needs and suggestions for engineering design. They appreciated the fact that this project will help transportation across the Bharathapuzha River which is need of the hour. The meetings were successfully conducted with participants who were directly and indirectly impacted.

General Opinion from Consultations:

- People welcome the project and said to start immediate.
- Employees at the Jungar (Ferry) service and some commercial shops could be impacted in terms of loss of their jobs/employment; however, they are willing to find alternative employment opportunities.
- Some local people opined that the choice of constructing the bridge through the left side of the harbour (Proposed now) is not the right choice as the wave action will damage the bridge more easily.
- Some are of opinion that alternate approach roads with Government land are available towards the coastal side which will spare private land from acquisition.

3.3.6 Socio Economic Benefits of Proposed Project

The proposed bridge project will provide ease in transportation. Currently, Jungar is used by local people to cross Bharathapuzha River, which will not be available after daylight hours. The land side crossing is over the Chamravottam Regulator Bridge, which is about 10 kms away from the proposed bridge development location. The proposed bridge provides an alternative to ferry service (Jungar) and continuous access anytime of the day/night.

The proposed bridge will provide a much improved/convenient access across the Bharathapuzha River. Currently vehicular movement to cross the river by road is over the Chamravottam Bridge. This proposed bridge will help reduce local travel distance by about 12-15 kms to cross the river and almost 40 kms for longer commute from Kochi – Ponnani.

Also, Ponnani being a major fishing town, this bridge will provide a very convenient access to fishing related vehicular movements with much reduced travel time/distance. It also provides key connectivity to the Coastal Highway; as such it has its own unique importance/benefit in the overall scheme of the Coastal Highway development

Hence the proposed construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches will provide significant overall socio-economic benefits.

3.3.7 Conclusions

The proposed Cable Stayed/Suspension Bridge across Ponnani Estuary project is a part of Coastal Highway and the proposed alignment will be linking the two points on southern side the Ponnani Junction (NH66 Bypass) and Northern side Padinjarekkara-Kuttayi Road. Hence the project will be a great importance to the Ponnani and its surrounding area(s).

Potential impacts due to the proposed development of the bridge/road project on environmental attributes like air quality, noise, water quality, soil, flora and fauna, as well as social aspects etc. have been assessed as part of this EIA study. Appropriate mitigation measures to help minimise/avoid impacts from the development have been recommended.

The measures include avoidance/mitigation measures. Based on the EIA study, development of the proposed project is unlikely to cause any significant environmental/social impacts. Potential impacts were identified attributable to the proposed project and most of which are localized and temporary in nature and can be mitigated with minor to negligible residual impacts. The proposed development is not envisaged to alter the existing environment of the project area. Impacts due to the proposed development are not envisaged to create any impacts which will be of permanent basis

The proposed development of the Cable Stayed/Suspension Bridge project is envisaged to have significant positive impacts, such as:

- Proposed bridge provides key connectivity to the Coastal Highway; as such it has its own unique importance/benefit in the overall scheme of the Coastal Highway development
- This bridge will provide a much improved/convenient access across the Bharathapuzha River. Currently vehicular movement to cross the river by road is over the Chamravottam Bridge. This proposed bridge will help reduce local travel distance by about 12-15 kms to cross the river and almost 40 kms for longer commute from Kochi – Ponnani
- Ponnani being a major fishing town, this bridge will provide a very convenient access to fishing related vehicular movements with much reduced travel time/distance
- This bridge/road will provide an alternative access for vehicular movement in the area as such it will help decongest traffic on existing road network in the area.
- This bridge/road will also provide an alternative to the Ferry service (Jungar) currently being used (especially by locals) to cross the river over water transport mode
- The bridge will be a safe alternative to Jungar/Ferry services which can be dangerous and unserviceable during night hours and heavy monsoon periods

In addition, the immediate benefits of the proposed development will come in the form of direct employment opportunities for several people such as wage labourers, petty contractors, suppliers of raw materials, etc. during the construction stage of the project.

3.4 ENGINEERING SURVEYS AND INVESTIAGTIONS

The engineering surveys and investigations have been carried out on the Project Road section for inventory, pavement evaluation, traffic surveys, soil investigations, Topographic features and structural evaluation by following the relevant Specifications/Codes to generate adequate database for preparing the most appropriate proposal for the rehabilitation / upgrading of the existing highway.

The various engineering surveys and investigations for the project road which have been carried out for the project are listed below

- Road Inventory
- Pavement Condition Survey
- Traffic Surveys
- Axle Load survey
- Topographic Survey
- Soil Investigations
- Structure inventory

3.4.1 Road Inventory Survey

3.4.1.1 General

A detailed inventory of roads and structures were carried, to prepare repair and rehabilitation proposals and widening proposals based on the recommendations made. The data/details of road inventory were collected, by actual verification & measurements are presented in **Annexure -1**. The following data was collected in the inventory survey.

- Terrain code - Plain, Rolling, Mountainous, Steep
- Land Use - Left (code), Right (code)
- Earthworks type - Cut, Fill, Ground level
- Earthworks height - m
- Width of Right of way - m
- Surfacing type - bitumen, gravel
- Carriage way width - m
- Shoulders - Left & Right side: Type, Width (m)
  Right side: Type, Width (m)
- Road Junctions - Type, Details
- Drainage type - Left side: Type, Width (m)
  Right side: Type, Width (m)
- Drainage Condition - Existing Type of drain
- Footpath Width - m

- Median - Type and Width
- Retaining structures and their condition
- Road side arboriculture - Yes / No
- Utilities - Shifting required, if any
- Critical structures - Location, if any
- Trees - No

The codes used in the inventory are as follows:

Terrain P = Plain R = Rolling M = Mountainous S = Steep	**Land use** AG = Agriculture C = Commercial BR = Barren Land BU = Built up Area IN = Industrial SBU = Semi built up
Signs I = Informatory R = Regulatory W = Warning	**Pavement** B = Bituminous C = Cement concrete W = Water bound macadam
Median 1 = Stone 2 = Steel 3 = Open 4 = Tapered	**Road Junction** M = Multi leg junction T = T Junction R = Rotary Y = Y junction + = 4 leg junction
Drain Type B = Box E = Earth L = Lined P = Pipe	**Drain Condition** G = Good F = Fair P = Poor VP = Very Poor

The site observation photographs are presented in **Table 3-12.**

Table 3-12: Observations at Site

Site Observations	
Ponnani Junction (Start point of Project)	Access Road to existing PWD Road
Ponnani Court/ Govt. offices	Road Stretch before Structure starts
Viaduct structure location	Bridge location

Port office

Bharathappuzha river

3.4.2 Geological Survey

The study area of proposed corridor is in Malappuram district.

Ponnani is situated on north-east end of Kerala on coast of Arabian Sea. Malappuram District is bounded by North Latitudes 10^0 40' and 11^0 32' and east Longitudes 75^0 50' and $76^0$36'. The geographical area of Malappuram district is 3550 km^2

Malappuram district is underlain by various geological formations. The geological formations of the district are as below.

Laterite is found abundantly in the midland areas of Malappuram district which is exploited economically for the construction work. There are hundreds of quarries cutting laterite stone locally called Vettukallu that provides employment to thousands are in operation currently. The thickness of laterite goes upto 25m in certain locations in the district. The district has got a upto 15m thick coastal alluvium and river alluvium deposits can be seen along the banks of Bharathapuzha and the major valleys. Malappuram has got rich valley fill deposits comprising of the flood plain deposits and materials eroded from the neighbouring hills and slopes.

The Malappuram district is mineral rich with deposits of lime shells found in the coastal belt, mainly in Ponnani and Kadalundi nagaram. The coastal sands of Ponnani and Veliyan code contain heavy minerals like ilmenite and monazite. China clay, the principal raw material for porcelain industry, is found abundantly in many parts of district. Main zones for auriferous gravels are present in Nilambur valley.

The geology map of Kerala and study area is shown in **Figure 3-4**.

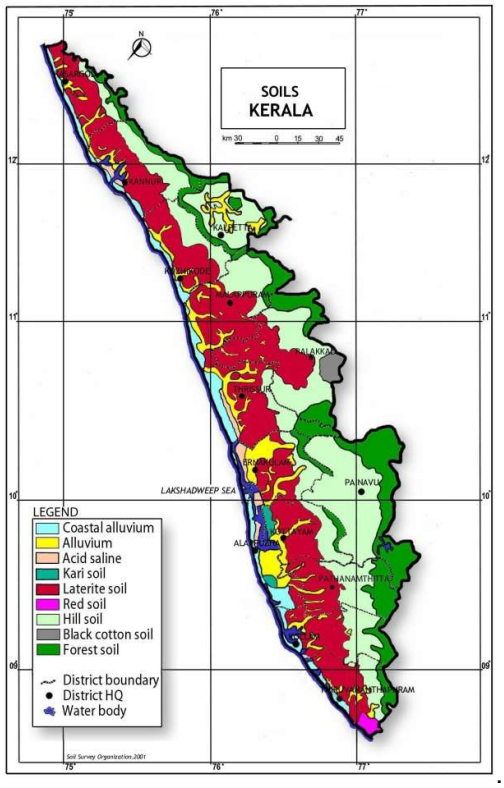


Figure 3-4 : Geology map of Kerala

3.4.3 Seismicity

The project location/study area falls in Zone-III which is categorised as a Moderate Risk Zone. The seismic map is presented in

Figure 3-1.

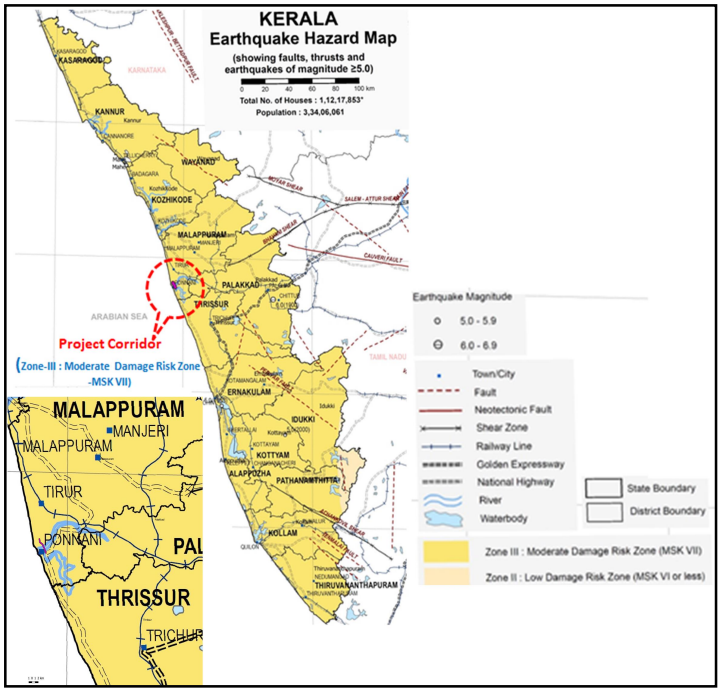


Figure 3-5 : Seismic Map of Kerala

3.4.4 Climatic Conditions

3.4.4.1 Temperature

March and April months are the hottest and January and February months are the coldest. The maximum temperatures ranges from 28.9 to 38.6°C and the minimum temperatures range from 11.2 to 23.4°C. The temperature starts rising from January and reaches the peak in the month of March and April and then decreases during the monsoon month and again rising from September onwards.

3.4.4.2 Rainfall

Malappuram has a tropical climate. Malappuram has significant rainfall most months, with a short dry season. The South West monsoon is usually very heavy and nearly 73.5% of the rainfall is received during this season. NE monsoon contributes nearly 16.4% and March to May summer rain contributes nearly 9.9% and the balance 0.2% is accounted for January and February months. The average annual rainfall in Malappuram is 3000mm.

3.4.4.3 Wind

Wind is predominant from east as well as west during morning and evening hours. The wind speed is more during December to February months. It ranges from 2.9 to 7.2 km per hour.

3.4.5 Pavement composition and condition survey

3.4.5.1 General

Pavement Investigation is an important aspect of any highway improvement project, since the performance of highway directly depends on the performance of its pavement and the cost of improvement of pavement is equally important to arrive at the cost of project. The data collected in the survey is an important factor and is utilised to identify the stretches of reconstruction and rehabilitation. Detailed Pavement Condition Survey was carried out along the entire project road. The details of the survey are presented in **Annexure -2.**

3.4.5.2 Survey Procedure

The consultant has carried out visual pavement condition survey on the project road to examine the functional efficiency of the existing pavement. Condition survey data was collected at every 100 m interval with the help of straight edge and measurement scale for main carriageway and paved shoulder.

Based on the above site investigation, the pavement condition analysis is carried out separately for main carriageway and paved shoulder.

3.4.5.3 Major Distresses observed

The general characteristics of pavement distresses observed during the survey of the project road corridor are presented below. Poor workmanship is also a key factor contributing to the pavement failure at many sections of the project road.

- Alligator Cracking
- Longitudinal & Transverse Cracking
- Rutting
- Block Cracking
- Potholes
- Patching
- Raveling
- Edge Crack

3.4.6 Inventory of bridges and other Structures

3.4.6.1 Inventory survey of bridges & culverts

Bridge inventory surveys were carried out as per IRC SP: 19-2001. The width of deck slab, footpath etc. was recorded in the prescribed format. Similar procedures were adopted for other structures and recorded data annexed.

The list of existing structures across the project corridor are shown in the below tables.

Table 3-13: List of Bridges

Sl. No	Location/Name of the Bridge	Design Chainage (km)	Type of Structure		Span Configuration (No. x m)
			Super-structure	Sub-structure	
-Nil-					

Table 3-14: List of Pedestrian Bridges

Sl. No	Location/Name of the Bridge	Design Chainage (km)	Type of Structure		Span Configuration (No. x m)
			Super-structure	Sub-structure	
-Nil-					

Table 3-15: List of Rail over Bridges

Sl. No	Location/Name of the Bridge	Design Chainage (km)	Type of Structure		Span Configuration (No. x m)
			Super-structure	Sub-structure	
-Nil-					

3.4.6.2 Condition survey for culverts and structures

A project team carried out the visual condition survey of existing culverts as per guidelines stipulated in IRC-SP: 35-1990. The project team inspected all structures on the project corridor. The deficiencies in the existing structures were noted and it is proposed that the existing culverts are to be widened.

3.4.7 Topographic Survey

Topographic survey is conducted in the following methods as per IRC: SP: 19-2001

- Study of topographical survey sheets, agricultural, soil, geological and meteorological maps, and aerial photographs, if available.
- Aerial reconnaissance (where necessary and feasible)
- Ground reconnaissance (including another round of aerial reconnaissance for inaccessible and difficult stretches, where called for)

3.4.7.1 Aerial reconnaissance

An aerial reconnaissance will provide a bird's eye view of the alignments under consideration along with the surrounding area. It will help to identify factors which call for rejection or modification of any of the alignment. Final decision about the alignments to be studied in detail on the ground could be taken on the basis of the aerial reconnaissance.

The main control points for the topographic survey will be fixed using Global Navigation satellite system (GNSS) or by using Global Positioning System (GPS). DGPS of size 40cmx40cmx60cm will be fixed along the project corridor at an interval of 250m and GPS observations will be recorded. Secondary control pillars of size 15cmx15cmx45cm will be fixed at 250m interval. The data will be captured by means of UAV technology and it will be processed to the required format.

3.4.7.2 Detailed Topographic Survey

Connectivity requirement to our project corridor and the major intersections / settlements along the project corridor has been identified and listed to sub consultants for taking survey of 25m on either side.

All the features on either side, along the project roads will be captured which includes electrical poles and lines, telephone pole and lines, high tension lines and towers, water/Oil/Gas pipe lines above ground, manholes, all OFC lines, tree positions, building lines, type of buildings (kutcha / semi pucca / pucca / shops / houses etc.), existing road pavement edges, shoulders, median, centre line of carriageway, footpaths, side drains at regular intervals, kerb top and bottom, kilometre / hectometre stones, places such as temples, temple mast, mosque, church, grave yard, bridges and cross drainage structures etc.. All such captured features will be shown in drawings.

3.4.7.3 Generation of Topo Drawing

While preparing the drawings, it was ensured that all lines are in 3D. All the topography features, reference pillars indicating complete details such as DGNSS control points, secondary control pillars and co-ordinates etc., were mentioned in the drawing. All key

features captured in the survey were described with specified text height and style in the drawing.

A Detailed topographic survey report **(RP 005-Topographic Survey Report)** is also submitted as a part of DPR.

3.4.8 Detailed Bathymetric Survey

Survey boat fitted with dual frequency echo sounder (having nominal frequencies of 30 KHz and 200 KHz) along with heave sensor, DGPS and PC/Laptop, is mobilized to carry out the bathymetric survey inside the river. Bathymetric survey is carried out at 50m spacing 1000m upstream and 1000m downstream of Tirur-Ponnani and Bharathapuzha near Ponnani harbour location.

There may be variation in salinity at different regions, hence sound velocity probe measurements is carried out frequently. Pre survey bar check for the echo sounder measurement is carried out, the bar check is repeated every day before the commencement of the survey or as instructed by engineer in charge. The survey tracks proposed for the survey is prepared and forwarded to the client for approval before the commencement of the survey. Very shallow patches inside the river are surveyed using small boat or using alternative method for collection of the level.

Automatic tide gauge station is established at site for continuous measurement during the survey period and the tidal station shall be connected to the bench mark. The position information is stored using DGPS, which provide accuracy better than +/- 1m. Necessary tidal correction to be applied for bathymetric measurements carried out at site. The surveyed tracks of the boat is worked out using hydro graphic software HYPACK MAX / equivalent and the map is presented in UTM & Geodetic co-ordinates using WGS-84 datum.

All the features on either side, along the new proposed centre line is captured which includes cut waters, high tide levels, low tide levels etc.., All such captured features is shown in drawings.

3.4.8.1 Bathymetry

Bathymetry Survey has been conducted 500m on either side of the proposed alignment to assess the water depth in the river crossing. It is observed that the maximum water depth along the alignment is about 9m. The Bathymetry Survey details are shown below:

3.4.8.2 Data from Bathymetry survey

Depth of water

Water depth with in the survey corridor varies in between 1.6 meters to 9.3 meters below the chart datum. Minimum water depth of 1.6 m below the chart datum was recorded at Southwest part near to the South break water stones within the survey corridor. Maximum water depth 9.3 m below chart datum was recorded near the Southern part within the survey corridor.

Sea bed

Undulated seabed was recorded along the either side of break water stones. Water depth along the southern break water stones varies as 1.6 meters to 8.5 meters below the chart

datum. Water depth along the northern break water stones varies as 2.0 meters to 7.1 meters below the chart datum.

Currents

The currents at Ponnani are influenced by the general wave climate that prevails in Arabian Sea. The current in the coastal zone is approximately in the range of 0.01m/sec to 1.1m/s which leads to higher littoral transport in the coastal region.

Tide Data

The tides at Ponnani are semi-diurnal with a tide level indicating mean spring tide of +1 metre. The tidal data of Ponnani is as follows:

- Mean High Water Spring (MHWS) +1.3 m CD
- Mean High Water Neap (MHWN) +1.1 m CD
- Mean Sea Level (MSL) +0.9 m CD
- Mean Low Water Neap (MLWN) +0.8 m CD
- Mean Low Water Spring (MLWS) +0.4 m CD

Bathymetry survey data is plotted in the form of coordinate system and is presented in AutoCAD format. The survey data is presented in the form of soft copy and is also attached as **Annexure -3**.

A Detailed Bathymetry Survey Report **(RP 006-Bathymmetry Survey Report)** is also submitted as a part of DPR.

3.4.9 Hydraulic and Hydrological Survey

This section pertains to the hydraulic calculations for Cable Stayed Bridge across Ponnani Estuary.

3.4.9.1 KEY POINTS ON BHARTAPUZHA RIVER

- The river originates at Annamalai Mountains of Tamilnadu state, situated at an elevation of 1964m above MSL.
- Flow of the river is North-Westerly direction through Pollachi in Coimbatore District of Tamilnadu state; Chittoor, Palakkad, Ottappalam and costal Ponnani of Kerala state.
- The total drainage area (catchment area) of the river basin is 6189 sq.km out of which 71% lies in Kerala State.
- Length of the river is approximately 209km long.
- Some of the river tributaries are Gayatripuzha, Kannadipuzha (or) Chitturpuzha (or) Amaravati Puzha, Kalppathipuzha, Thoothapuzha and they originate from either side of Palakkad Gap.
- The river discharges into the Arabian Sea/Lakshadweep Sea at Ponnani.

3.4.9.2 KEY POINTS ON TIRUR RIVER

- The river originates from the hillocks of Athvanad village, Tirur taluk of Malappuram district, Kerala, situated at an elevation of 85m above MSL.
- Flow of the river is southwest to Thiruvnavaya and then North-west to Elamkulam where it turns south-west joining the Bharatapuzha river.
- The total drainage area (catchment area) of the river basin is 117 sq.km.

- Length of the river is approximately 48km long.
- Canoli Canal, which passes through the Niramaruthur and Vettom Grama Panchayaths, joins with Tirur River at Kuttayi.
- The river joins the Bharatapuzha River and discharges into the Arabian Sea/Lakshadweep Sea at Ponnani.

3.4.9.3 Purpose of hydraulic study

Structures built in rivers and estuaries are prone to scour around their substructure and foundations. If the depth of scour becomes significant, the stability of the foundations may be endangered, with a consequent risk of the structure suffering damage or failure. The factors influencing the development of scour are complex and differ according to the type of the structure.

In this project since the most of the stretch is proposed along the banks of the river, there is possible influence of scour in the structural behaviour and stability of the structure. The hydraulic & hydrological survey pertains to the sample hydraulic analysis and estimation of scour for the Bharathapuzha river stretch of the corridor alignment.

3.4.9.4 Data collected from site

The proposed Bridge is in the estuary of Bharatapuzha River and Chamravattom Bridge which is a regulator cum Bridge is constructred around 6 Km on upstream side. The salient hydraulic features of Chamravattom Bridge collected is as follows:

Length of River: 1000m

Length of Bridge: 978m

Reservoir Capacity: 24.49 Mm^3

Maximum flood discharge: 8496 cumecs

Catchment area: 6189 Km^2

3.4.9.5 Procedure as per IRC SP-13

For stream with erodible bed material the cross section will be large when the flood happens. During the flood the velocity is high and therefore the stream scours its bed, but when the flood subsides, the velocity diminishes and the bed progressively silts up again. So discharge obtained from the existing cross section cannot be used for any hydraulic calculations and cannot be comparable with the flood discharge data available from the records.

The hydraulic data obtained from Water resources department, PWD gives the flood discharge for a return period of 50 years for the river stretch near the alignment.

The hydraulic analysis is done for each km of the river stretch along the alignment. The HFL and flood discharge (Q) for each km is interpolated from the values given for each reach.

Streams flowing in alluvium (with erodible bed material) are wide and shallow and meander to some extent. So the normal scoured depth of such streams has to be calculated theoretically from concepts which are not wholly rational.

The Bharathapuzha river can be alluvial channel if the banks are not rigid to resist erosion and carries erodible bed material and at stretches with defined boundaries and erodible bed material it behaves as quasi alluvial channel.

“Lacey’s theory of flow in Incoherent Alluvium” has been used widely in India for hydraulic calculations. Long term characteristics of the alluvial channels can be predicted by using the empirical formula given by Lacey.

3.4.9.6 Normal depth of scour

Case 1

When the river behaves as **alluvial channel**, the normal scour depth can be calculated as

$D_{sm} = 1.34\ [D_b{}^2/k_{sf}]^{1/3}$ (Cl 9.1.3 IRC SP:13-2004) '(Cl.703.2,IRC:78-2014)

Where

D_{sm} – Normal scour depth in m

D_b – Discharge in m^3/s per m width (Q/W)

W – the regime width of the stream

k_{sf} – Silt factor of material at the anticipated scour level. ($1.76\sqrt{d_m}$)

d_m –Weighted mean diameter of particles in mm

This formula takes care of the contraction and therefore no further modifications are needed.

Case 2

When the river behaves as quasi alluvial channel and the linear waterway is less than the natural unobstructed width of the channel (contraction), the normal scoured depth

$$D_{sm} = 1.34\ [D_b{}^2/k_{sf}]^{1/3}$$

(Cl 9.2.9 IRC SP:13-2004)

Where

D_b – Discharge in m^3/s per m width (Q/L)

L – Linear waterway

W – Fixed width of the stream, obtained from the cross section.

The silt factor (k_{sf}) of the bed material is calculated from the particle size distribution curve given in borehole data. Normal depth of scour is calculated as above and if the scour occurs at the same level as the bed material considered, the assumption made is correct. Otherwise consider bed material at the scoured level obtained from first trial. The procedure is repeated till the scoured level matches with the level from which the bed material is considered and hence the normal depth of scour.

3.4.9.7 Maximum depth of scour

In natural streams the scouring action of the current is not uniform all along the bed width. In straight reaches as well as bends, and also around the obstructions there is deeper scour than normal i.e., (local scour).Maximum scour at pier locations can be estimated as a multiple of normal scour based on guidelines given in IRC SP-13.

For bad sites on curves or where diagonal current exists or the bridge is multi span structure the maximum scour depth should be taken as 2 times the normal scour depth, modified for the effect of contraction when necessary.

3.4.9.8 METHODOLOGY ADOPTED

As the Bridge is crossing across Ponnani Estuary, the river characteristics of both Tirur and Bharathapuzha rivers shall be studied. At estuary locations, there will reverse flow of sea tides from the Arabian Sea / Lakshadweep Sea towards the estuary. Hence the velocity and discharge for the same shall be evaluated by model studies and the same shall be considered for the overall discharge along the Ponnani Estuary.

It is also observed that at the upstream side of the proposed bridge location, there is a Regulator cum Bridge (RCB) at Chamravottam across Bharatapuzha River. Hence the flood discharge is also considered for hydraulic analysis. The flood discharge of Chamravottam RCB is 8496 cumecs.

The total discharge and scour calculations considering the above points are shown in **Annexure-4** of this report.

3.4.10 Traffic Surveys and Analysis

Traffic surveys such as mid-block classified volume counts (CVC), Origin – Destination (OD), Axle load, turning movement count (TMC), ferry terminal survey and speed and delay survey were carried out at identified locations to understand the existing traffic pattern and assess the potential traffic that would use the proposed bridge. The locations for the surveys were finalised based on the reconnaissance survey.

3.4.10.1 Traffic Survey Locations and Schedule

Due to heavy rain in Malappuram District and flood in regional area, most of the roads were closed/ blocked. Therefore, surveys were stopped in between and details of the traffic surveys conducted are presented in **Table 3-16**. The survey locations map is shown in **Figure 3-6.**

Table 3-16: Details of Traffic Surveys

S. No.	Type of Survey	Location
Classified Traffic Volume Count (CVC)		
1	7 day CVC	NH-66 (Near Urban Bank)
2		Ponnani- Tirur Road (Near Chamravattom Bridge)
3		SH-62 (Near Kundukadav Bridge)
Origin-Destination Survey (OD)		
4	1 Day OD (24 hrs)	NH-66 (Near Urban Bank)
5		Ponnani- Tirur Road (Near Chamravattom Bridge)
Axle Load Survey (OD)		
6	2 Day	NH-66 (Near Urban Bank)

S. No.	Type of Survey	Location
7	Axle Load (48 hrs)	Ponnani- Tirur Road (Near Chamravattom Bridge)
Turning Movement Count (TMC)		
7	1 day TMC (24 hrs)	Bus Stand Jn.
8		Kodathippadi Jn.
9		Kavilakkad Jn.
10		Koottayi Jn.
11		Alathiyoor Jn
12		Chamaravattom jn
13	12 hrs Survey	**Ferry Terminal Survey**
14	**Speed and Delay Survey -** Along existing road network in Project Influence Area	

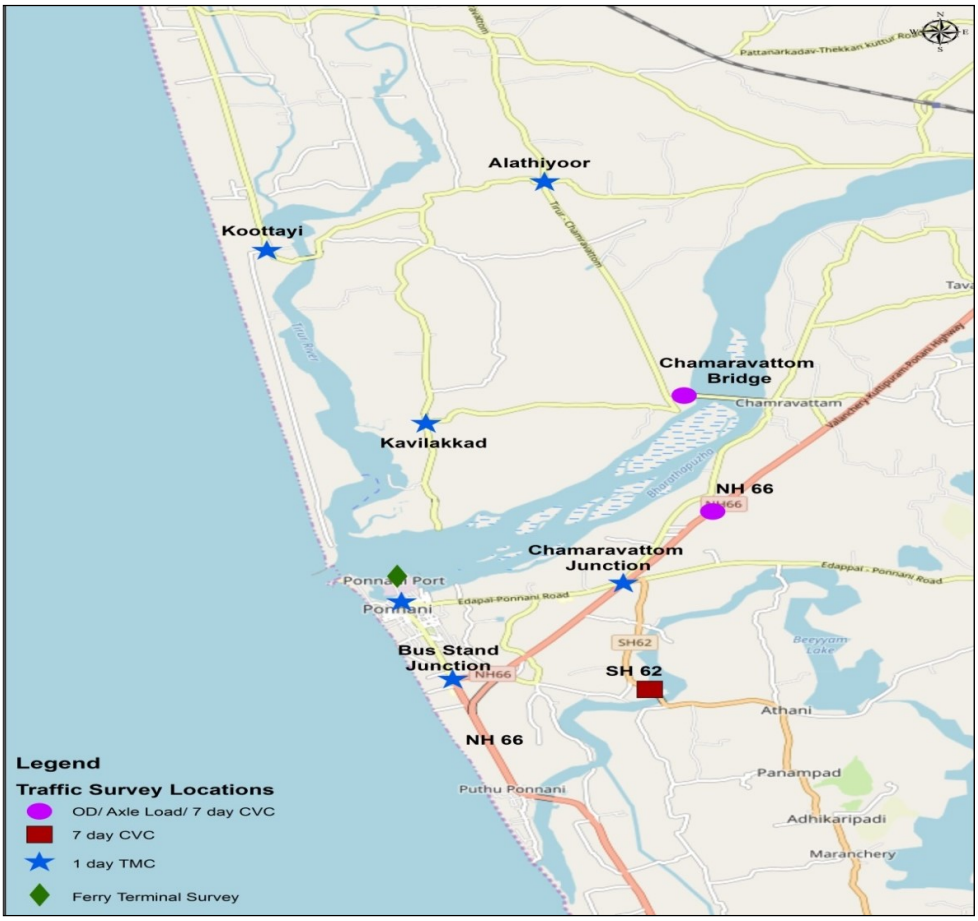


Figure 3-6 : Map of Traffic Survey locations

3.4.10.2 Analysis of Traffic Surveys

3.4.10.2.1 Analysis of Classified Traffic Volume Count Survey

Classified volume count survey has been carried out various locations and analysis of the same is discussed in this section. Analysis of classified volume counts has been carried out to understand the following traffic characteristics:

- Average Daily Traffic (ADT)
- Peak Hour Traffic and Peak Hour share
- Traffic Composition
- Hourly Variation and Daily Variation of Traffic
- Directional Split
- Seasonal Variation
- Annual Average Daily Traffic (AADT)

Different type of vehicles with wide range of physical and traffic characteristics ply on Indian roads. A way of accounting the interaction of various kinds of vehicles is to express the capacity of roads in terms of a common unit, generally identified as the 'Passenger Car Unit' (PCU). The Passenger Car Unit (PCU) factors recommended by Indian Road Congress in "**Guidelines for Capacity of Roads in Rural Areas" (IRC-64-1990)** have been used for conversion, and are presented in **Table 3-18.**

Table 3-17: Recommended PCU Factors for Rural Roads

Sl. No.	Vehicle Type	Equivalency Factor
1	Motor Cycle or Scooter	0.50
2	Passenger Car, Pick-up Van or Auto-rickshaw	1.00
3	Agricultural Tractor, Light Commercial Vehicles	1.50
4	Truck or Bus	3.00
5	Truck-trailer, Agriculture Tractor-trailer	4.50
6	Cycle	0.50
7	Cycle-rickshaw	2.00
8	Hand cart	3.00
9	Horse-drawn Vehicle	4.00
10	Bullock cart	8.00

Photos of Classified volume count surveys are shown in **Figure 3-7.**

SH-62 (Near Kundukadav Bridge)

Ponnani- Tirur Road (Near Chamravattom Bridge)

NH-66 (Near Urban Bank)

Figure 3-7 : Photos of Classified Volume Count Surveys

3.4.10.2.2 Average Daily Traffic (ADT)

Based on reconnaissance survey, 7-day classified volume count surveys (direction-wise) were carried out along various major roads in Ponnani. The daily traffic is averaged to obtain the Average Daily Traffic (ADT) and the total vehicles are converted into Passenger Car

Units (PCU's) using Passenger Car Unit Factor. The location wise Average Daily Traffic (ADT) and equivalent Passenger Car Units (PCUs) are presented in **Table 3-18**. The day-wise, mode-wise summary of classified volume count is given in Annexure 1 of RP004-Traffic Analysis Report.

Table 3-18: Location-wise Average Daily Traffic (ADT)

Vehicle Type	Location		
	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)	SH-62 (Near Kundukadav Bridge)
Two Wheeler	7,538	10,372	11,407
Three Wheeler	1,290	1,664	1,325
Car	5,669	5,401	3,997
Mini Bus	112	63	84
Bus	268	240	437
Goods Auto	179	191	180
Tata Ace / Mahindra	423	546	343
LCV	711	361	448
2-Axle Truck	491	365	462
3-Axle Truck	263	200	130
MAV	218	137	187
Agriculture Tractor-Trailer	2	4	3
Bi-Cycle	253	61	234
Others*	11	9	3
Total Vehicles	**17,429**	**19,615**	**19,238**
Total PCUs	**17,115**	**17,134**	**16,652**

*Cycle Rickshaw, Animal/Hand Drawn, Hand Cart, Other NMV

Observations:

- The Passenger traffic especially **Car** and **Two-wheeler** traffic is observed to be high at all the locations. The share of above traffic varies between **76%** and **80%** at all the survey locations. This is because of the local city bound traffic plying on all the roads
- The overall share of passenger traffic at NH-66 (Near Urban Bank), Ponnani- Tirur Road (Near Chamravattom Bridge) and SH-62 (Near Kundukadav Bridge) is observed to be **85%, 90%** and **90%** respectively
- The share of commercial traffic at NH-66 (Near Urban Bank), Ponnani- Tirur Road (Near Chamravattom Bridge) and SH-62 (Near Kundukadav Bridge) is observed to be **13%, 9%** and **9%** respectively

- 2-axle trucks are observed to be high compared to 3-axle and MAV at all the survey location

3.4.10.3 Peak Hour Traffic

Peak hour traffic at all the survey locations are presented in **Table 3-19.** The peak hour traffic varies from **6.9% to 7.8%** of the total daily traffic.

Table 3-19: Peak Hour Traffic

Location	Peak Hour	Peak Hour PCU	Peak Hour Share
NH-66 (Near Urban Bank)	17:00-18:00	1183	6.9%
Ponnani- Tirur Road (Near Chamravattom Bridge)	17:30-18:30	1329	7.8%
SH-62 (Near Kundukadav Bridge)	16:30-17:30	1227	7.4%

3.4.10.4 Traffic Composition

The traffic composition of vehicles at all the survey locations are worked out and presented in **Figure 3-8**.

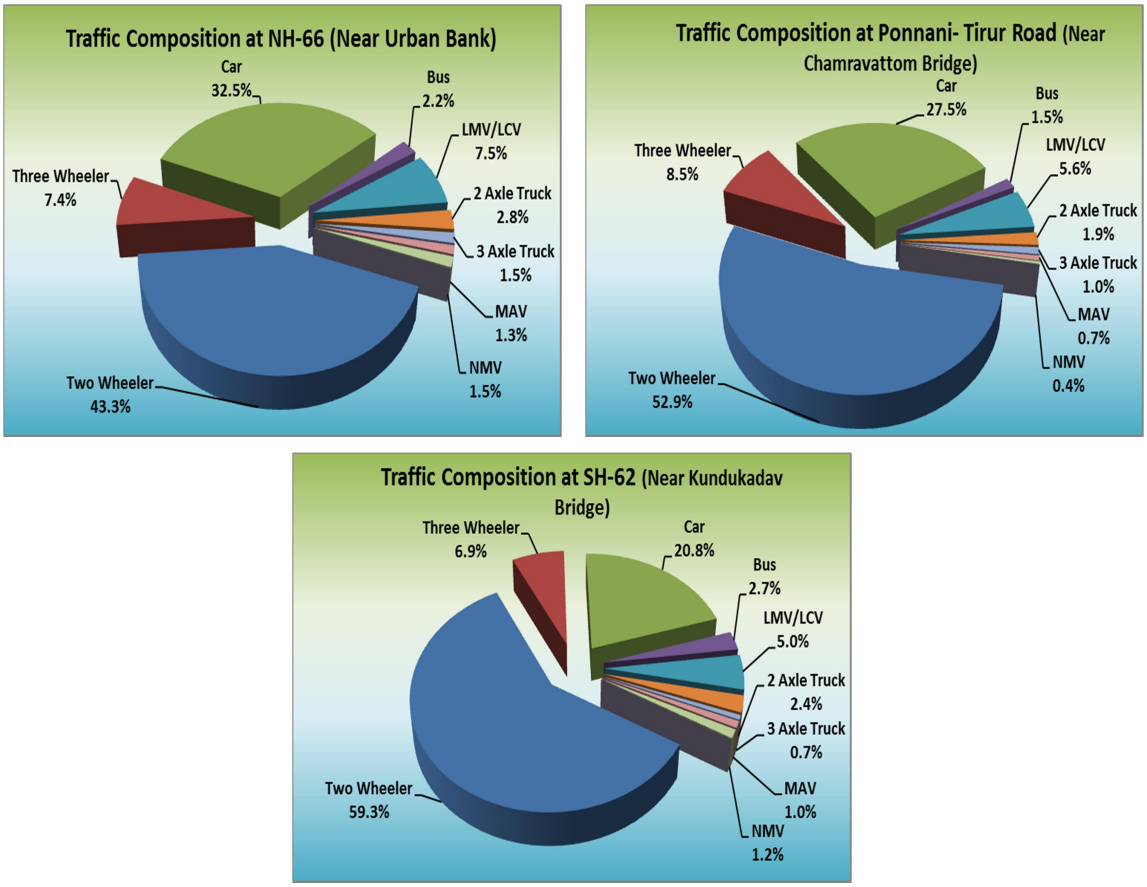


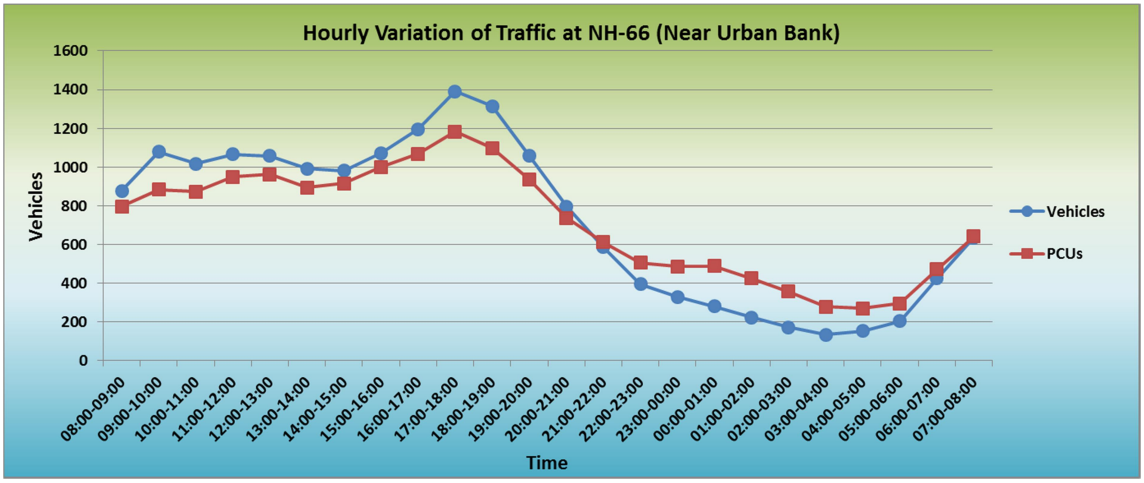
Figure 3-8 : Location-wise Traffic composition

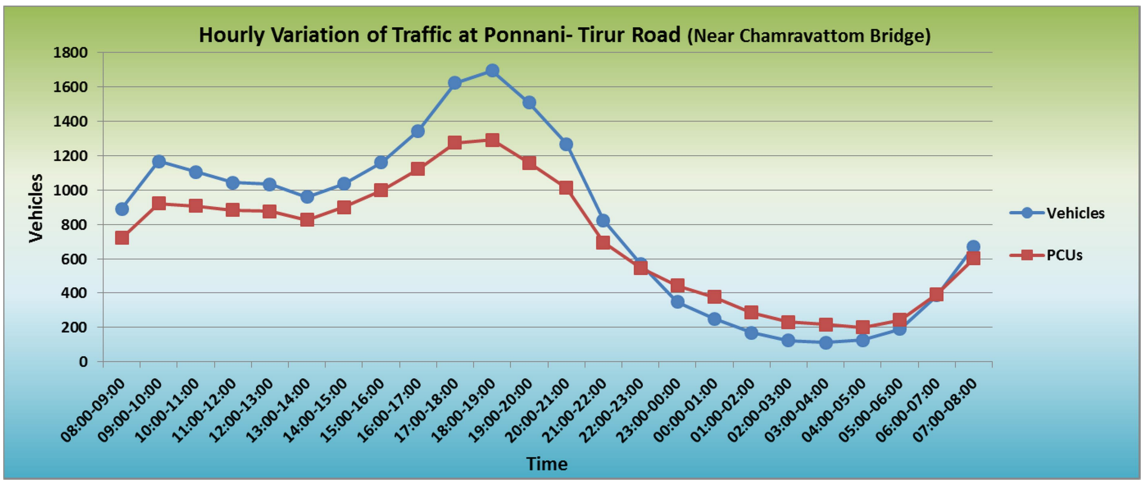
Observations:

- The share of passenger vehicles is high among the share of car and two wheeler being the highest at all the locations

3.4.10.5 Hourly Variation of Traffic

Hourly variation (average of 7 days) of traffic at the survey locations is presented in **Figure 3-9.**





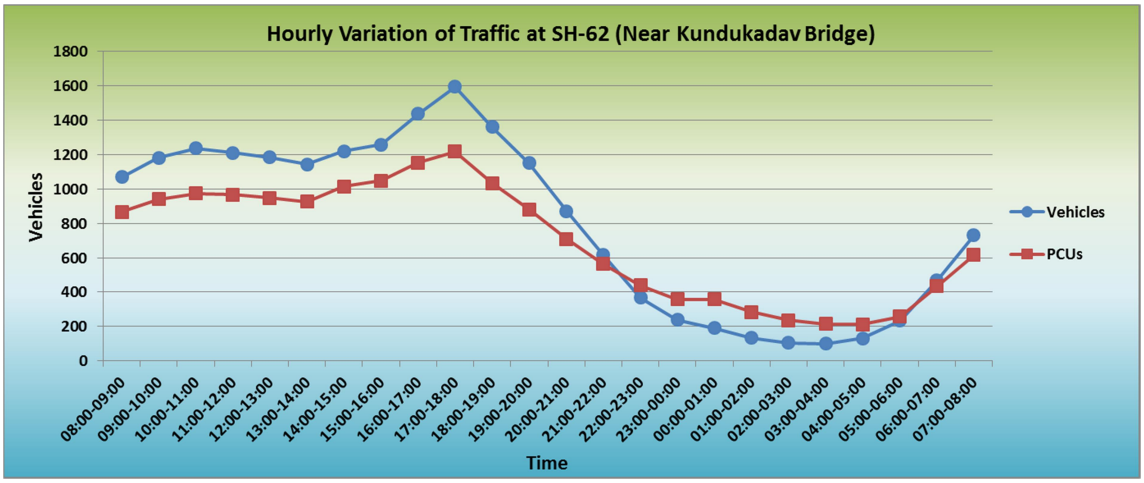


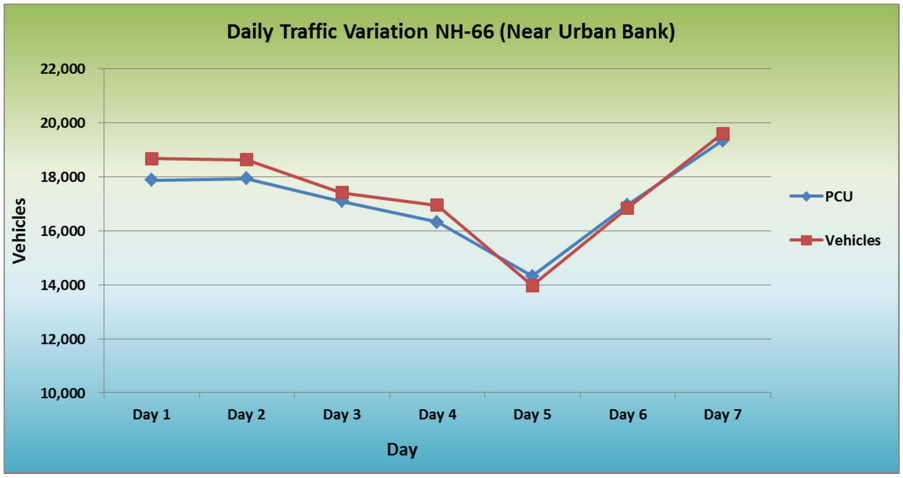
Figure 3-9 : Hourly Variation of Traffic

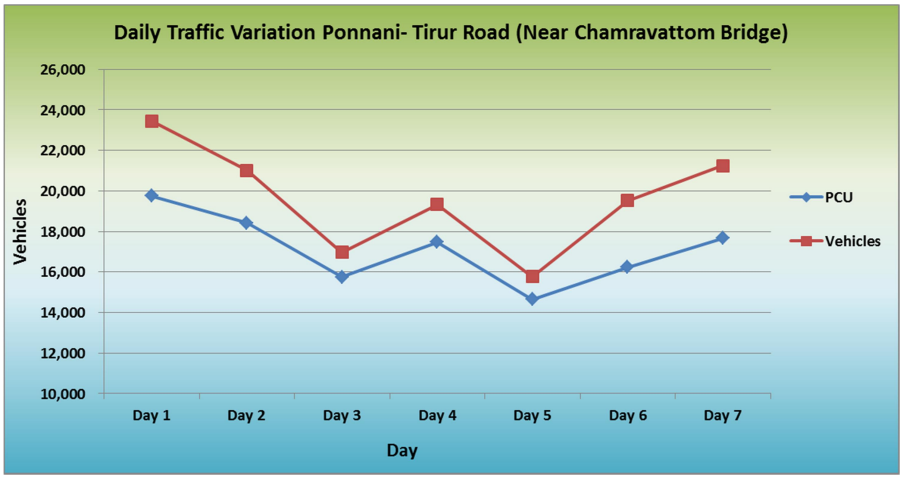
Observations:

- Traffic during the night hours is observed to be very low at all the locations
- There is a distinctive morning and evening peaks in all the directions with the evening peak having more traffic than the morning peak.

3.4.10.6 Daily Variation of Traffic

Daily variation of traffic at all the survey locations is presented in **Figure 3-10.**





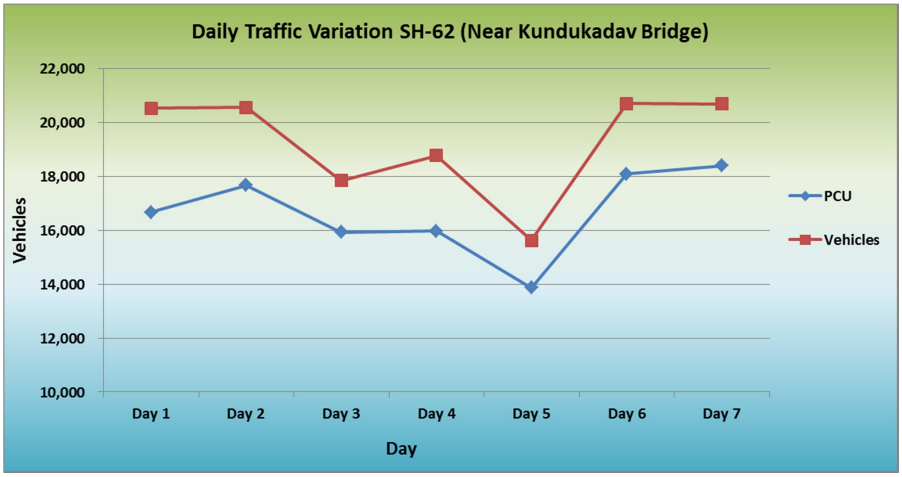


Figure 3-10 : Daily Variation of Traffic

Observations:

- Traffic during weekends is observed to be high
- There is slight variation on daily traffic during 3rd and 5th day of the surveys due to heavy rain in Malappuram District and flood in the regional area

3.4.10.7 Direction-wise Split of Traffic

Direction-wise variation of traffic at all the survey location is presented in **Figure 3-11**.

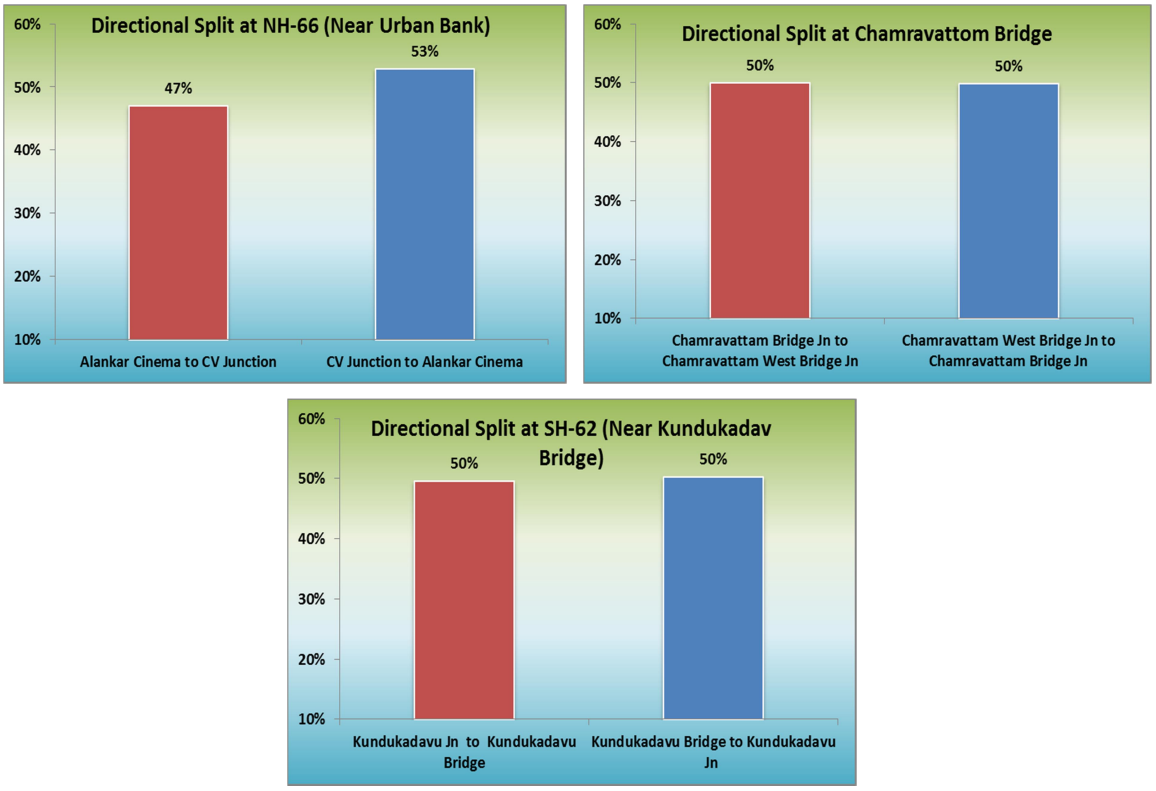


Figure 3-11 : Direction-wise split of Traffic

Observations:

- The directional split shows that directional traffic is almost equal at all the survey locations

3.4.10.8 Seasonal Correction Factor (SCF)

The traffic plying on any road generally varies over different periods of the year depending on the cycle of different socio-economic activities in the influencing regions. Therefore, in order to have more realistic picture of the traffic on the proposed bridge, it is required to assess the seasonal variation in traffic. This would help in estimating the Annual Average Daily Traffic (AADT).

The seasonal correction factor is generally derived from secondary data. To understand the seasonal variation of traffic in project influence area, the monthly fuel sales data for Petrol and Diesel from various fuel stations located in project influence area have been collected. The ratio of total volume of fuel sold in the month of August (survey month) and average monthly volume sold has been taken to calculate the seasonal variation factor. This multiplicative factor works out to 0.93 and 1.24 for MS and HSD respectively. Based on fuel sales data, Seasonal Correction Factor (SCF) is arrived are presented in **Table 3-20.**

Table 3-20: Seasonal Correction Factor

Seasonal Correction Factor (SCF)		
Month	**Petrol**	**Diesel**
April	0.88	0.78
May	0.89	0.84
June	1.00	1.19
July	0.91	1.22
August	**0.93**	**1.24**
September	1.22	1.31
October	0.93	1.19
November	1.09	1.13
December	1.09	0.94
January	1.05	0.83
February	1.11	0.90
March	1.03	0.83

3.4.10.9 Annual Average Daily Traffic (AADT)

The mode wise seasonal correction factor has been applied for converting the average daily traffic to annual average daily traffic. Location-wise annual average daily traffic is presented in **Table 3-21**.

Table 3-21: Location-wise Annual Average Daily Traffic (AADT)

Vehicle Type	Location		
	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)	SH-62 (Near Kundukadav Bridge)
Two Wheeler	7,011	9,647	10,608
Three Wheeler	1,199	1,548	1,233
Car	5,984	5,700	4,219
Mini Bus	139	79	104
Bus	334	299	543
Goods Auto	223	237	223
Tata Ace / Mahindra	526	679	426
LCV	885	450	558
2-Axle Truck	610	454	574
3-Axle Truck	327	248	161

Vehicle Type	Location		
	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)	SH-62 (Near Kundukadav Bridge)
MAV	271	170	232
Agriculture Tractor-Trailer	3	5	4
Bi-Cycle	253	61	234
Others*	11	9	3
Total Vehicles	**17,775**	**19,586**	**19,123**
Total PCUs	**18,582**	**18,119**	**17,719**

*Cycle Rickshaw, Animal/Hand Drawn, Hand Cart, Other NMV

3.4.10.10 Analysis of Turning Movement Count Survey

To assess the impact of major cross roads, turning movement survey is carried out at identified important junctions and the details of the junctions are presented in this section. Total junction traffic, peak hour and peak hour traffic at all the survey location is presented in **Table 3-22**. Summary of turning movement count survey is presented in Annexure 2 of RP004-Traffic Analysis Report.

Table 3-22: Summary of Turning Movement Count

S. No.	Name of the Junction	Junction Type	Peak hour		Peak hour Traffic (PCUs)		Total PCUs
			Morning	Evening	Morning	Evening	
1	Kodathippadi Jn.	4-Arm	10:30-11:30	16:45-17:45	1,049	1,108	12,126
2	Bus Stand Jn.	3-Arm	09.00-10.00	16.15-17.15	1,782	1,698	20,413
3	Kavilakkad Jn.	3-Arm	09.30-10.30	16.30-17.30	831	1,059	10,593
4	Koottayi Jn.	4-Arm	10:00-11:00	16:45-17:45	680	588	5,071
5	Alathiyoor Jn	4-Arm	10:30-11:30	16:45-17:45	2,579	2,638	35,107
6	Chamaravattom Jn	5-Arm	08:30-09:30	17:00-18:00	3,850	4,213	59,644

Location-wise directional movement at all the survey locations are presented in **Table 3-23**.

Table 3-23:Location-wise Directional Movement of Traffic

S. No.	Name of the Junction	Direction	Total	
			Vehicle	PCU
1	Kodathippadi Jn.	From Ponnani Harbour	770	470
		To Ponnani Harbour	705	420
		From Chandappadi	6,747	5,142
		To Chandappadi	6,042	4,211
		From Ponnani Bus Stand	5,935	4,144
		To Ponnani Bus Stand	6,568	5,049
		From Ponnani Beach	526	327
		To Ponnani Beach	663	403
2	Bus Stand Jn.	From Ponnani Court	11,747	8,806
		To Ponnani Court	11,623	8,326
		From Pandithara Road	7,148	4,953
		To Pandithara Road	7,382	5,536
		From NH-66	8,963	6,654
		To NH-66	8,853	6,551
3	Kavilakkad Jn.	From Mangalam Road	6,051	4,055
		To Mangalam Road	6,629	4,402
		From Purathur Service Co-operative Bank	3,989	2,584
		To Purathur Service Co-operative Bank	3,806	2,485
		From Purathur Bus Stand	5,957	3,955
		To Purathur Bus Stand	5,562	3,706
4	Kottayi Jn	From Tippu Sulthan Road	1,478	1,267
		To Tippu Sulthan Road	1,432	1,245
		From Hayathul Islam Sabha Hall	166	132
		To Hayathul Islam Sabha Hall	171	121
		From Mangalam Road	824	643
		To Mangalam Road	809	640
		From Padinjarekkara Road	2,075	1,752
		To Padinjarekkara Road	2,131	1,788
5	Alathiyoor Jn	From Ponnani- Tirur Road (N)	5,743	4,110
		To Ponnani- Tirur Road (N)	6,503	4,505
		From Codachal	7,164	5,080

S. No.	Name of the Junction	Direction	Total	
			Vehicle	PCU
		To Codachal	7,185	5,283
		From Ponnani- Tirur Road (S)	5,895	4,339
		To Ponnani- Tirur Road (S)	4,655	3,328
		From Ambalappadi	3,994	2,753
		To Ambalappadi	4,453	3,165
6	Chamaravattom Jn	From NH-66 (N)	10,476	10,239
		To NH-66 (N)	9,218	9,010
		From Ponnani-Palakkad (E)	23,992	18,717
		To Ponnani-Palakkad (E)	20,078	16,773
		From NH-66 (S)	16,162	12,916
		To NH-66 (S)	13,457	10,568
		From Ponnani-Palakkad (W)	15,439	10,626
		To Ponnani-Palakkad (W)	23,530	16,358
		From Ponnani-Tirur Road	9,391	7,147
		To Ponnani-Tirur Road	9,177	6,935

Location-wise traffic composition is presented in **Table 3-24**.

Table 3-24: Location-wise Traffic Composition

S. No.	Name of the Junction	Two Wheeler	Three Wheeler	Car	Bus	Goods Auto	LMV / LCV	Truck	Cycle
1	Kodathippadi Jn.	68%	18%	8%	2%	1%	1%	-	1%
2	Bus Stand Jn.	65%	18%	9%	3%	1%	1%	-	2%
3	Kavilakkad Jn.	69%	12%	10%	1%	1%	2%	-	5%
4	Koottayi Jn.	48%	26%	18%	2%	1%	2%	-	1%
5	Alathiyoor Jn	60%	14%	19%	1%	1%	2%	2%	-
6	Chamaravattom	62%	12%	17%	1%	1%	2%	3%	1%

3.4.10.11 Survey Methodology

Roadside Interview method, as detailed in **IRC: 102-1988**, is used for conducting O-D survey. The survey was carried out for both passenger and goods vehicles for 24 hours (in both directions) on a working day. Trained enumerators under the supervision of a team of Traffic Engineers collected the travel information.

The information collected contained trip origin and trip destination. In addition, commodity details for goods vehicles and purpose and frequency for passenger vehicles were also collected. The data analysis is carried out to assess the movement pattern on the existing major road and estimate the trip frequency, trip length, trip purpose etc. Photos of Axle load and Origin-Destination surveys are shown in **Error! Reference source not found.**

Figure 3-12 : Photos of Axle load and Origin-Destination Surveys

3.4.10.12 Sample Size

The sample size for various categories of goods vehicles range from 15% to 63% whereas the sample size ranges for various passenger vehicles are 6% to 34%. Location-wise the sample size for various categories of vehicles is summarized in **Table 3-25**.

Table 3-25: Sample Size of O-D Survey

Vehicle Type	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)
Two Wheeler	6%	11%
Auto	17%	31%
Car	19%	27%
Bus	15%	34%

Vehicle Type	NH-66 (Near Urban Bank)	Ponnani- Tirur Road (Near Chamravattom Bridge)
Goods Auto	19%	27%
Tata Ace	15%	25%
LCV	21%	25%
2 Axle Truck	42%	63%
3 Axle Truck	58%	26%
MAV	63%	32%

3.4.10.13 Zoning System

For the purpose of analysis, the entire country was broadly divided into two regions. They are, Immediate Influence Area (IIA) and Broad Influence Area (BIA). In order to assess the traffic pattern on the project influence area, zoning system is developed keeping in view the major generation and attraction points. While defining zones, the following were considered:

- Important towns and industrial areas along or near the major roads
- Administrative boundaries, e.g., district and state boundaries

The entire project influence area is divided into 56 zones and the same is presented in **Table 3-26**.

Table 3-26: Adopted Zoning System

S.No.	Zone Name	S.No.	Zone Name
1	Puthu Ponnani, Anappadi	29	Alamcode,Changaramkulam, Kadavallur
2	Ponnani Beach	30	Rest of Malappuram District
3	Ponnani Harbour	31	Kozhikode
4	Chandappadi	32	Wayanad
5	Kollan padi, Mukkilepeedika	33	Guruvayur
6	Kuttadu	34	Kunnamkulam
7	Biyyam, Thuyyam	35	Pattambi, Shoranur
8	Chamaravattom, Pothanoor	36	Thrissur
9	Parappuram	37	Palakkad, Alathur
10	Tavanur, Koorada	38	Kochi
11	Thrikkannapuram, Kandankam	39	Eranakulam
12	Kuttipuram, Valenchery	40	Alappuzha
13	Perintalmanna	41	Kottayam
14	Purathur, Kavilakkad	42	Idukki
15	Padinjarekkara	43	Pathanamthitta

S.No.	Zone Name	S.No.	Zone Name
16	Triprangode, Alathiyoor, Mangalam	44	Kannur
17	Koottayi, Unniyal	45	Kasaragod
18	Talakkad, Trikkandiyoor	46	Kollam
19	Tirur	47	Thiruvananthapuram
20	Tanur	48	Coimbatore,Tiruppur,Erode,Karur
21	Kottakkal	49	Pollachi, Dindigul
22	Malappuram Town	50	Rest of Tamil Nadu
23	Edavanna, Nilambur	51	Mangaluru
24	Tirurangadi, Kooriyad	52	Bengaluru
25	Veliancode, Palappetty	53	Rest of Karnataka
26	Purangu	54	Goa
27	Marancherry, Perumbadappu	55	Maharashtra
28	Edappal, Naduvattom	56	Rest of India

The collected data is coded, processed and expanded to total traffic using the expansion factors for each vehicle type. The expansion factor is calculated from the sample size collected for various categories of vehicles from the O-D survey.

3.4.10.14 Estimation of Traffic Demand

Based on the review of secondary data and analysis of primary survey data, Consultant estimated base year traffic. The same has been used to arrive at the traffic forecast for horizon years:

1) Divertible Traffic
2) Generated Traffic
3) Induced Traffic

3.4.10.14.1 Traffic Diversion Analysis

Diverted traffic is defined as the component of traffic that will get diverted from the existing road network/ other features to the proposed new bridge for taking advantage of the new proposed bridge for various reasons such as savings in generalised cost of travel (VOC benefits), better accessibility, improved riding quality, savings in travel time, improved travel speeds etc. With respect to proposed bridge, diverted traffic consists of two components, namely:

1) Diverted traffic from existing road network
2) Diverted traffic from ferry/ junkar (ro-ro) service

Diverted traffic from existing road network is estimated primarily using traffic survey data. It comprises of identifying the O-D pairs which have potential to divert to the proposed bridge from alternate roads. The identified number of trips on proposed bridge multiplied with diversion potential gives the diverted traffic on the proposed bridge. The identified the O-D pairs which have potential to divert to the proposed bridge from alternate roads are given in **Table 3-27**.

Table 3-27: Potential Zones considered for Estimating Divertible Traffic

S.No.	Zone Name	S.No.	Zone Name
1	Puthu Ponnani, Anappadi	35	Pattambi, Shoranur
2	Ponnani Beach	36	Thrissur
3	Ponnani Harbour	37	Palakkad, Alathur
4	Chandappadi	38	Kochi
5	Kollan padi, Mukkilepeedika	39	Eranakulam
6	Kuttadu	40	Alappuzha
7	Biyyam, Thuyyam	41	Kottayam
15	Padinjarekkara	42	Idukki
17	Koottayi, Unniyal	43	Pathanamthitta
20	Tanur	44	Kannur
25	Veliancode, Palappetty	45	Kasaragod
26	Purangu	46	Kollam
27	Marancherry, Perumbadappu	47	Thiruvananthapuram
28	Edappal, Naduvattom	48	Coimbatore,Tiruppur,Erode,Karur
29	Alamcode,Changaramkulam, Kadavallur	49	Pollachi, Dindigul
31	Kozhikode	51	Mangaluru
32	Wayanad	54	Goa
33	Guruvayur	55	Maharashtra
34	Kunnamkulam		

The procedure for estimating diversion potential is briefed below:

- → Cost Ratio factors are derived for each type of vehicle considering the parameters such as travel distance, travel time/ mileage and fuel rate i.e. comparison of generalised cost of travel on proposed bridge and alternate roads
- → The diversion potential for each type of vehicle from each of the alternate roads is estimated using the cost ratio factors and diversion equations (which are similar to Logit Curve)
- → The diversion equations used for estimation of the diversion potential of the proposed bridge are given in **Table 3-28**.

Table 3-28: Diversion Equations used for Diversion Analysis

Type of Vehicle	Cost Ratio Interval	Relationship
Car	< 0.634	% Div = 98.75 – ((CR/0.634)*8.125)
	0.64 = CR < 1.465	% Div = 90.625 – ((CR - 0.634)/0.831)*84.375
	1.465 = CR <= 2.00	% Div = 6.25 – ((CR – 1.465)/0.535))*5.25
Bus and Truck	<=0.75	% Div = 100 – (CR/0.75)*5

Type of Vehicle	Cost Ratio Interval	Relationship
	0.75 = CR < 1.25	% Div = 95 – ((CR-0.75)/0.5)*90
	1.25 = CR <= 2.00	% Div = ((2-CR)/0.75)*5

Percentage of traffic that can be diverted from alternate roads to proposed bridge using diversion equation is calculated and total traffic that will get diverted from the alternate roads to the proposed bridge is estimated and presented in **Table 3-29.**

The modes which are currently being transported via the existing ferry service are two-wheeler, car, auto, mini bus and goods auto. Once the proposed bridge becomes functional, these modes will start using the bridge due to savings in travel time and waiting time. The traffic that will get diverted from the existing ferry/ junkar (ro-ro) service is given in **Table 3-29.**

Table 3-29: Diversion of Traffic to the Proposed Bridge

Vehicle Type	Divertible Traffic			
	Ponnani- Tirur Road (Near Chamravattom Bridge)	NH-66 (Near Urban Bank)	Ferry Terminal	Total Divertible Traffic
Two Wheeler	496	177	307	980
Auto	99	24	107	230
Mini Bus	21	0	3	24
Private Bus	8	12	-	20
Car	974	349	236	1,560
Goods Auto	37	6	28	71
Tata Ace	171	39	-	209
LCV	216	37	-	253
2A Truck	207	80	-	287
3A Truck	121	51	-	172
MAV	77	48	-	125
Total Vehicle	**2,425**	**823**	**681**	**3,928**
Total PCU	**3,339**	**1,228**	**543**	**5,111**

Divertible traffic from Ponnani- Tirur Road (Near Chamravattom Bridge), NH-66 (Near Urban Bank) and Ferry Terminal to the proposed bridge is **3,339 PCUs, 1,228 PCUs** and **543 PCUs** respectively. The total estimated divertible traffic on the proposed bridge is **5,111 PCUs** (3,928 vehicles).

3.4.10.14.2 Generated Traffic

Generated traffic is defined as the component of traffic that will get generated due to new developments that will happen within the project influence area mostly because of the improved road conditions i.e., New bridge connectivity. Generated Traffic on the proposed

bridge is mainly due to the local development by providing connectivity to the surrounding areas.

Generated Traffic due to Local Development

It is an important component for the study as the project has been planned as part of the Coastal Highway proposal. Ponnani is a major fishing hub in Kerala and therefore it forms a major component in generated traffic. The proposed cargo port in Ponnani will also generate traffic on to the proposed bridge. **"Master Plan for Ponnani- 2035"** prepared by Department of Town and Country Planning has been reviewed to understand the future developments in and around Ponnani town. Other possible developments such as tourist destinations and subsequent impact of traffic generated have also been assessed. The various development proposals/ land use details that are considered for trip generation is presented in **Table 3-30**.

Table 3-30: List of Proposals considered for Trip Generation

S. No.	Type of Development*	Location	Area (acres)
1	Craft Village	Biyyam Kayal	7.56
2	Tourism Village	Near Veliyamkode Bridge	4.97
3	Beach Recreation including Aquarium and Sea Expo	Near Munambam Beevi Jaaram at Puduponnani	4.32
4	Cargo Port (Phase 1 & 1A)	Ponnani	711.90
5	Parks and open spaces	Ponnani	32.81

**Source: Proposed Landuse Map in Master Plan for Ponnani- 2035*

Standard trip generation rates such as Institute of Transportation Engineers' (ITE) Trip Generation rates are not available for Indian conditions to estimate the trip generation from various land uses. Therefore, trip rates of various development sites derived in previous studies by Consultant are referred for estimation of trips for various land uses. Trip generation rate of goods vehicles for tourism sector and port/ logistics (per 100 TEU) is 0.2 truck/ acre and 0.5 truck/ acre whereas for passenger vehicles is 10 car/ acre and 0.2 car/ acre.

Trip generation rates applicable to each land use are multiplied with respective area of the development to get the trips generated. All the trips thus generated are not expected to use the proposed bridge as the developments are located in various locations. Therefore, potential traffic that will use the proposed bridge is assessed based on the relative distance of development with respect to the proposed bridge, availability of alternative road network, influence of the particular zone on the proposed bridge based on O-D data.

3.4.10.14.3 Induced Traffic

Induced traffic is defined as the component of traffic that is potentially existing but not presently evident or realised. It is like release of latent demand for travel due to the proposed bridge. It is the traffic generated due to availability of superior facility which will result in new trips other than generated traffic.

Basically, details such as travel behavioural data of users, selection of type of vehicle and type of route for the trip by the user etc. details are required for assessment of induced

traffic. In the absence of such detailed level of data, 10% of the generated traffic is considered as the induced traffic for the proposed bridge. The total generated traffic due to the local developments thus estimated is presented in **Table 3-31.**

Table 3-31: Generated and Induced Traffic on the Proposed Bridge

Type of Vehicle	Total Generated and Induced Traffic
Two Wheeler	55
Auto	15
Car	187
Mini Bus	9
Private Bus	11
Goods Auto	30
Tata Ace	55
LCV	105
2A Truck	85
3A Truck	24
Total Vehicles	**575**
Total PCUs	**887**

Generated traffic due to local development on the proposed bridge is estimated as **806 PCUs** (523 vehicles) where as induced traffic is estimated as **81 PCUs** (52 vehicles).

The total generated and induced traffic on the proposed bridge due to the developments is estimated as **887 PCUs** (575 vehicles). It is assumed that all the proposed developments will occur in next 5 years and the traffic will generate from year 2025.

3.4.10.15 Recommended Growth Rates

Generally, the spread of economic development induces changes in the spatial distribution of activities and corresponding changes in transport demand elasticity. As regions become more and more self-sufficient, the need for long-distance transport diminishes. Therefore, it is generally assumed that transport demand elasticity, for both truck and passenger traffic would tend to decline over time despite growth in NSDP/ NSVA, population and per capita income. Hence a decline in elasticity has been assumed for the future period.

- In future years, the growth rate is expected to reduce gradually and therefore, the growth rate is assumed such that it will decrease by 5% for every five year block for the first 15 year period and by 10% thereafter
- However, minimum of 5% growth has been assumed for Bus

Considering the above criteria, recommended growth rate is estimated and the same is considered for all three scenarios i.e.

- Most-Likely Scenario
- Optimistic Scenario
- Pessimistic Scenario

Since the growth rates are arrived based on the actual economic growth indicators such as NSDP, population and per-capita income, the recommended growth rates can be considered as Most-Likely Scenario and presented in **Table 3-32.**

For optimistic scenario, it is assumed that elasticity values will be 20% more than that of most-likely scenario and for pessimistic scenario, it is assumed that the elasticity values will be 20% less than that of most-likely scenario. Based on the above assumption, the growth rates are arrived for both optimistic and pessimistic scenarios and presented in **Table 3-33** and **Table 3-34**.

Table 3-32: Recommended Traffic growth rates (Most-Likely Scenario)

Type	2019 (Base Year)	2020-2023	2024-2028	2029-2033	2034-2038	2039-2043	2043-2048	2049-2053
Two Wheeler	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
Auto	5.0%	5.0%	4.8%	4.5%	4.1%	3.7%	3.3%	3.0%
Car	7.0%	7.0%	6.7%	6.3%	5.7%	5.1%	4.6%	4.1%
Mini Bus	5.0%	5.0%	4.8%	4.5%	4.1%	3.7%	3.3%	3.0%
Private Bus	5.0%	5.0%	4.8%	4.5%	4.1%	3.7%	3.3%	3.0%
Goods Auto	5.0%	5.0%	4.8%	4.5%	4.1%	3.7%	3.3%	3.0%
Tata Ace	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
LCV	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
2 Axle	4.0%	4.0%	3.8%	3.6%	3.2%	2.9%	2.6%	2.4%
3 Axle	5.0%	5.0%	4.8%	4.5%	4.1%	3.7%	3.3%	3.0%
MAV	6.5%	6.5%	6.2%	5.9%	5.3%	4.8%	4.3%	3.8%

Table 3-33: Recommended Traffic growth rates (Optimistic Scenario)

Type	2019 (Base Year)	2020-2023	2024-2028	2029-2033	2034-2038	2039-2043	2043-2048	2049-2053
Two Wheeler	7.2%	7.2%	6.8%	6.5%	5.8%	5.3%	4.7%	4.3%
Auto	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
Car	8.4%	8.4%	8.0%	7.6%	6.8%	6.1%	5.5%	5.0%
Mini Bus	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
Private Bus	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
Goods Auto	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%

Type	2019 (Base Year)	2020-2023	2024-2028	2029-2033	2034-2038	2039-2043	2043-2048	2049-2053
Tata Ace	7.2%	7.2%	6.8%	6.5%	5.8%	5.3%	4.7%	4.3%
LCV	7.2%	7.2%	6.8%	6.5%	5.8%	5.3%	4.7%	4.3%
2 Axle	4.8%	4.8%	4.6%	4.3%	3.9%	3.5%	3.2%	2.8%
3 Axle	6.0%	6.0%	5.7%	5.4%	4.9%	4.4%	3.9%	3.6%
MAV	7.8%	7.8%	7.4%	7.0%	6.3%	5.7%	5.1%	4.6%

Table 3-34: Recommended Traffic growth rates (Pessimistic Scenario)

Type	2019 (Base Year)	2020-2023	2024-2028	2029-2033	2034-2038	2039-2043	2043-2048	2049-2053
Two Wheeler	4.8%	4.8%	4.6%	4.3%	3.9%	3.5%	3.2%	2.8%
Auto	4.0%	4.0%	3.8%	3.6%	3.2%	2.9%	2.6%	2.4%
Car	5.6%	5.6%	5.3%	5.1%	4.5%	4.1%	3.7%	3.3%
Mini Bus	4.0%	4.0%	3.8%	3.6%	3.2%	2.9%	2.6%	2.4%
Private Bus	4.0%	4.0%	3.8%	3.6%	3.2%	2.9%	2.6%	2.4%
Goods Auto	4.0%	4.0%	3.8%	3.6%	3.2%	2.9%	2.6%	2.4%
Tata Ace	4.8%	4.8%	4.6%	4.3%	3.9%	3.5%	3.2%	2.8%
LCV	4.8%	4.8%	4.6%	4.3%	3.9%	3.5%	3.2%	2.8%
2 Axle	3.2%	3.2%	3.0%	2.9%	2.6%	2.3%	2.1%	1.9%
3 Axle	4.0%	4.0%	3.8%	3.6%	3.2%	2.9%	2.6%	2.4%
MAV	5.2%	5.2%	4.9%	4.7%	4.2%	3.8%	3.4%	3.1%

3.4.10.15.1 Growth considered for Generated Traffic

The growth of generated traffic for all the three scenarios is considered.

- For most-likely scenario, it is assumed that all the proposed developments will be implemented in next 5 years
- For optimistic scenario, it is assumed that generated traffic will be 20% more than that of most-likely scenario
- For pessimistic scenario, it is assumed that there will be no development in the project influence area

3.4.10.16 Traffic Forecast

Based on the recommended growth rates, traffic forecast of AADT has been done for proposed bridge (Diverted Traffic + Generated Traffic + Induced Traffic) for all the three scenarios namely most-likely scenario, optimistic scenario, and pessimistic scenarios and presented in tables fromError! Reference source not found. To **Table 3-37.** The proposed bridge will be operational from year 2023 (as per TOR), therefore traffic is forecasted further period of 30 years from completion of proposed bridge.

Table 3-35: Traffic Forecast (AADT) for Most-likely Scenario for Proposed Bridge

Year	Two Wheeler	Auto	Car	Mini Bus	Private Bus	Goods Auto	Tata Ace	LCV	2A Truck	3A Truck	MAV	Total Vehicles	Total PCU
2023	1,237	279	2,044	29	24	86	264	319	336	209	160	**4,987**	**6,417**
2024	1,307	292	2,180	30	25	90	279	337	349	219	170	**5,279**	**6,775**
2025	1,382	306	2,325	32	26	94	295	357	362	229	181	**5,589**	**7,154**
2030	1,813	384	3,188	40	33	118	388	468	434	288	243	**7,397**	**9,356**
2035	2,336	475	4,280	49	40	146	499	603	515	356	319	**9,619**	**12,039**
2040	2,936	575	5,582	60	49	177	628	758	601	431	408	**12,204**	**15,138**
2045	3,609	683	7,095	71	58	210	771	931	690	512	510	**15,141**	**18,635**
2050	4,346	798	8,808	83	68	245	929	1,122	781	598	624	**18,403**	**22,499**
2053	4,826	871	9,949	90	74	268	1,031	1,245	838	653	699	**20,546**	**25,028**

Table 3-36: Traffic Forecast (AADT) for Optimistic Scenario for Proposed Bridge

Year	Two Wheeler	Auto	Car	Mini Bus	Private Bus	Goods Auto	Tata Ace	LCV	2A Truck	3A Truck	MAV	Total Vehicles	Total PCU
2023	1,294	290	2,153	30	25	89	276	334	346	217	168	**5,223**	**6,706**
2024	1,382	306	2,325	32	26	94	295	357	362	230	181	**5,590**	**7,156**

Year	Two Wheeler	Auto	Car	Mini Bus	Private Bus	Goods Auto	Tata Ace	LCV	2A Truck	3A Truck	MAV	Total Vehicles	Total PCU
2025	1,477	324	2,511	34	28	99	316	381	379	243	194	**5,984**	**7,638**
2030	2,043	425	3,659	44	36	131	437	527	471	318	276	**8,366**	**10,530**
2035	2,764	547	5,198	57	47	168	591	713	577	410	382	**11,456**	**14,245**
2040	3,632	688	7,138	71	59	211	776	937	694	516	514	**15,237**	**18,753**
2045	4,648	845	9,505	88	72	260	993	1,199	819	634	671	**19,734**	**24,076**
2050	5,805	1,018	12,309	106	87	313	1,241	1,498	951	763	853	**24,943**	**30,205**
2053	6,579	1,131	14,238	117	96	347	1,406	1,698	1,034	847	977	**28,472**	**34,340**

Table 3-37: Traffic Forecast (AADT) for Pessimistic Scenario for Proposed Bridge

Year	Two Wheeler	Auto	Car	Mini Bus	Private Bus	Goods Auto	Tata Ace	LCV	2A Truck	3A Truck	MAV	Total Vehicles	Total PCU
2023	1,182	269	1,939	28	23	82	253	305	326	201	153	**4,760**	**6,137**
2024	1,236	279	2,043	29	24	86	264	319	336	209	160	**4,983**	**6,411**
2025	1,292	289	2,151	30	25	89	276	333	346	217	168	**5,216**	**6,697**
2030	1,608	347	2,774	36	30	107	344	415	400	260	213	**6,533**	**8,306**
2035	1,971	412	3,515	43	35	127	421	509	459	309	265	**8,065**	**10,164**
2040	2,368	480	4,352	50	41	148	506	611	519	360	324	**9,759**	**12,206**
2045	2,795	551	5,277	57	47	169	597	721	580	413	387	**11,597**	**14,409**
2050	3,245	625	6,279	65	53	192	694	837	641	468	455	**13,555**	**16,745**
2053	3,530	670	6,925	70	57	206	754	911	678	502	499	**14,802**	**18,228**

3.4.10.16.1 Capacity Analysis for the Proposed Bridge

As per **IRC: 64-1990 Guidelines for Capacity of Roads in Rural Areas**, the design service volume for two lane road with Level of Service (LOS) 'B' is 15,000 PCU/day. Based on the IRC guidelines capacity assessment for the proposed bridge is arrived for all the three scenarios and presented in **Table 3-38.**

Table 3-38: Capacity Analysis/ Lane Requirement for the Proposed Bridge

Lane Requirement	Most-Likely Scenario	Optimistic Scenario	Pessimistic Scenario
2-lane with LOS B	Till 2040	Till 2036	Till 2047
4-lane with LOS B	After 2040	After 2036	After 2047

- The proposed bridge will cater the traffic of 2-lane capacity till the year 2040

3.4.10.17 Major Findings on the Traffic Analysis

Following are the major findings from Traffic analysis:

- The share of overall passenger traffic at NH-66 (Near Urban Bank), Ponnani- Tirur Road (Near Chamravattom Bridge) and SH-62 (Near Kundukadav Bridge) is observed to be **86%, 90%** and **90%** respectively whereas the share of commercial traffic is observed to be **13%, 9%** and **9%** respectively
- 2-axle trucks are observed to be high compared to 3-axle and MAV at all the survey location
- The influence of Ponnani town is observed to be high at both the survey locations which is due to proximity from the survey locations for all modes
- Present major influencing area for bus is observed to be **Chamravattom, Tavanur, Pattambi and Thrissur,** for car is observed to be **Chamravattom, Kuttipuram and Kozhikode** and for truck traffic is observed to be **Chamravattom, Kuttipuram, Kozhikode, Ernakulam and Mangaluru** at NH-66 (Near Urban Bank)
- Present major influencing area for bus is observed to be **Malappuram, Kozhikode, Guruvayur and Ernakulam**, for car is observed to be **Tirur, Kozhikode and Thrissur** and for truck traffic is observed to be **Tirur, Kozhikode, Ernakulam, Alappuzha and Kannur** at Ponnani- Tirur Road (Near Chamravattom Bridge)
- The influence of Kerala state is very significant at both locations for all modes
- The other major influencing states for commercial vehicles are Karnataka and Maharashtra
- Terminal survey analysis of passenger trips reveals that a total of 4,315 trips per day are being made Ponnani Ferry Terminal. Major mode of access to the ferry terminal is two-wheeler (48%). Around 60% of the total trips are made twice daily.

- Based on the review of secondary data and analysis of primary survey data, Consultant estimated base year traffic on the proposed bridge which includes divertible, generated and induced traffic.
- Divertible traffic from Ponnani- Tirur Road (Near Chamravattom Bridge), NH-66 (Near Urban Bank) and Ferry Terminal to the proposed bridge is **3,339 PCUs, 1,228 PCUs** and **543 PCUs** respectively. The total estimated divertible traffic on the proposed bridge is **5,111 PCUs** (3,928 vehicles).
- Generated traffic due to local development on the proposed bridge is estimated as **806 PCUs** (523 vehicles) where as induced traffic is estimated as **81 PCUs** (52 vehicles).
- The total generated and induced traffic on the proposed bridge due to the developments is estimated as **887 PCUs** (575 vehicles).
- Traffic growth rate has been estimated based on economic and demographic factors of the influencing states using traffic demand elasticity method
- Traffic forecast done for all the three scenarios i.e. Most-likely scenario, Optimistic scenario and Pessimistic scenario
- Forecasted traffic for Most-Likely Scenario on proposed bridge
  - ✓ **Year 2019 is 5,111 PCUs**
  - ✓ **Year 2030 is 9,356 PCUs**
  - ✓ **Year 2045 is 18,635 PCUs**
- Forecasted traffic for Optimistic Scenario on proposed bridge
  - ✓ **Year 2019 is 5,111 PCUs**
  - ✓ **Year 2030 is 10,530 PCUs**
  - ✓ **Year 2045 is 24,076 PCUs**
- Forecasted traffic for Pessimistic Scenario on proposed bridge
  - ✓ **Year 2019 is 5,111 PCUs**
  - ✓ **Year 2030 is 8,306 PCUs**
  - ✓ **Year 2045 is 14,409 PCUs**
- The proposed bridge will cater to the traffic of **2-lane capacity at LOS-B till the year 2040.**
- A Detailed Traffic analysis report (**RP 004-Traffic Analysis Report**) is also submitted as a part of DPR.

3.4.11 Material Survey

As per **Volume-III: Material Survey Report**, the following conclusions were made.

3.4.11.1 Aggregate Sources

Feasible aggregate resources available along the project road are found at Vengara Malappuram at private stone crushing units located at an offset distance of about 40 Km from the project road.

3.4.11.2 Sand Sources

Sand material resources available for the project road are from the Bharathapuzha River. It is noted during the site visit that the sand material from this location are available in plenty.

3.4.12 Geotechnical Investigations

The geotechnical investigation is done to identify the sub soil profile and to arrive at the engineering properties of soil for design consideration. The geotechnical investigation is done by conducting 12 boreholes (Marine Borehole 4 nos, Land Boreholes 8 Nos.) at selected locations. The borehole location plan is attached in **Annexure I of RP008-Foundation recommendation Report**. The co-ordinates and existing ground levels of the boreholes are presented in **Table 3-39**.

Table 3-39: Borehole (BH) coordinates and existing ground level (EGL)

Chainage (km.)	Bore Hole (BH) No.	Easting (m)	Northing (m)	EGL (RL, m)	Borehole termination depth (m)
2+900	LBH-01	600330	1192223	0.000	50
2+940	LBH-02	600291	1192259	1.000	60
3+170	LBH-03	600073	1192293	-2.400	60
3+250	LBH-04	599993	1192536	0.500	60
3+480	MBH-01	599894	1192737	-9.408	50
3+580	MBH-02	599844	1192614	-7.758	50
3+780	MBH-03	599744	1192737	-5.058	50
3+880	MBH-04	599694	1192874	-7.808	50

Chainage (km.)	Bore Hole (BH) No.	Easting (m)	Northing (m)	EGL (RL, m)	Borehole termination depth (m)
3+990	LBH-05	599629	1192993	5.100	62
4+080	LBH-06	599610	1193049	4.200	60
4+230	LBH-07	599537	1193218	5.200	60
4+320	LBH-08	599508	1193328	5.200	60

The soil investigation comprised of the following activities:-

- Drilling through soil;
- Collection of disturbed and undisturbed sample in soil;
- Measuring Ground Water Table (GWT) in boreholes and
- Laboratory tests on soil samples.

Detailed soil investigation report with field and lab test results of the Land boreholes (LBH) and Marine boreholes (MBH) are presented in **Annexure II** and **Annexure III** respectively **of RP008-Foundation recommendation Report**.

3.4.12.1 Soil Profile

Based on the geotechnical investigation data, the sub soil profile is heterogeneous along the stretch (Refer sub soil profile diagram of **Annexure IV of RP008-Foundation recommendation Report** and comprises of disproportionate layers of silty sand, silty clay and poorly graded sand at various depths.

3.4.12.2 Ground water level

Based on the factual report in **Annexure II** and **Annexure III of RP008-Foundation recommendation Report**, borehole wise measured ground water levels are presented in **Table 3-40.**

Table 3-40: Summary of ground water level

Chainage (km.)	Reference borehole	Borehole existing ground level (RL, m)	Depth of water table below Bore Hole EGL (m)
2+900	LBH-01	0.000	1.2
2+940	LBH-02	1.000	1.6
3+170	LBH-03	-2.400	1.1

3+250	LBH-04	0.500	1.6
3+480	MBH-01	-9.408	-6.0
3+580	MBH-02	-7.758	-6.5
3+780	MBH-03	-5.058	-3.5
3+880	MBH-04	-7.808	-6.5
3+990	LBH-05	5.100	1.8
4+080	LBH-06	4.200	1.6
4+230	LBH-07	5.200	1.6
4+320	LBH-08	5.200	2.1

3.4.12.3 Summary of analysis

Pile capacity calculations for the proposed structures are done as per reference [1]. The summary of analysis is presented in **Table 3-41**. The diameter considered is 1.2m and 1.8m for Land borehole (LBH) and Marine borehole (MBH) respectively.

Additional analysis is also done considering 1.5m for Land borehole (LBH) and 2m for Marine Borehole (MBH). The summary of the analysis is presented in **Table 3-42**.

It can be noted that in the pile capacity calculations only skin friction is considered because of non-homogenous soil strata. The sub soil profile is erratic might be due to constant erosion and deposition of river soil and sea soil.

Moreover considering the length of pile, the complete end bearing resistance may not mobilize with respect to the construction issues. Hence it is suggested to arrive at the number of piles with respect to skin friction which will be more appropriate.

For detailed calculations of Vertical pile capacity calculations, refer **Annexure VI of RP008-Foundation recommendation Report.**

Table 3-41: Summary of pile capacity for pile diameter 1.2m and 1.8m

Reference borehole	Pier no	GL (m)	Pile cutoff level (m)	Free length (m)	Pile embedment length, L_e (m)	Pile length from cutoff level	Pile toe level (m)	Recommended Pile capacity (kN)	Pile diameter (m)
LBH-01	A1	1.974	-0.526	0.0	49.5	49.5	-50.03	3500	
LBH-01	P1	-0.285	-2.785	0.0	49.5	49.5	-52.29	3500	
LBH-02	P2	-2.608	-0.950	1.7	54.5	56.2	-57.11	3500	
LBH-02	P3	-2.608	-0.950	1.7	54.5	56.2	-57.11	3500	
LBH-02	P4	-2.608	-0.950	1.7	54.5	56.2	-57.11	3500	
LBH-02	P5	-2.608	-0.950	1.7	54.5	56.2	-57.11	3500	
LBH-03	P6	-2.608	-0.950	1.7	46	47.7	-48.61	3500	
LBH-03	P7	1.549	-0.950	0.0	46	46.0	-46.95	3500	
LBH-03	P8	1.717	-0.950	0.0	46	46.0	-46.95	3500	1.2m
LBH-03	P9	2.204	-0.950	0.0	46	46.0	-46.95	3500	
LBH-03	P10	2.282	-0.950	0.0	46	46.0	-46.95	3500	
LBH-04	P11	1.709	-0.950	0.0	51	51.0	-51.95	3500	
LBH-04	P12	-1.608	-0.950	0.7	51	51.7	-52.61	3500	
LBH-04	P13	-1.708	-0.950	0.8	51	51.8	-52.71	3500	
LBH-04	P14	-1.908	-0.950	1.0	51	52.0	-52.91	3500	
LBH-04	P15	-1.908	-0.950	1.0	51	52.0	-52.91	3500	
MBH-01	P16	-1.808	-0.950	0.9	52.0	52.9	-53.81	3500	
MBH-01	P17	-1.858	-0.950	0.9	52.0	52.9	-53.86	3500	
MBH-01	P18	-9.408	-0.950	8.5	52.0	60.5	-61.41	7500	
MBH-02	P19	-7.758	-0.950	6.8	52.0	58.8	-59.76	7500	1.8m
MBH-03	P20	-5.058	-0.950	4.1	46.5	50.6	-51.56	7500	
MBH-04	P21	-7.808	-0.950	6.9	50.2	57.1	-58.01	7500	
MBH-04	P22	-7.658	-0.950	6.7	50.2	56.9	-57.86	3500	
MBH-04	P23	-7.708	-0.950	6.8	50.2	57.0	-57.91	3500	
LBH-05	P24	2.653	0.153	0.0	59.5	59.5	-59.35	3500	
LBH-05	P25	2.376	-0.124	0.0	59.5	59.5	-59.62	3500	
LBH-05	P26	2.412	-0.088	0.0	59.5	59.5	-59.59	3500	
LBH-06	P27	2.410	-0.090	0.0	53	53.0	-53.09	3500	
LBH-06	P28	2.369	-0.131	0.0	53	53.0	-53.13	3500	
LBH-06	P29	2.487	-0.013	0.0	53	53.0	-53.01	3500	
LBH-06	P30	2.536	0.036	0.0	53	53.0	-52.96	3500	1.2m
LBH-06	P31	2.719	0.219	0.0	53	53.0	-52.78	3500	
LBH-07	P32	2.774	0.274	0.0	43.5	43.5	-43.23	3500	
LBH-07	P33	2.677	0.177	0.0	43.5	43.5	-43.32	3500	
LBH-07	P34	2.759	0.259	0.0	43.5	43.5	-43.24	3500	
LBH-08	P35	2.728	0.228	0.0	51	51.0	-50.77	3500	
LBH-08	P36	2.639	0.139	0.0	51	51.0	-50.86	3500	
LBH-08	P37	2.572	0.072	0.0	51	51.0	-50.93	3500	
LBH-08	A2	2.694	0.194	0.0	51	51.0	-50.81	3500	

Table 3-42: Summary of pile capacity for pile diameter 1.5m and 2m

Reference borehole	Pier no	GL (m)	Pile cutoff level (m)	Free length (m)	Pile embedment length Le (m)	Pile length from cutoff level	pile toe level (m)	Recommended Pile capacity (kN)	Pile diameter (m)
LBH-01	A1	1.974	-0.526	0.0	38.5	38.5	-39.03	3500	
LBH-01	P1	-0.285	-2.785	0.0	38.5	38.5	-41.29	3500	
LBH-02	P2	-2.608	-0.950	1.7	40.0	41.7	-42.61	3500	
LBH-02	P3	-2.608	-0.950	1.7	40.0	41.7	-42.61	3500	
LBH-02	P4	-2.608	-0.950	1.7	40.0	41.7	-42.61	3500	
LBH-02	P5	-2.608	-0.950	1.7	40.0	41.7	-42.61	3500	
LBH-03	P6	-2.608	-0.950	1.7	42.0	43.7	-44.61	3500	
LBH-03	P7	1.549	-0.950	0.0	42.0	42.0	-42.95	3500	
LBH-03	P8	1.717	-0.950	0.0	42.0	42.0	-42.95	3500	1.5m
LBH-03	P9	2.204	-0.950	0.0	42.0	42.0	-42.95	3500	
LBH-03	P10	2.282	-0.950	0.0	42.0	42.0	-42.95	3500	
LBH-04	P11	1.709	-0.950	0.0	48.5	48.5	-49.45	3500	
LBH-04	P12	-1.608	-0.950	0.7	51.0	51.7	-52.61	4000	
LBH-04	P13	-1.708	-0.950	0.8	51.0	51.8	-52.71	4000	
LBH-04	P14	-1.908	-0.950	1.0	51.0	52.0	-52.91	4000	
LBH-04	P15	-1.908	-0.950	1.0	51.0	52.0	-52.91	4000	
MBH-01	P16	-1.808	-0.950	0.9	52.0	52.9	-53.81	4000	
MBH-01	P17	-1.858	-0.950	0.9	52.0	52.9	-53.86	4000	
MBH-01	P18	-9.408	-0.950	8.5	52.0	60.5	-61.41	8500	
MBH-02	P19	-7.758	-0.950	6.8	52.0	58.8	-59.76	8500	2m
MBH-03	P20	-5.058	-0.950	4.1	46.5	50.6	-51.56	8500	
MBH-04	P21	-7.808	-0.950	6.9	50.2	57.1	-58.01	8500	
MBH-04	P22	-7.658	-0.950	6.7	50.2	56.9	-57.86	4000	
MBH-04	P23	-7.708	-0.950	6.8	50.2	57.0	-57.91	4000	
LBH-05	P24	2.653	0.153	0.0	41.0	41.0	-40.85	4000	
LBH-05	P25	2.376	-0.124	0.0	41.0	41.0	-41.12	4000	
LBH-05	P26	2.412	-0.088	0.0	41.0	41.0	-41.09	4000	
LBH-06	P27	2.410	-0.090	0.0	53.0	53.0	-53.09	4000	
LBH-06	P28	2.369	-0.131	0.0	53.0	53.0	-53.13	4000	
LBH-06	P29	2.487	-0.013	0.0	53.0	53.0	-53.01	4000	
LBH-06	P30	2.536	0.036	0.0	53.0	53.0	-52.96	4000	1.5m
LBH-06	P31	2.719	0.219	0.0	53.0	53.0	-52.78	4000	
LBH-07	P32	2.774	0.274	0.0	43.5	43.5	-43.23	4000	
LBH-07	P33	2.677	0.177	0.0	43.5	43.5	-43.32	4000	
LBH-07	P34	2.759	0.259	0.0	43.5	43.5	-43.24	4000	
LBH-08	P35	2.728	0.228	0.0	51.0	51.0	-50.77	4000	
LBH-08	P36	2.639	0.139	0.0	51.0	51.0	-50.86	4000	
LBH-08	P37	2.572	0.072	0.0	51.0	51.0	-50.93	4000	
LBH-08	A2	2.694	0.194	0.0	51.0	51.0	-50.81	4000	

3.4.13 Utility Survey

Utilities such as electrical / telephone poles and transformers are located along the project road. Low Tension and High Tension lines also cross the project road at one location. There are OFC cables passing at some sections of the existing road. The details of utilities are given in **Table 3-43**.

Table 3-43: Details of utilities

Sl. No	Type of Utility	No. of Utilities
1	High Tension lines	01
2	Electrical poles	110
3	OFC	22
4	Telephone tower	02
5	Transformers	10

Refer Volume-X: Strip Plans for Utility Relocation plan.

3.5 FUNCTIONAL DESIGN

3.5.1 Alignment Option Study

Different Alignment options have been studied and the pros & cons were identified considering Highway Geometric aspects, Land use, Environmental Impact, Social Impact, Traffic dispersion, Bridge Constructability and Cost. The study for the same shall be referred from Section 3 of RP003- Final Feasibility Report.

It was concluded that, the Alignment Option-1C is the preferable option from the Consultants purview.

3.5.2 Theme of Bridge and Aesthetics

Aesthetics can be subjective but, the impression made by the general public needs to be impactful and generally pleasant. A bridge is commonly seen as a utilitarian infrastructure and might be viewed from afar or in a fleeting glimpse during transit. But this is not really the case. It is important to realize the beauty of the context where this bridge is being proposed. There is ample opportunity to observe it from a distance, especially in a serene landscape where the built infrastructure is more than conspicuous. No structure more clearly shows its objective and use; and the opportunity is therefore offered to appreciate the overall form. With the presence of multiple vantage points in the immediate context, the structure can be observed in greater detail as well. Moreover, with the bridge being pedestrian and cyclist friendly, people are bound to witness the design from close quarters. All this makes the bridge's architecture and aesthetic considerations a crucial part of the overall design process.

Cable stayed bridges have great potential to express the dynamic qualities of the structure. It presents an opportunity to be innovative with the design of the pylon. Inclined pylons, cantilever spar, asymmetric cable stays etc. can give a sculptural quality to the structure.

3.5.2.1 Pleasing Outlines and Proportions

The primary form or outline of the bridge is the most obvious image that will be retained by the public. The relative proportions play an important role in satisfying the eye, and should be chosen carefully. The continuity of lines is necessary and the consistency in the angles will result in a more pleasing form and design language. The dominating elements of the bridge viz. the pylon's upper part and the deck should have clean silhouettes and harmonious proportions.

3.5.2.2 Regional Iconography & Expression

The location of this bridge at the mouth of Kerala's biggest river (Bharathapuzha) is culturally significant. Ponnani river also merges at this estuary; and this beautiful setting has the potential of being a mini destination in itself. In order to be context specific and to reflect the local culture, the structure that spans across this waterbody should be culturally connected to a local iconic design language in Architecture or Maritime tradition. Of course, the regional iconography still needs to be suitably abstracted to fit the functional and structural requirements of a large span bridge. Moreover, the proportions of the overall structure should take precedence over the adaptation of silhouettes, for better aesthetics.

3.5.2.3 Chundan Vallam/Snake Boat

With the site spanning the estuary and with the sea as the backdrop, it is ideal to take reference from the local maritime and fishing traditions. The presence of the fishing harbour nearby and the constant movement of boats further emphasize this point. The simple fishing boat also has pleasing outline that can be an inspiration.

The most iconic boat though, which fairly represents the state of Kerala and communal spirit, is the Snake Boat or Chundan Vallam. It has an instantly recognizable profile with the high raking bow. After careful consideration of its proportions, it has been adapted to the profile of the bridge pylons. The structure takes the form of an inclined A-frame.

Figure 3-13: Typical view of Chundan Vallam/ Snake Boat

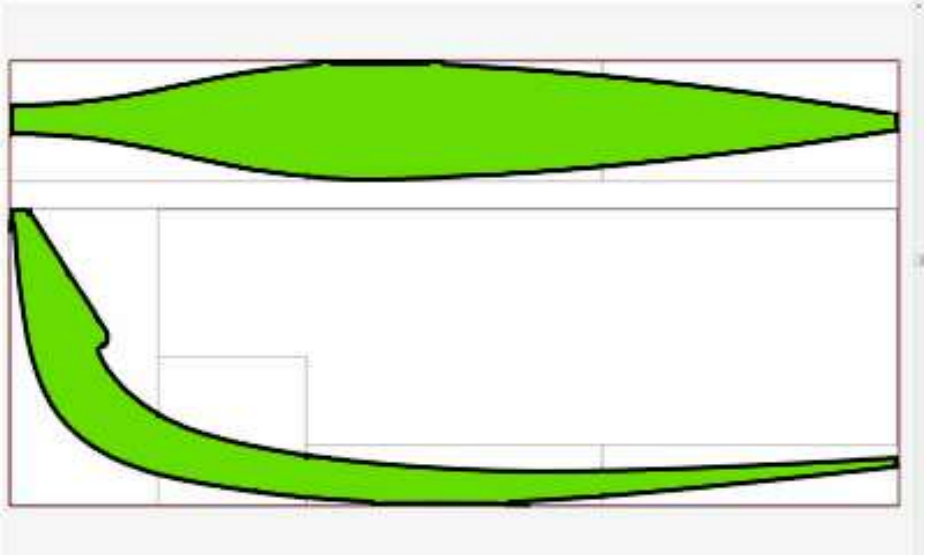


Figure 3-14: Proportion Study of Chundan Vallam/Snake Boat

Figure 3-15: Typical 3D views of Main Bridge with concept of Chundan Vallam/Snake Boat

3.5.3 Blending Geometries of Various Elements

Other structural elements like the cable stays and lower pylons should complement the main form i.e. the angles made by the shape of the upper pylon and the shape, curvature of the deck. Any beam, girder or struts that support the deck should blend with its cross-section; and this should continue with the lower pylon as well. Crash barriers, medians, balustrades, lighting elements etc. should be designed in the same language and shall endeavour to blend with the geometry of the deck and pylon.

3.5.4 Bridge as a public space

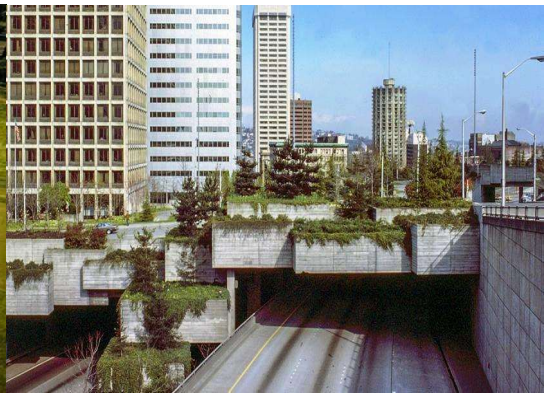
It is very unique that a vehicular bridge can double up as a public space for pedestrians and cyclists. In India, there is a major dearth of quality public spaces for people to enjoy. The pedestrian corridor/deck can extend the coastal experience by giving a platform to enjoy the best views of the estuary. It is also essential that the bridge structure that meets the ground level, does not adversely affect the existing coastline. The design of the lower pylons and its spacing should be considerate of the existing usage pattern of the public beach, forest area; and it should not end up being a visual hindrance. The access to the elevated deck and ease of circulation from the existing public areas will be crucial to the success of the bridge as a mini destination and a public space. Addressing the following aspects will help in making the bridge a successful public space which will attract tourists and locals alike.

3.5.5 Landscape

Planting of trees and greenery on a bridge has not been explored much. There are only a few examples around the world where this has been done to some extent. Most of these are merely pedestrian bridges. By integrating the planter boxes with other amenities such as

urban furniture, full sized trees can also be maintained with a soil depth of about 1 metre. Trees which can grow upto 3m tall can have a good canopy and act as a shading device. This will add a unique character to the bridge. With a wide pedestrian corridor, a range of planters and urban furniture can be designed with a variety of greenery. This project can be a rare case of having landscaped areas on a vehicular bridge.

Vancouver, Canada



Seattle, USA

Stuttgart, Germany

Orlando, USA

Figure 3-16: Typical 3D views of Amenities over Main Bridge

3.5.6 Accessibility

For a space to be utilized effectively, the approach must be clear, safe and convenient. Being a public space, it should be universally accessible. The route taken by the public from grade level to the top of the deck of the bridge should be friendly and inviting. The north bank currently has a beach and park with Car parking facilities- and this is a major convenience for visitors coming via vehicles. This kind of a landscaped area with Car Parking facility is to be developed in the south bank as well. A park/green area near the south bank is already earmarked in the 2035 masterplan for the region. The vertical access can be via a lift and ramp/staircase. If a ramp is proving to be space consuming, a staircase with a steep sloped cycle ramp can be proposed. This vertical access has to be well integrated with the landscaped area, in order to make it part of the bridge.

Figure 3-17: Typical 3D views of Bridge access from at grade roads

3.5.7 Lighting & Safety

Although coloured lighting of the structure improves aesthetics at night, it also adds to the safety aspect. Various structural elements like the cable stays, pylon, lower pylon, girders etc. can be highlighted by proper lighting. The pedestrian corridor can have low level lighting to light up the paved surface. The design of the lamp post should also be in harmony with the design language of the rest of the bridge. Since this bridge is projected as a tourist destination, it is important to emphasize on safety.

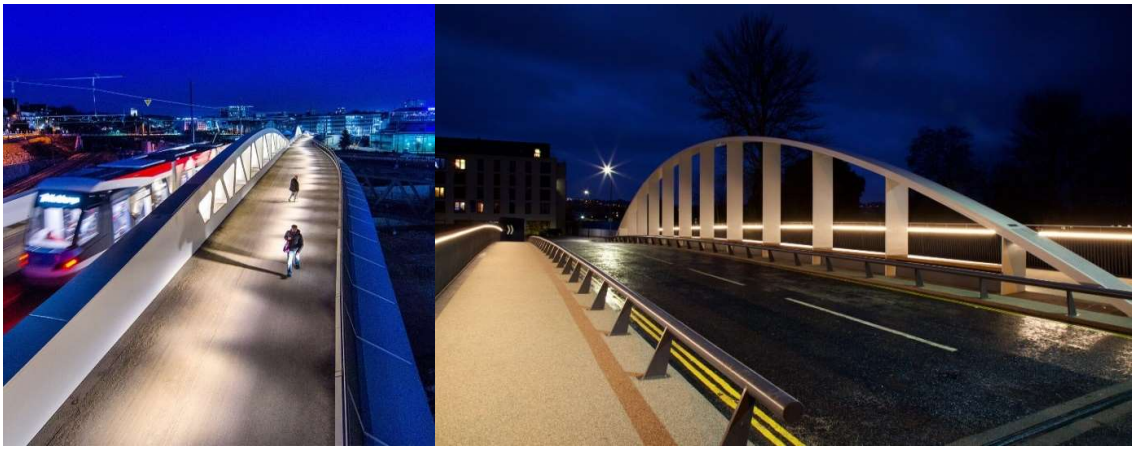


Figure 3-18: Typical sample bridges with lighting concepts

3.5.8 Amenities and attractions

Bridges being utilitarian infrastructure; they seldom have dedicated amenities for the public. There are bridges which have innovative designs, where pedestrians can linger for a bit, or take a seat to enjoy the ambience. But inhabited bridges, where the public can access the pylon or any other indoor space are very rare. Some large span bridges have pylons thick enough that they can be hollow; and people can access it for touristic or servicing purposes. Then there are some historic bridges where the pylon or the main structure enables access for touristic purposes. This also owes to the large size of the structure. The attraction in these cases is getting to a higher level to take in the great skyline of these big cities.

Copenhagen, Denmark

Buenos Aires, Argentina

London Tower Bridge

Sydney Harbour Bridge

The proposed pedestrian/cycle corridor in this project is as wide as the 2 lane motorway. This gives ample opportunity to have landscaping and the public space can be flexible

enough to accommodate a variety of small scale events- such as food stalls, exhibitions, awareness drives etc.

In order to explore the option of having an elevated viewing platform, an A-frame pylon is more ideal where the platform can span across the deck at a height of approximately 15-20 meter from the main deck. For this span of 200 meters, the pylon will not be thick enough to enclose a lift. Hence an exposed hydraulic lift core has to be envisioned in the middle of the pedestrian corridor. This type of isolated lift core is not ideal as it will hinder free movement. Furthermore, from a structural and safety point of view, this kind of exposed lift and view deck will be of some concern. A representative view of such an attraction is provided here.

Figure 3-19: Typical 3D view of hydraulic lift over main bridge

Another possible attraction is a café/restaurant that can be suspended from the main deck. A steel structure can be hung from the main box girder at a height of 5.5 meter below the deck level in order to get enough headroom. This can be easily accessed via 3 flights of stairs. Such an attraction can return some revenue as well. The ambience will be the unique selling point of this café. It can be similar to a lower level deck of a ship. The fact that public can have a snack or beverage while sitting underneath a bridge and above a river, with boats operating below and vehicles above, will be a draw in itself.

Figure 3-20: Typical 3D view of bridge amenities below main bridge deck

3.6 ENGINEERING DESIGN

The detailed design of Structure portion and Road portion shall be referred from **Volume-II: Design Report.**

3.7 FINANCIAL ESTIMATES & COST PROJECTIONS

Cost estimation is a vital input for assessing financial and economic viability of the project. This chapter presents cost estimation for the development of the project. Total project cost includes construction of road and structures, Utility relocation and Environmental & Social Costs.

3.7.1 Methodology

- Quantities of various components are worked out based on preliminary engineering
- To arrive at construction cost, rate analysis was done as per PRICE software which includes cost of an item based on man, material and machinery required for that item

3.7.2 Total Project Cost

Detailed Bills of Quantities were prepared based on the preliminary design of all project components and costs worked out using the rates derived. The detailed cost estimate shall be referred from **Volume-VII: Cost Estimates.** A summary of costs under various heads for the project stretch from Chainage Km 0+000 to Chainage Km. 4+800 is presented in **Table 3-44.**

Table 3-44: Total Capital Cost of the project

S. No.	Bill of Items	Total Amount (In Crore Rupees)
A	**Total Civil Work Cost (Rs. In Cr) as per PRICE (including GST)**	**265.577**
i	Add physical contingency @ 2.8% of total civil work cost	7.436
B	**Total including Physical Contingency of 2.8% (Rs. In Cr) B = A + i**	**273.013**
ii	Add Agency Charges 3% on A	7.967
iii	Add Quality Control 0.25% on A	0.664
iv	Add Road Safety 0.25% on A	0.019
v	5% Maintenance of A	13.279
C	**CENTAGES C = ii+iii+iv+v**	**21.929**
D	**Total project cost (Including Centages) D = B + C**	**294.942**
vi	Cost of Utility shifting (Rs. In Cr)	0.500
vii	Cost of Rehabilitation and Resettlement R&R (Rs. In Cr)	4.000
viii	Cost of Land Acquisition LA (Rs. In Cr)	10.000
E	**Total Capital Cost for the Project (Rs. In Cr), E = D + vi+vii+viii**	**309.442**

3.8 REVENUE STREAMS

In line with the discussion with RBDCK, the possibility of collecting the toll revenue is minimal. Hence in the analysis, the revenue from other sources viz., commercial revenue which can be collected from the space allocated in and around the proposed bridge has been considered for the financial analysis. The details of revenue streams are given in the following paragraphs.

3.8.1 View Gallery

It is assumed that on an average 100 visitors will be coming to View gallery on daily basis wherein an entry fee of Rs 10 has to be paid by each visitor. Thus the daily revenue from view gallery amounts to Rs 1000 per day.

3.8.2 Parking facility

The adjacent space located southern side of the bridge, parking space for 200 two wheelers and 150 Cars will be provided. For the estimation of revenue, it is assumed the facility will have an utilisation rate of 60% and an average duration of parking will be around 2 hours per day. The parking charges per hour for Two wheelers and Four Wheelers are assumed at Rs 10 and Rs 20, respectively. Thus parking fee per day amounts to Rs 6000 .

3.8.3 Vendor huts

Along the view gallery, vendors will be permitted to use huts for transacting snacks and other refreshment to the various visitors in the gallery. It is assumed 5 huts will be facilitated for the vendors for which a daily fee of Rs 75 will be charged. Thus daily revenue from vendor huts amounts to Rs 375.

3.8.4 Bridge Café

The overall space available for the bridge cafe is about 2400 Sqft for which a monthly rent of Rs 5 can be collected. Thus the annual revenue from the facility amounts to Rs 144,000

The annual revenue of the above mentioned revenue streams works out to Rs 0.279 Crores in the base year which will be escalated by 3% per annum.

3.9 COST BENEFIT ANALYSIS & INVESTMENT CRITERIA

Any public funded project has to be economically viable which implies that the said project is beneficial to the society. The main objective of the economic analysis is to identify all the direct and indirect benefits and to compare them over the economic life of the project so as to justify the implementation of the project based on its benefits/ profits to the economy/ nation. This necessitates consideration of different streams of cost and benefits over time. In this chapter, economic viability of the project is assessed and presented.

3.9.1 Economic Appraisal of the Project

The Economic Appraisal of the proposed project i.e. "**Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches"** has been assessed within the broad framework of *Cost-Benefit Analysis* generally used for appraisal of public infrastructure projects. The economic analysis/ viability involve the estimation of benefits to the society from the project in terms of costs and benefits. This necessitates consideration of different streams of cost and benefits of the Project over time. In the present economic analysis, the economic costs and benefits of the project over the life of the project have been identified under ***"with" and "without" the proposed project road*** and are expressed in terms of Economic Internal Rate of Return (EIRR).

The EIRR indicates the return, which the society would derive from the investment made to develop the proposed Project Road. The EIRR is compared with the accounting rate of return of 12% considered as the cut-off point for judicious investment decision regarding transport infrastructure projects, by the Government of India and International funding agencies like the World Bank and the Asian Development Bank (ADB) (Source: ADB Guidelines).

The main steps followed in the economic evaluation are:

1. Estimation of economic cost of the proposals, both capital as well as annual operating and maintenance costs, for the assumed economic life of 30 years after commencement of the project.
2. Estimation of direct and indirect benefits to the users, non-users and economy/ community such as Value of Time (VOT) and Vehicle Operation Cost (VOC) to traffic, and comfort savings.
3. Comparison of annual streams of costs and benefits and estimation of EIRR on the basis of Discounted Cash Flow (DCF) technique.

Estimation of above costs and benefits over a 30 year period i.e. till 2049 assuming the year of commissioning of the Project as 2019 and Project Road will be operational by 2023. The analysis is done as per the guidelines of ***"IRC: SP: 30-2009 Manual on Economic Evaluation of Highway Projects in India"*** which has been prepared on the basis of various assumptions and by using various relationships established by the Central Road Research Institute (CRRI) Study "***Updation of Road User Cost Study Data: 2001, Final Report***", commissioned by the Ministry of Surface Transport, Government of India, New Delhi.

3.9.2 Evaluation of Economic Costs

The project cost consists of two main component viz. Capital Cost and Operating and Maintenance (O & M) cost. These costs for the project are estimated in financial terms at base year price level of 2019 and at market prices, which include taxes & duties as well as subsidies. The economic analysis requires the conversion of financial costs into economic costs so as to take care of distortions in prices due to market imperfections, Government policies and regulations.

In the present study the estimated financial costs have been converted into economic cost by applying conversion factor of **0.9**, so as to represent exclusion of taxes & duties, which are considered as transfer payments and cost relating to depreciation, interest charges.

The total project cost of the proposed road which is inclusive of construction cost, operation & maintenance cost, land acquisition cost and social cost is estimated a*s **Rs. 309.442 crores*** that is to be incurred between 2019 and 2049. For economic analysis, it is assumed that the construction cost, land acquisition and social cost will be incurred in phase-wise from 2019 till 2022 whereas operation & maintenance cost will be once in every 5 years. The detailed description about estimation of the total project cost is discussed in the ***Volume-VII: Cost Estimates***.

The financial and economic cost considered for the economic analysis is as follows:

Financial Cost including Other Charges	Rs. 309.442 Crore
Economic Cost with Conversion Factor of 0.9	Rs. 278.498 Crore

3.9.3 Estimation of Economic Benefits

The Project Road is expected to generate direct and indirect benefits. The direct economic benefits that will accrue because of the project include savings in vehicle operation cost and travel time costs to passengers. Construction of the proposed project road will result in reassignment of traffic on the surrounding road network system and considerable change in the travel pattern within the study area. The following categories of benefits have been quantified in monetary values:

- **VOC Savings:** Vehicle Operation Cost (VOC) benefits are those that are accrued for all vehicles due to the improved riding quality provided by the project road. The variable component of VOC comprises of the fuel cost, spare parts, repairs, lubricants and tyre, and the fixed component consists of crew wages, interest on capital, depreciation, sales tax and insurance.

  IRC: SP: 30 – 2009 Manual provides various equations to derive the congestion factors and road user costs relating all the above mentioned parameters based on the operating speed, road roughness and rise and fall of the road (with reference to Central Road Research Institute Study). These equations have been used for the VOC estimation.

- **VOT Savings:** The savings in travel time is an important component of the benefits from the highway improvements. Value of Time benefits are those that are accrued for all vehicles due to savings in shorter travel time which in turn is attributed to increase in speed. Savings in the vehicle-km travelled due to improvement in transport infrastructure is converted to monetary benefits using the value of time.

Generally, savings in time are enjoyed by passenger traffic i.e. car, bus and two wheeler passengers. In case of truck traffic, it is not exactly the savings in the travel time but the savings are in terms of the commodity holding cost. Speedier travel leads to reduction in fixed charges per km which every operator has to pay in other words for transporting same quantity of goods in a certain period less number of commercial vehicles can be used. IRC: SP: 30 – 2009 has provided updated values of value of time for passenger traffic and commodity holding cost for truck traffic based on the study "Updation of Road User Cost Data" conducted by CRRI in 2001 by considering the WPI price levels as on March, 2009. Consultant has updated the values based on the WPI price levels as on March 2019 based on the data obtained from the "Ministry of Commerce and Industry, Office of Economic Advisory and Board.

- **Comfort Benefits:** Any new facility in transport infrastructure is certain to provide or increase the quality of riding/ commuting both on proposed project road and on the existing alternate road network. This comfort factor should also be taken into account in doing economic analysis. In our current study the cost of comfort benefit is taken as 10% of VOT Savings.

The year-wise monetary benefits for the above mentioned benefit streams due to the development of the proposed Project Road that are considered for the economic analysis is presented in ***Table 3-45.***

Table 3-45: Year-wise Monetary Benefits due to the Development of the Project Road

(Rs. In millions)

Year	VOC Benefits	VOT Benefits	Comfort Benefits
2023	475.9	73.2	7.3
2024	520.0	77.8	7.8
2025	572.9	82.7	8.3
2026	624.9	87.9	8.8
2027	671.8	93.5	9.4
2028	722.5	99.4	9.9
2029	772.4	105.4	10.5
2030	823.5	111.8	11.2
2031	888.2	118.5	11.9
2032	959.1	125.7	12.6
2033	1038.9	133.3	13.3
2034	1139.5	140.5	14.0
2035	1260.0	148.1	14.8
2036	1387.7	156.2	15.6
2037	1530.1	164.7	16.5
2038	1681.9	173.7	17.4
2039	1817.6	182.2	18.2
2040	1963.7	191.2	19.1
2041	2122.3	200.6	20.1
2042	2143.6	210.5	21.0
2043	2072.9	220.8	22.1
2044	1993.7	230.6	23.1

Year	VOC Benefits	VOT Benefits	Comfort Benefits
2045	1887.9	240.8	24.1
2046	1748.4	251.5	25.1
2047	1588.9	262.7	26.3
2048	1632.7	274.3	27.4
2049	1672.5	285.3	28.5
2050	1712.5	296.7	29.7
2051	1755.4	308.6	30.9
2052	1814.4	320.9	32.1
2053	1875.4	333.8	33.4

3.9.4 Economic Appraisal

The annual stream of economic costs and benefits has been computed over the analysis period. The project's economic viability is assessed in terms of Economic Internal Rate of Return (EIRR) and Net Present Value (NPV) by applying the discounted cash flow technique of discounting all future costs and benefits to the common year of the annual stream of the net benefits of the project. The Internal Rate of Return (IRR) Method is popular with international lending agencies like Work Bank.

The NPV of the stream of net benefits have been computed using prevailing discount rate of 12%. The cut off rate for the economically viable project at present is considered as 12% by the Government of India and International funding agencies like the World Bank and the Asian Development Bank (ADB). **The project gives the EIRR of 22.15%. Since the EIRR is greater than the rate of interest obtainable (i.e. 12%) by investing the capital in the open market, the Project is considered Viable**.

3.9.5 Sensitivity Analysis

Sensitivity analysis has been carried out to consider the change in various parameters (such as inflation during the project implementation period, cost over heads, government policies, regulations, investment planning etc.) that will dictate the EIRR of the Project and to understand the economic strength of the Project to withstand the future risks and uncertainties.

The sensitivity analysis is performed for the following three scenarios using prevailing rate of discount of 12% for all the three scenarios and the results are provided in **Table 3-46**.

Scenario – I: Basic Cost and Basic Benefit Streams

Scenario –II: 5% increase in Basic Cost and Basic Benefit Streams

Scenario –III: 10% increase in Basic Cost and 5% increase in Basic Benefit Streams

Table 3-46 Results of Sensitivity Analysis

S. No.	Scenario Number	NPV (in Rs)	EIRR
1	Scenario – I	2813.5 millions	22.15%
2	Scenario – II	2716.6 millions	21.48%
3	Scenario - III	2857.3 millions	21.52%

It is observed that the EIRR ranges in between 20 % and 23% for all the scenarios which is greater than the prevailing discount rate of 12%. The NPV values are also observed as positive for all the scenarios. Therefore based on EIRR and NPV values it can be concluded that the Project is able to withstand 5% to 10% changes in the cost and benefit streams (above mentioned scenarios) and is Viable.

Please refer section 13 of RP 003- Feasibility Report for Cost Benefit Analysis.

3.10 ENVIRONMENTAL & SUSTAINABILITY ASPECTS

Typically any developmental project triggers a set of environmental and social impacts. These environmental and social impacts due to infrastructure development projects occur in different forms. While significant benefits result for the communities, the project affected people (PAPs) may often bear the brunt of adverse impacts. To address the various issues, carrying out Environmental/Social Impact Assessments, preparing Environmental Management Plans (EMP), Resettlement Action Plans (RAP), etc. are means to develop mitigation plans so as to identify and overcome the potential negative impacts on people and the environment due to infrastructure development projects.

An Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) study has been carried out to study the potential environmental and social impacts due to the proposed Cable Stayed/Suspension Bridge and Approaches development project. Appropriate mitigation measures to help minimise/avoid impacts from the development have been recommended. The measures include avoidance measures, mitigation measures and environmental enhancement measures. This chapter provides a summary of the EIA/EMP. Detailed EIA/EMP and RAP is presented as **Volume IV** of the DPR.

3.10.1 Environmental Assessment

3.10.1.1 Policy and Administrative Framework

3.10.1.1.1 Environmental Impact Assessment (EIA) Notification

Highway projects are listed as Item 7(f) in the Schedule of the EIA Notification 2006 (as amended). This Ministry of Environment, Forest and Climate Change's (MoEF&CC) Notification is applicable only for:

- *Development of New National Highways*[1] *(NH)*
- *Expansion of National Highways greater than 100 km involving additional Right of Way (RoW) greater than 40 m involving Land Acquisition on existing alignments and 60 m on re-alignments or by-passes*
- *Development of all New State Highways*
- *Expansion of State Highways in hilly terrain (above 1000 m AMSL) and in ecologically sensitive areas*

Proposed development corridor is a bridge project with approach roads with total length of about **4.8 km**. Approach roads will be developed by having improvements to existing road network itself. As such there is no green field component for approach roads. Development of a bridge is not under the purview of the EIA Notification. As such, this project will not come under the purview of MoEF&CC's EIA Notification and subsequent Environmental Clearance (EC) requirements from State/Central Government are not triggered.

Although EC for proposed development project is not required, the EIA study is proposed to be carried out as envisaged in the Terms of Reference (ToR) provided by RBDCK, Government of Kerala. In addition, any development project will most likely have environmental/social impacts and although an EC is not required it is considered essential to conduct an ESIA as a Best Management Practice. Moreover without an ESIA a meaningful

[1] Highways include Expressways

EMP for implementation of a project cannot be prepared. The ESIA study will help serve as a due diligence tool and help streamline environmental/social issues during the preliminary project design stage itself. It will help to address potential environmental/social issues more appropriately during construction and operational stages of the project.

3.10.1.2 CRZ Notification

Through the CRZ Notification, the Ministry of Environment and Forests & Climate Change (MoEF&CC), Government of India imposed certain restrictions on setting up and expansion of industries, operations or processes, etc. in the Coastal Regulation Zone (CRZ). The CRZ is area influenced by tidal action (in the landward side) up to 500 metres from the High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the High Tide Line (HTL).

Proposed development of the Suspended/Cable Stayed Bridge along with approach roads falls in the CRZ area and thereby attracts the provisions of CRZ Notification, 2011 and 2019 (as amended). Necessary process for obtaining CRZ Clearance will be taken up in subsequent stages of the DPR study. National Centre for Earth Science Studies (NCESS), Thiruvananthapuram, will be engaged to carry out the CRZ Mapping.

3.10.1.3 Forest Clearance/Tree Felling Permissions

The proposed development corridor passes through patches of Casuarina and Coconut plantations in the coastal area. Also, there are few trees along the alignment. It is likely that some of the Casuarina/Coconut trees and some other trees will need to be felled. Based on the finalized alignment of the approach road, the total number of trees needed to be felled shall be identified. An inventory of trees to be felled will be prepared and necessary application will be submitted to the concerned Divisional Forest Office to obtain necessary permission for felling of the trees from State Forest Department.

3.10.2 Environmental Sensitivity

3.10.2.1 Air Environment

Air environment is defined in terms of Ambient Air Quality. In general the ambient air quality in the project area appears to lie within the permissible limits (CPCB National Ambient Air Quality Standards, 2009). The area does not have industrial developments along the corridor. The corridor is along the coast as such the open coastal areas will provide adequate dispersion of gaseous emissions, dust thereby minimizing the impacts on air quality both during the construction and operation stage of the project. The major source of air pollution in the area is from vehicular movements. Proposed development will provide better riding conditions in the area. As such, the development is not envisaged to increase pollution issues in the area. On the contrary, proposed development can help reduce pollution issues, if any, by having better designed road network which will provide better riding conditions for the road users.

3.10.2.2 Water Environment

Proposed bridge will be constructed across the Bharathapuzha River (across the mouth of the river). Appropriate construction methods will be adopted to avoid/minimse likely impacts

to the water body. Proposed development is not anticipated to have adverse effects on the water quality of the area.

3.10.2.3 Noise Environment

The corridor conditions prevailing in regards with air pollution also mostly applies for the noise environment. Proposed development is not envisaged to increase noise pollution issues in the area but it can be seen as a measure to reduce noise pollution issues by means of providing better riding conditions for road users.

3.10.2.4 Reserve Forests

There are no identified Reserve Forests (RF's) along proposed development Corridor. As such the development will not involve diversion of any forest land needing Forest Clearance.

3.10.2.5 Wildlife Protected Areas

Proposed development corridor does not pass through any declared Wildlife Protected Area.

3.10.3 Identification of Impacts

Likely impacts due to the proposed bridge/approach road development project on environmental/social attributes have been assessed and discussed. The project activities during construction and operational phase include various activities like leveling of site, clearing of trees, construction of structures, transportation of material, etc. All these activities contribute to different types of impacts. **Table 3-47** presents general/typical activities and its associated nature/extent of potential impacts envisaged due to the proposed development.

Table 3-47: General Impact Matrix

Activity	Degree of Impacts		Duration of Impact	
	Positive	Negative	Short Term	Long Term
CONSTRUCTION PHASE				
Site clearance	---	Yes	---	---
Generation of debris	---	Yes	Yes	---
Non Concrete waste	---	Yes	Yes	---
Hot Mix/Ready Mix Concrete waste	---	Yes	Yes	---
Planning Traffic diversion	---	Yes	Yes	---
Quarries	---	Yes	Yes	---
Transportation of construction material	---	Yes	Yes	---
Material storage	---	Yes	Yes	---
Excavation	---	Yes	Yes	---
Natural drainage	---	Yes	Yes	---
Construction in Aquatic Environment (piers)	---	Yes	Yes	---
Bridge and Road construction	---	Yes	Yes	---
Environmental Attributes				
Air	---	Yes	Yes	---
Water	---	Yes	Yes	---
Noise	---	Yes	Yes	---

Activity	Degree of Impacts		Duration of Impact	
	Positive	Negative	Short Term	Long Term
Soil	---	Yes	Yes	---
OPERATION PHASE (Movement of Traffic)				
Environmental Attribute				
Air	Yes	---	---	Yes
Noise	Yes	---	---	Yes
Social Environment				
Increase in property Value	Yes	---	---	Yes
Transportation Development	Yes	---	---	Yes
Employment Opportunities	Yes	---	---	Yes
Road User				
Safety, Improved Facility, Benefits to Locals	Yes	---	---	Yes

Table 3-48 presents the potential impacts due to the above activities in a matrix format.

Table 3-48: Environmental Impacts Matrix

S. No.	Environmental Attribute	Impact	Remarks
1.	Land Use	Impacts due to road development/ concrete structures and felling of trees	Required activity for proposed construction of cable stayed/ suspension bridge
2.	Air Quality	Impacts due to vehicular emissions, dust from use of construction machinery, hot mix plants/concrete batching plants, etc.	Most impacts are envisaged during construction phase, which will be short term and be localized to the areas of construction related activities
3.	Noise	Impacts due to vehicular traffic noise, heavy machinery noise, etc.	Most impacts are envisaged during construction phase and will be short term and localized to the areas of construction related activities
4.	Soil Characteristics	Potential for soil contamination due to construction related activities such as generation of debris, fuel & lubricants, waste etc.	Impacts shall be short-term; appropriate mitigation measures shall be recommended. Also, impacts are not envisaged during the operation stage.
5.	Ecology/Flora & Fauna	Impacts due to tree felling; Loss biomass, removal of vegetation; disturbance & habitat loss, etc.	No loss of bio-diversity is envisaged due to the proposed project; some trees will need to be felled for which compensatory afforestation will need to be taken up. The proposed project site doesn't have endangered floral and/or faunal species. As such proposed development is not envisaged to cause adverse impacts to Flora and Fauna.
6.	Water Quality	Minimal impacts due to construction related activities (construction of piers/pillars in the river, site clearance, earthworks, storage of construction materials, worker	Impacts are expected to be localized; proposed project is not expected to alter the existing water quality on a permanent basis. Also, impacts are not envisaged during the operation stage.

S. No.	Environmental Attribute	Impact	Remarks
		camps near water bodies (if any), transportation of construction material, etc.)	

3.11 RISK ASSESSMENT AND MITIGATION MEASURES

Consultant does not foresee any major risks in implementation of this project. However, few minor perceived risks are identified during implementation and the same is classified into various categories of severity. Effective mitigation measures to obviate these risks of execution is also studied in detail and presented below.

Table 3-49: Risk Assessment and mitigation measures

S.No.	Perceived Risk	Severity	Implication	Mitigation measures
1	EMP approvals during construction	Less	Delay in implementation	
2	CRZ clearances	Less	Delay in implementation	
3	Land Acquisition and Rehabilitation & Resettlement (North Side)	High	Delay in starting of the project since whole of the alignment on North side, passes through private land. Approx area = xxxx	LA activities shall be started before award of work, so that space is completely available for construction.
4	Land Acquisition and Rehabilitation & Resettlement (South side)	Medium	Project can be started, but due to inferior geometry, speed will be restricted	Since this is critical only for the approaches and not for bridge, LA here can be taken up in phases. This can also be implemented as part of Coastal Road Project. (The section on project implementation can be referred from section 2.5.)
5	Hindrance of Commercial activities during construction.	Medium	This may create resentment among locals and culminate in non-cooperation to the project implementation	The alignment is carefully chosen avoiding directly the commercial activities. However the schedule of construction can be made in such a way that the contracting company can execute with least disturbance to the public.

S.No.	Perceived Risk	Severity	Implication	Mitigation measures
6	Construction in marine environment in particular to the construction of foundation due to heavy currents.	High	Adhering to the schedule & Risk of machinery	The insistence of qualification of the contractor in such environment. Vetting of the construction methodology by competent Authority.

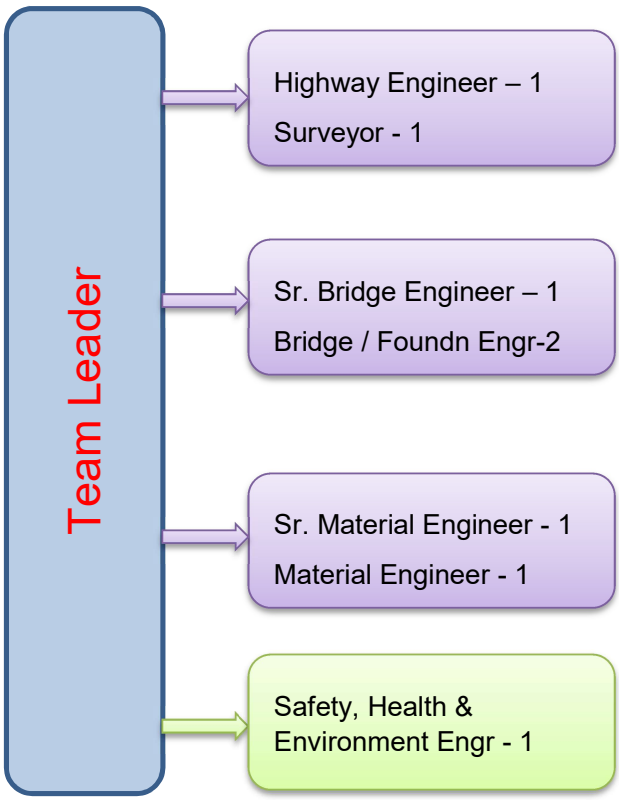
3.12 PROJECT MANGEMENT ORGANISATION

This being a specialised project, which is implemented in challenging environment, inorder ensure the quality as well as to monitor the project, an efficient Project Management Team is required.

The Project Management Group will be acting on behalf of the employer and will be responsible for schedule, quality, conformity to drawings, standards and bill certification. The group will have regular reporting mechanism to employer about the progress and presentation of catchup plan if any delay. They will facilitate the contractor for liaising with all the stake holders for permissions and clearances

A typical Project Management organisation to accomplish the tasks of construction can be as given below.

The qualification of the below personnel can be suitably decided, during the time of implementation, in consultation with the Client.



3.13 CONTRACT MANAGEMENT STRATEGY

The project is proposed to be implemented in EPC mode.

The bidding documents are prepared based on the NHAI formats and adequately covers various aspects such as escalation, EOT, defect liability, force majure, liquidated damages etc.

At present no incentives are proposed for early completion of the project.

The only material which may be required to be imported for the construction of special bridge is the stay cables. The cost greatly depends on the international market rate and other duties which may change from time to time. However since the project duration is only 24 months and the quantity required is less, any variation on account of these factors may not affect the overall cost of the project.

The overall implementation on EPC mode shall be as per the Niti Aayog's guidelines on EPC model document

Within the specified time Client shall appoint **Authority Engineer (AE),** as per the guidelines given in Model document for EPC by Niti Aayog.

The Authority Engineer shall be assisted by able staff to execute the following responsibilities.

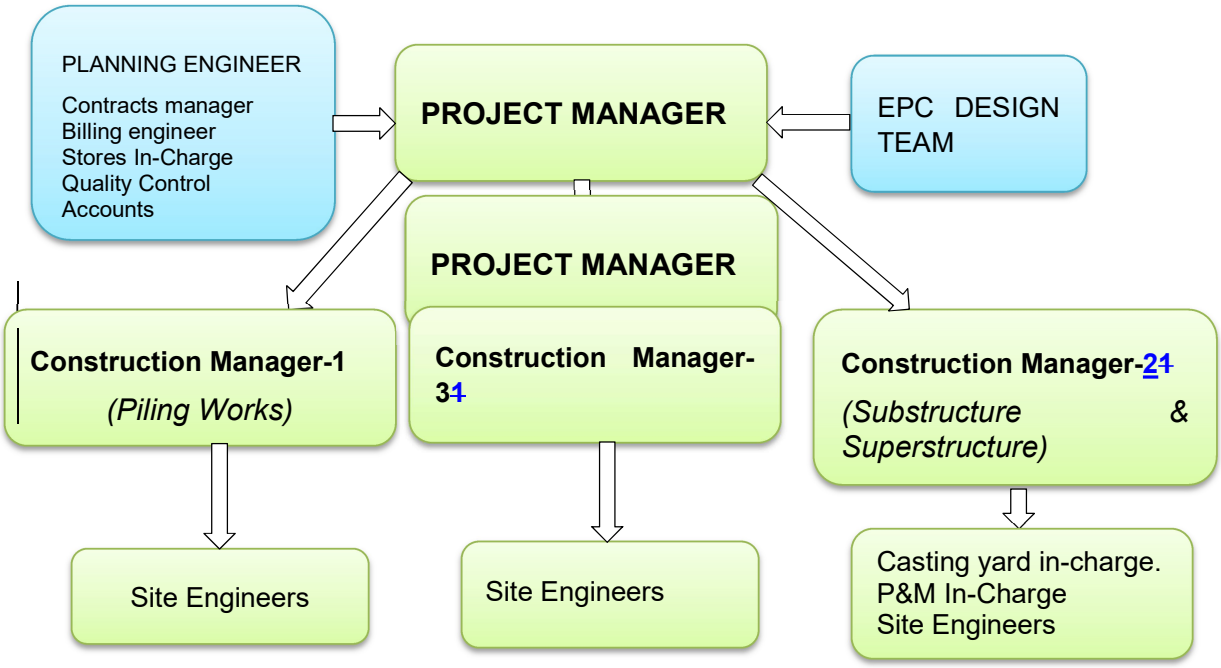
- Review of Drawings
- Appointment of Proof Consultant.
- Review of Quality Assurance Plan
- Programme for Construction of Works
- Review of proposed Work Methodology
- Inspection of Construction works
- Review of Safety at site
- Review of Monthly Progress Report
- Processing of Periodical Payments
- Processing of Time Extension, Variation Order
- Provisional / Completion Certificates

Since the project is time-bound, an efficient team of Contractor at site, which will closely work with the primary stake holder, i.e. Government of Kerala, inorder to seamlessly achieve the milestones and eventually accomplish the assigned task is required.

As per the guidelines of EPC contract, the contractor shall appoint a "**Design Director"** who is competent to lead the contractor's design team and is responsible to certify the accuracy and correctness and safety of all the design and drawings.

The Contractor shall recommend a panel of 3 consulting companies as **"Proof Check Engineers"** to Authority Engineer for his final decision and selection.

The proposed organogram of contractor is as below.



The Project Manager is responsible for the overall delivery of project, its schedule and conforming to the adherence to quality, safety and scope of work. He shall have an overall experience of minimum 20 years in marine environment and should have executed one long span bridge. He is the authorised person representing the contractor and shall communicate with client.

Construction Managers report to Project Manager and are responsible for quality and schedule. The qualification and experience criteria for each of these can be decided in consultation with the client.

3.13.1 Quality control system

The Contractor shall establish a quality control mechanism to ensure compliance with the provisions of the Agreement (the “Quality Assurance Plan”or “QAP”).

The Contractor shall, within 30 (thirty) days of the Appointed Date, submit to the Authority’s Engineer its Quality Assurance Plan which shall include the following:

(a) organisation, duties and responsibilities, procedures, inspections and documentation;

(b) quality control mechanism including sampling and testing of Materials, test frequencies, standards, acceptance criteria, testing facilities, reporting, recording and interpretation of test results, approvals, check list for site activities, and proforma for testing and calibration in accordance with the Specifications and Standards and Good Industry Practice; and

(c) Internal quality audit system.

The Authority’s Engineer shall convey its comments to the Contractor within a period of 21 (twenty-one) days of receipt of the QAP stating the modifications, if any, required, and the Contractor shall incorporate those in the QAP to the extent required for conforming with the provisions.

3.13.2 External technical audit

At any time during construction, the Authority may appoint an external technical auditor to conduct an audit of the quality of the Works. The findings of the audit, to the extent accepted by the Authority, shall be notified to the Contractor and the Authority's Engineer for taking remedial action in accordance with this Agreement. The Contractor shall provide all assistance as may be required by the auditor in the conduct of its audit hereunder. Notwithstanding anything contained in the agreement, the external technical audit shall not affect any obligations of the Contractor or the Authority's Engineer under this Agreement.

3.14 IMPLEMENTATION SCHEDULE & WBS

Since this project is a time bound project, proper scheduling and parallel work fronts to be explored. Keeping this in view, consultant has proposed pre-casting for the complete structure so that the progress is largely insulated to the seasonal changes.

The project is proposed to be phased in two stages, depending upon the land availability. The Southern side i.e. Ponnani side approach is highly built-up and it is expected to take longer time for concluding LA and R&R activities. This is necessarily required for improving the geometric only. Hence this may be taken up as and when the land is available. However the existing pavement strengthening alone can be completed on south side.

Contracting Packages	Details
1	1. Strengthening of existing pavement on South side. 2. Bridge works and approaches on North side. 3. Junction development at Karma Road.
2	LA and widening of the approach and junction developments on the South side.

The critical item identified in the whole project is the piling in marine environment and construction of cable stayed bridge. This is accounted in the attached schedule in **Annexure-5**, so that the complete assignment can be completed in the stipulated time frame.

3.15 STAUTORY CLEARANCES

3.15.1 CRZ CLEARANCE

Proposed development of the Suspended/Cable Stayed Bridge along with approach roads falls in the Coastal Regulation Zone (CRZ) area and thereby attracts the provisions of CRZ Notification, 2011 (as amended). Necessary process for obtaining CRZ Clearance is being pursued. The CRZ Mapping at the project area is to be carried out by a MoEF authorised agency. We have previously approached National Centre for Earth Science Studies (NCESS), Thiruvananthapuram, to conduct the survey. However due to shortage of manpower they are unable to conduct the survey at this point. As such we have approached National Centre for Sustainable Coastal Management (NCSCM), Chennai to conduct the survey. Upon completion of the surveys and preparation of the necessary CRZ Maps/Reports, the application for CRZ Clearance shall be submitted to Kerala State Coastal Zone Management Authority (KSCZMA).

3.15.2 FOREST CLEARANCE/TREE FELLING PERMISSIONS

There are few trees along the project development corridor that will need to be felled. Also, the proposed development will pass through a patch of Casuarina plantations. Based on the finalized ROW of the approach road, the total number of trees needed to be felled is to be identified. An inventory of trees to be felled will be prepared and necessary application will be submitted to the Malappuram Divisional Forest Office to obtain necessary permission for felling of the trees from State Forest Department.

3.16 QUALITY MANAGEMENT PLAN

A detailed QMP shall be provided by the contracting agency before the start of the execution.

A full-fledged laboratory as part of the site facilities shall be installed. This facility shall include the testing of all materials used in the construction. A third party validation from approved laboratory is required for items such as stay cables, prestress cables & bearings.

The laboratory shall have facilities to carry out in-situ tests of concrete and strengths.

All the tests shall be documented and produced for verification of PMC.

For further details, **Volume-V: Technical Specifications** shall be referred for equipment's required for testing of aggregates, soil etc.

A system of checking and approving of all the construction activities shall be in-place. The following procedures, which are generally used in such construction is as follows.

1. A detailed work procedure for each activity shall be submitted to the PMC for prior approval
2. A Request for Inspection (RFI) in specified format shall be raised by the contractor to the PMC at least 6 hours before the intended activity.
3. RFI shall be accompanied by the test reports of the materials used in the particular work, along with the approved GFC drawing.
4. Upon obtaining the written clearance from PMC, contractor shall proceed with the activity.
5. Once the activity is completed, contractor shall raise another RFI for final inspection by PMC.
6. All non-conformities shall be cleared within 72 hours of issue of the same.

3.17 OPERATIONS AND MAINTENANCE PLAN

The structural proposed structural system is such that there will be least requirement for maintenance. However a detailed maintenance regime as given below for the approaches shall be enforced.

The maintenance of the bridge structure and its approach are required to be inspected periodically to

i) Ensure the safety of personnel deployed on and end users of the project section facilities or part thereof.

ii) Keep the project section facilities from undue deterioration and wear

3.17.1 Inspection for Maintenance

For maintenance of the bridges regular and periodic inspection should be carried out for different elements of the bridge. In general three types of inspection are required to be carried out:

- Routine regular inspections at close time intervals, say, alternate month
- Periodic Detailed inspection at longer time intervals, twice in a year
- Special or occasional inspection after special time events such as accidents, earthquake, and major weakness noticed during routine or detailed inspection, unusual settlement of foundations, substantial changes in traffic pattern, etc.

3.17.2 Types of Inspection

3.17.2.1 Routine Visual Inspection

The bridge should be inspected bi-monthly by following different routes.

By walking on carriageway on top of the deck and inspect the top portion of the deck, crash barrier, expansion joint, wearing coat, etc. This inspection will be very useful and can be carried out easily. Visual inspection should include noting down any structural cracks more than 0.3mm width and any signs of deterioration and distress.

For viaduct portion, by walking around each pier and examining the pier cap, one can inspect for any deficiencies.

3.17.2.2 Detailed Visual Inspection

This inspection may be carried out twice a year. On this the external surface of the superstructure should be inspected from below using powerful binoculars. The observations made during earlier routine inspections shall be taken a benchmark for detailed inspections. Close inspection of each compartment of the flyover & bridge both by visual aids and by special instruments in case of distress is observed if necessary.

Regarding the main cable stayed bridge; a monitoring mechanism by way of reporting the deflections at salient points needs to be implemented. The instrumentation for this shall be embedded in the special bridge location by reputed expert vendors.

The maintenance regime for special bridge is very important shall be separately treated by experts in this particular field. A detailed recommendation on this is given as part of the Detailed Project Report **(Refer Volume-V: Technical Specifications).**

3.17.3 Expenses

Expenses are recurring in nature and would be incurred on day to day basis. The details of expenses are given in following paragraphs.

3.17.3.1 Repairs and Maintenance expenses (Routine)

The Concessionaire will be incurring some expenses for up-keeping the road and other allied infrastructure on an annual basis. Considering the level of maintenance required during the concession period, the following amount has been is considered as Repairs and Routine maintenance expenses. The assumptions on the same are given in **Table 3-50.**

Table 3-50: Repairs & Maintenance details in Rs Crs per Km Base rate

Section Details	Overall expenses in Rs Crs
Rigid Pavement	0.06
Flexible Pavement	0.05

With the above assumption, the repairs and maintenance expense comes to Rs 0.16 Crs per annum.

3.17.3.2 Repairs and Maintenance Expenditure (Periodical)

On completion of every five year period, the concessionaire will be incurring periodical repair and maintenance expenditure. Considering the project facilities and the uniqueness of the project, a provision of Rs 1.09 Crores has been considered for meeting the periodical maintenance expenditure for the entire project. The periodical maintenance will be required on completion of every 5 year period.

ANNEXURE-1
(ROAD INVENTORY)

Road Inventory Survey

Name/Location of road:		**Ponnani junction to Padinjarekara road**											**Enumerator:**														**Sheet No:**	1
		DPR for Ponnani Cable Stayed Bridge																											
		From : 0.000		**To : 5.000**			**Enumerator :**	**HMS**					**Checked By:**	**NCB**														**Date:**	

Terrain		**Landuse**				**Carriageway Type**		**Condition**		**Shoulder**		**Drain Type**	
P	Plain	BU	Built UP Area	IN	Industrial Area	B	Bituminous	G	Good	P	Paved	L	Lined
R	Rolling	SBU	Semi Built Up Area	FR	Forest Area	CC	Cement Concrete	F	Fair	P	Paved	E	Earthen
M	Mountainous	BR	Barren Land	AG	Agricultural Land	E	Earthen Road	P	Poor	E	Earthen	P	Pipe
S	Steep					Gr	Gravel Road	VP	Very Poor			B	Box

Chainage (Km)		**Terrain (P/R/M/S)**	**Land use (BU/SBU/AG/FR/I N/BR)**	**Name of the Village / Town**	**Carriageway**					**Left Shoulder Width (m)**		**Right Shoulder Width (m)**		**Drainage details**						**Junction Details**		**Electric Poles in Nos L/R**	**Transformers in Nos L/R**	**Available Right of Way (m)**		**High Tension Wires**	**Remarks**
														LHS			**RHS**										
From	**To**				**Type (B/CC/E/GR)**	**Left Width (m)**	**Right Width (m)**	**Median Width (m)**	**Type of Median Steel/Stone/ Open/Taper**	**Paved**	**Unpaved**	**Paved**	**Unpaved**	**Type (L/E/P/B)**	**Condition(G /F/P/VP)**	**Width (m)**	**Type (L/E/P/B)**	**Condition (G/F/P/VP)**	**Width (m)**	**L/R**	**Type Y/T/+/Z**			**Left**	**Right**		
0.0	0.1	P	BU	Ponnani	B	7.0					0.3		1.40	L								7.00		5.5	2.5	1.00	Fuel station
0.1	0.2	P	BU	Ponnani	B	7.0					0.4		1.8	L								3.00		3.0	5.0		Nishad palace
0.2	0.3	P	BU	Ponnani	B	7.0					0.8		1.8	L						L	T	4.00	1	7.8	5.1		
0.3	0.4	P	BU	Ponnani	B	7.0					0.8		2.0	L						L	T	4.00		-	5.7		
0.4	0.5	P	BU	Ponnani	B	7.0					0.8		1.7	L								3.00	1	7.7	8.0		MES ponnani college
0.5	0.6	P	BU	Ponnani	B	7.5					1.2		2.0	L						R	T	3.00		4.6	2.5		
0.6	0.7	P	BU	Ponnani	B	7.5					1		1.7							L	T	3.00	1	2.6	-		KSRTC bus depot
0.7	0.8	P	BU	Ponnani	B	8.5					1		1.4				D			L/R	T/Y	5.00		5.0	-		
0.8	0.9	P	BU	Ponnani	B	10.5					0.8		-				D			L/L	T/T	4.00	2	2.6	1.0		
0.9	1	P	BU	Ponnani	B	8.5					0.4		-				D			L/R	T/T	5.00	1	-	4.0		
1.0	1.1	P	BU	Ponnani	B	8.5					0.7		0.3				D			L	T	3.00		3.0	1.8		
1.1	1.2	P	BU	Ponnani	B	8.5					0.8		0.8	L			D			L	T	8.00	1	2.5	-		TB hospital ponnani
1.2	1.3	P	BU	Ponnani	B	7.0					1.2		0.5	L			D					5.00		2.0	-		
1.3	1.4	P	BU	Ponnani	B	6.2					1		1.0							L	T	4.00		2.5	1.0		
1.4	1.5	P	BU	Ponnani	B	7.0					1		0.5							L-R / L	+/T	4.00		2.0	1.4		
1.5	1.6	P	BU	Ponnani	B	7.3					1		1.0									3.00		4.0	1.4		
1.6	1.7	P	BU	Ponnani	B	7.3					0.5		0.5							R	T	5.00		3.5	5.0		
1.7	1.8	P	BU	Ponnani	B	7.3					0.5		0.5							R	T	4.00	1	1.0	1.7		
1.8	1.9	P	BU	Malappuram	B	6.3					0.4		0.4							L	T	3.00		2.5	-		
1.9	2.0	P	BU	Malappuram	B	6.4					0.4		0.4							L/L	T/T	5.00		3.5	1.0		
2	2.1	P	BU	Malappuram	B	5.0					0.4		0.4							L-R	+	3.00		1.4	1.8		
2.1	2.2	P	BU	Malappuram	B	5.3					0.4		0.4							R	T	3.00		3.0	3.3		
2.2	2.3	P	BU	Malappuram	B	5.0					0.4		0.4							L	T	3.00	1	1.7	5.2		
2.3	2.4	P	BU	Malappuram	B	4.3					0.4		0.4				D			L	T	4.00		2.8	2.8		
2.4	2.5	P	BU	Malappuram	B	5.5					0.4		0.4				D			L	Y	1.00	1	-	0.5		
2.5	2.6	P	BU	Malappuram	B	4.5					0.5		0.5							L-R	+	4.00		1	0.5		
2.6	2.7	P	Harbour land	Malappuram	B	16.0		2.30			0.5		0.5							L	T	3.00		0.5	-		
2.7	2.8	P	Harbour land	Malappuram	B																	1.00		6.8	6.8		
2.8	2.9	P	Harbour land	Malappuram	B															R	Y			6.8	6.8		
2.9	3	P	River location	Malappuram	B																						
3	3.1	P	River location	Malappuram	B																						
3.1	3.2	P	River location	Malappuram	B																						
3.2	3.3	P	River location		B																						
3.3	3.4	P	River location		B																						
3.4	3.5	P	River location		B																						
3.5	3.6	P	River location		B																						
3.6	3.7	P	River location		B																						
3.7	3.8	P	River location		B																						
3.8	3.9	P	River location		B																						
3.9	4	P	River location		B																						
4.0	4.1	P	BU	Padinjarekara	B																			6.8	6.8		Government park
4.1	4.2	P	BU	Padinjarekara	B																			6.8	6.8		
4.2	4.3	P	BU	Padinjarekara	B																			6.8	6.8		
4.3	4.4	P	BU	Padinjarekara	B																			6.8	6.8		
4.4	4.5	P	BU	Padinjarekara	B																			6.8	6.8		
4.5	4.6	P	BU	Padinjarekara	B																			6.8	6.8		
4.6	4.7	P	BU	Padinjarekara	B	5.3					0.8		0.8									1.00		6.8	6.8		
4.7	4.8	P	BU	Padinjarekara	B	5.3																2.00		6.8	6.8		

ANNEXURE-2
(PAVEMENT CONDITION SURVEY)

Annexure No - Pavement Condition Survey Format

Name/Location of Road: Ponnnani Junction to Padinjarekara beach

Direction Towards: Ponnani junction to Padinjarekara beach

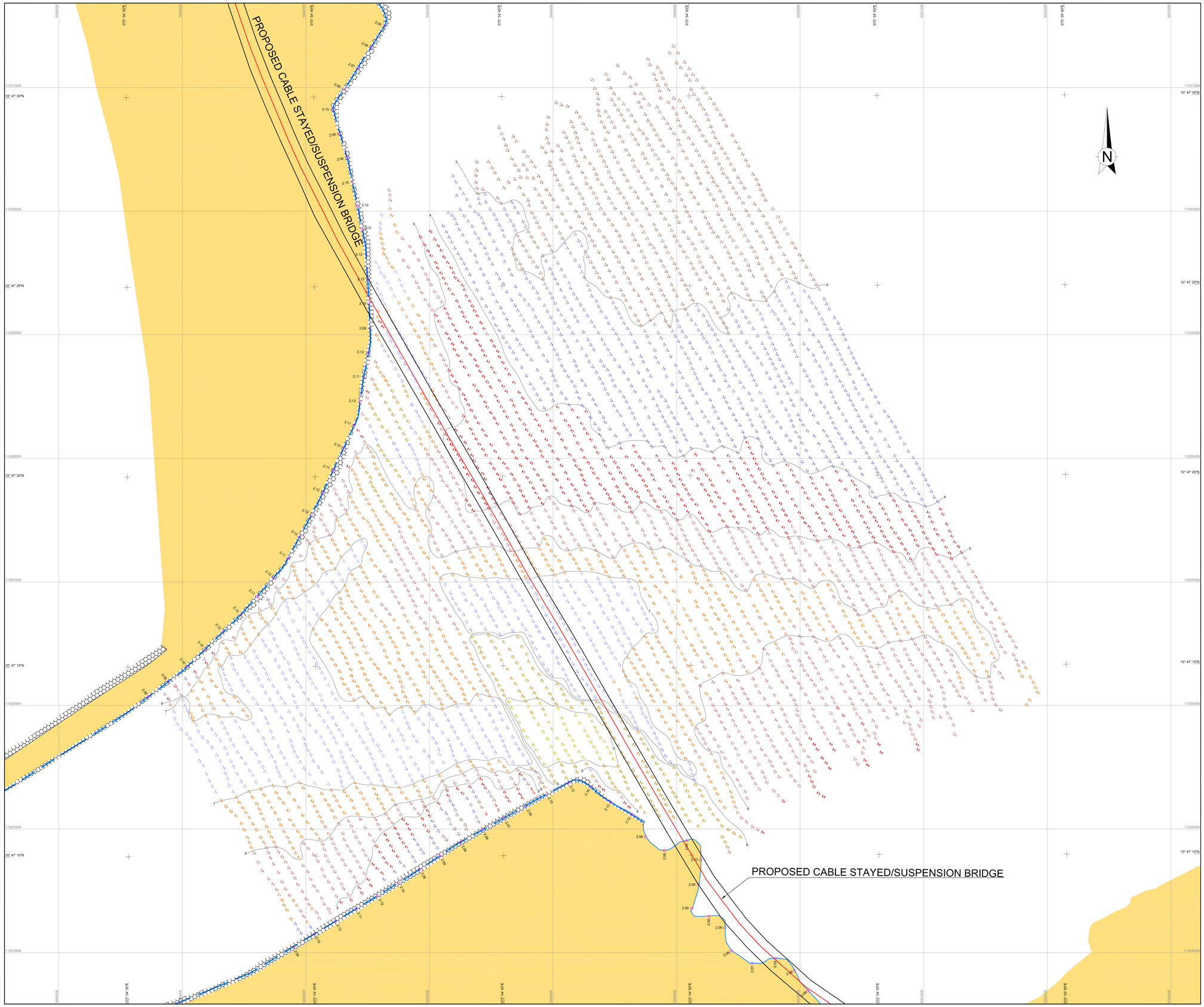
L-Low Severity; M-Moderate Severity; H-High Severity **G:Good, F:Fair, P:Poor, VP:Very Poor**

climate condition:Summer

Chainage (Km)		Cracking										Rutting			Ravelling		Pot holes			Bleeding		Patching		Edge Cracking, m	Shoulder Drop off		Condition	Remarks
		Longitudinal		Transverse		Aligator			Block																			
From	To	Crack Width, mm	Crack length, m	Crack Width, mm	Crack length, m	H/M/L	L, m	B, m	H/M/L	L, m	B, m	Depth in mm	L, m	B, m	L, m	B, m	Nos	Depth in mm	Diameter, m	L, m	B, m	L, m	B, m		Depth, mm	Length,m	(G/F/P/ VP)	
0.1	0.2																									G	Good
0.2	0.3					M	20	0.10																	100.0	50.0	F	Fair
0.3	0.4																					0.30	0.50				G	Good
0.4	0.5	30	100																								F	Fair
0.5	0.6																										G	Good
0.6	0.7																										G	Good
0.7	0.8														10.00	7.00	2										F	Fair
0.8	0.9																					100.0	4.0				F	Fair
0.9	1.0																										G	Good
1.0	1.1																										G	Good
1.1	1.2	30	100																								G	Good
1.2	1.3	20	100			M	70	0.10														100.0	4.0				F	Fair
1.3	1.4																					50.0	7.0				F	Fair
1.4	1.5																1	2	0.10								G	Good
1.5	1.6																										G	Good
1.6	1.7																										G	Good
1.7	1.8																										G	Good
1.8	1.9																										G	Good
1.9	2.0																										G	Good
2.0	2.1																										G	Good
2.1	2.2	10	50																								G	Good
2.2	2.3																										F	Fair
2.3	2.4														5.00	2.00	**1.0**										F	Fair
2.4	2.5	10	50																								F	Fair
2.5	2.6					M	30	0.10																			F	Fair
2.6	2.7																										F	Fair
2.7	2.8																										G	Good
2.8	2.9																										G	Good
2.9	3.0																										G	Good

ANNEXURE-3
(BATHYMMETRY DRAWING)

BATHYMTERY CHART



LEGEND:

GENERAL

- UTM GRID INTERSECTION
- GEOGRAPHICAL GRID INTERSECTION

BATHYMETRY

- 6.4 WATER DEPTH IN METRES & DECIMETRES BELOW CHART DATUM
- BATHYMETRY CONTOUR
- ROCK DUMPING AREA
- LAND PORTION
- HIGH WATER LINE
- 2.08 SPOT LEVEL ABOVE CHART DATUM

NOTES:

1) BATHYMETRY SURVEY WAS CARRIED OUT FROM THE SHALLOW DRAFT VESSEL MB MASOOD ON 20th & 22nd OCTOBER 2019.
2) POSITION FIXING WAS CONTROLLED FROM HEMISPHERE DGPS POSITIONING SYSTEM.
4) ODOM HYDROTRAC SINGLE BEAM ECHOSOUNDER WAS DEPLOYED FOR RECORDING WATER DEPTHS.
5) PREDICTED TIDE FOR PONNANI WAS USED FOR REDUCING RAW WATER DEPTHS TO CHART DATUM.
6) PROPOSED BATHYMETRY SURVEY LOCATION CO- ORDINATES WERE PROVIDED BY THE CLIENT.

GEODETIC PARAMETERS:

HORIZONTAL CO-ORDINATE SYSTEM	:	WGS84
GEODETIC DATUM	:	WGS84
ELLIPSOID	:	WGS84
Semi major axis	:	6378137.000 m
Semi minor axis	:	6356752.314 m
Inverse flattening	:	298.2572236
PROJECTION	:	Universal Transverse Mercator
Central Meridian (CM)	:	75° E (Zone 43)
Latitude of Origin	:	0°
False Easting	:	500000 m
False Northing	:	0 m
Scale factor at CM	:	0.99960

REFERENCE DRAWINGS

Rev. No.	Date:	Drawing No.	Description:

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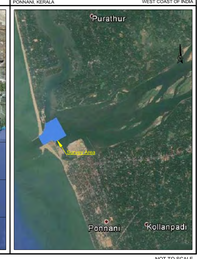
OVERVIEW PLAN

LAYOUT PLAN

PONNANI, KERALA — WEST COAST OF INDIA



NOT TO SCALE

CLIENT

L&T INFRASTRUCTURE ENGINEERING LTD.

L&T Infra Engineering

ECC CAMPUS 4th FLOOR CRR CENTRE,
MOUNT POONAMALLAE HIGH ROAD,
MANAPAKKAM,
PO BOX : 979, CHENNAI- 600 089, INDIA

SURVEY CONTRACTOR

GEOSTAR SURVEYS INDIA PVT. LTD.

GEOSTAR SADAN
PLOT NO : 46, SECTOR - 19C,
VASHI, NAVI MUMBAI - 400 703. INDIA
TEL.: +91 22 2783 0098 Fax : +91 22 2783 0098

PROJECT

BATHYMETRY SURVEY FOR THE CONSTRUCTION OF CABLE STAYED/SUSPENSION BRIDGE ACROSS PONNANI ESTUARY WITH APPROACHES IN THE STATE OF KERALA, WEST COAST OF INDIA

BATHYMTERY CHART

HORIZONTAL SCALE 1 : 1,000

20m 0m 20m 40m 60m 80m 100m

Vessel : MB MASOOD		Survey Date : 20th & 22th Oct 2019.			Project Ref :		
Rev. No:	Date:	Description:	Surveyed:	Interpr:	Drawn:	Chkd:	Appr:
0	31-10-2019	Issued For Clients Comment	SS	AK	RBR	PSJ	PPK
Drawing File No: 1887-01R1		Drawing No: J042_19\L&TIKERALA\BATHY\2019\01\1887			Chart: 1 OF 1		P.Size A0

ANNEXURE-4

(HYDROLOGY CALCULATIONS FOR PONNANI CABLE STAYED BRIDGE)

ANNEXURE-4

1 Discharge Calculations

The Flood Discharge at Ponnani Estuary location is calculated by using the Maximum Flood Discharge of Chamravottam Regulator Cum Bridge (RCB) and Discharge of Tirur River.

Input Data:

Catchment Area of Bharatapuzha River	=	6189	km^2
Length of Bharatapuzha River	=	209	km
Level at Source Point of Bharatapuzha River	=	1964	m
Catchment Area of Bharatapuzha River	=	117	km^2
Length of Bharatapuzha River	=	209	km
Level at Source Point of Bharatapuzha River	=	1964	m
Maximum Flood discharge of Chamravottam RCB	=	8496	cumecs

1.1 Discharge calculation

Q_1 = Maximum flood discharge from Chamravottam Bridge

= 8496 cumecs

Q_2 = Flood discharge from Tirur River

= 161 cumecs

$Q = Q_1 + Q_2$

= 8496 + 161 = 8657 cumecs

1.2 Calculation of cross sectional Area of Estuary at Bridge location

High tide level,HTL = 1.000 m

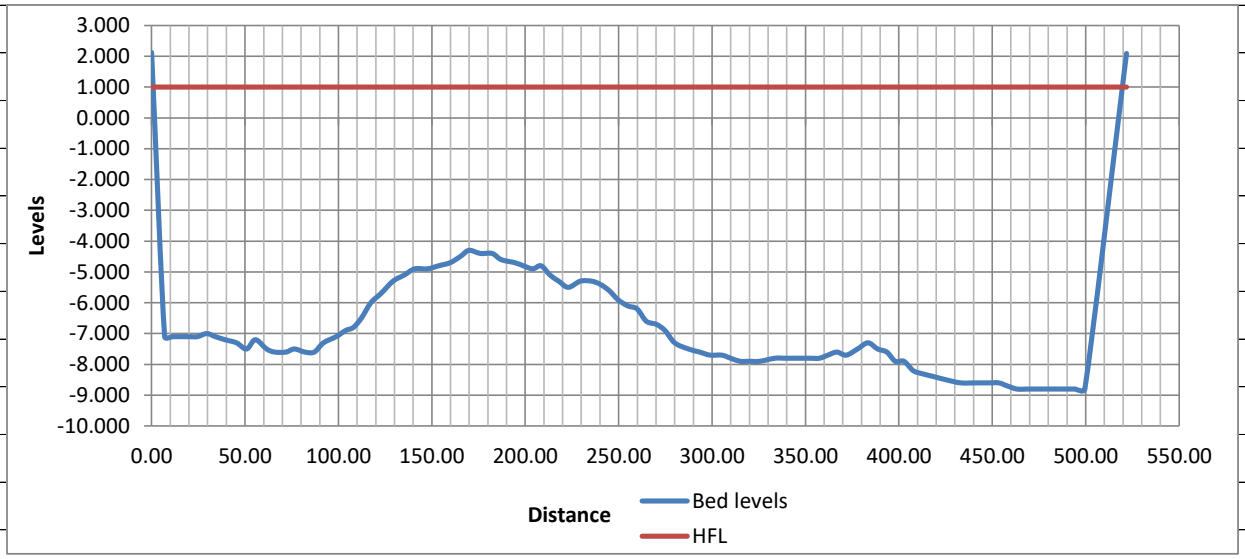
Distance	RL of Existing BL (m)	Mean Depth (m)	Area (A,sq.m)	Diff. In GL (m)	Wetted Perimeter (P),m
0.00	2.120	-	-	-	-
6.978	-7.100	3.490	24.35	9.22	11.56
10.817	-7.100	8.100	31.10	0.00	3.84
16.280	-7.100	8.100	44.25	0.00	5.46
20.309	-7.100	8.100	32.63	0.00	4.03

	24.557	-7.100	8.100	34.41	0.00	4.25	
	29.458	-7.000	8.050	39.45	0.10	4.90	
	34.165	-7.100	8.050	37.89	0.10	4.71	
	39.290	-7.200	8.150	41.77	0.10	5.13	
	45.448	-7.300	8.250	50.80	0.10	6.16	
	50.823	-7.500	8.400	45.15	0.20	5.38	
	55.551	-7.200	8.350	39.48	0.30	4.74	
	61.551	-7.500	8.350	50.10	0.30	6.01	
	65.883	-7.600	8.550	37.04	0.10	4.33	
	71.944	-7.600	8.600	52.12	0.00	6.06	
	76.410	-7.500	8.550	38.18	0.10	4.47	
	82.031	-7.600	8.550	48.06	0.10	5.62	
	87.063	-7.600	8.600	43.28	0.00	5.03	
	92.005	-7.300	8.450	41.76	0.30	4.95	
	98.771	-7.100	8.200	55.48	0.20	6.77	
	103.879	-6.900	8.000	40.86	0.20	5.11	
	108.034	-6.800	7.850	32.62	0.10	4.16	
	112.267	-6.500	7.650	32.38	0.30	4.24	
	117.361	-6.000	7.250	36.93	0.50	5.12	
	122.764	-5.700	6.850	37.01	0.30	5.41	
	129.210	-5.300	6.500	41.90	0.40	6.46	
	135.262	-5.100	6.200	37.52	0.20	6.06	
	140.815	-4.900	6.000	33.32	0.20	5.56	
	147.661	-4.900	5.900	40.39	0.00	6.85	
	153.648	-4.800	5.850	35.02	0.10	5.99	
	159.803	-4.700	5.750	35.39	0.10	6.16	
	165.234	-4.500	5.600	30.41	0.20	5.43	
	169.901	-4.300	5.400	25.20	0.20	4.67	
	175.971	-4.400	5.350	32.47	0.10	6.07	
	182.318	-4.400	5.400	34.27	0.00	6.35	
	187.119	-4.600	5.500	26.41	0.20	4.81	
	194.470	-4.700	5.650	41.53	0.10	7.35	
	199.000	-4.800	5.750	26.05	0.10	4.53	

	204.036	-4.900	5.850	29.46	0.10	5.04	
	208.465	-4.800	5.850	25.91	0.10	4.43	
	213.258	-5.100	5.950	28.52	0.30	4.80	
	217.958	-5.300	6.200	29.14	0.20	4.70	
	223.047	-5.500	6.400	32.57	0.20	5.09	
	229.464	-5.300	6.400	41.07	0.20	6.42	
	235.516	-5.300	6.300	38.13	0.00	6.05	
	240.093	-5.400	6.350	29.06	0.10	4.58	
	244.823	-5.600	6.500	30.74	0.20	4.73	
	249.650	-5.900	6.750	32.58	0.30	4.84	
	254.845	-6.100	7.000	36.37	0.20	5.20	
	259.877	-6.200	7.150	35.98	0.10	5.03	
	264.820	-6.600	7.400	36.58	0.40	4.96	
	270.208	-6.700	7.650	41.22	0.10	5.39	
	274.805	-6.900	7.800	35.86	0.20	4.60	
	280.013	-7.300	8.100	42.18	0.40	5.22	
	287.353	-7.500	8.400	61.66	0.20	7.34	
	293.371	-7.600	8.550	51.45	0.10	6.02	
	298.974	-7.700	8.650	48.47	0.10	5.60	
	305.263	-7.700	8.700	54.71	0.00	6.29	
	309.956	-7.800	8.750	41.06	0.10	4.69	
	315.031	-7.900	8.850	44.91	0.10	5.08	
	319.817	-7.900	8.900	42.60	0.00	4.79	
	325.519	-7.900	8.900	50.75	0.00	5.70	
	333.682	-7.800	8.850	72.24	0.10	8.16	
	339.076	-7.800	8.800	47.47	0.00	5.39	
	345.224	-7.800	8.800	54.10	0.00	6.15	
	352.599	-7.800	8.800	64.90	0.00	7.38	
	357.474	-7.800	8.800	42.90	0.00	4.88	
	362.012	-7.700	8.750	39.71	0.10	4.54	
	366.791	-7.600	8.650	41.34	0.10	4.78	
	371.814	-7.700	8.650	43.45	0.10	5.02	
	377.877	-7.500	8.600	52.14	0.20	6.07	

	383.464	-7.300	8.400	46.93	0.20	5.59	
	388.634	-7.500	8.400	43.43	0.20	5.17	
	393.557	-7.600	8.550	42.09	0.10	4.92	
	398.084	-7.900	8.750	39.61	0.30	4.54	
	402.736	-7.900	8.900	41.40	0.00	4.65	
	407.633	-8.200	9.050	44.32	0.30	4.91	
	412.301	-8.300	9.250	43.18	0.10	4.67	
	418.901	-8.400	9.350	61.71	0.10	6.60	
	425.222	-8.500	9.450	59.73	0.10	6.32	
	433.170	-8.600	9.550	75.90	0.10	7.95	
	441.350	-8.600	9.600	78.53	0.00	8.18	
	448.461	-8.600	9.600	68.27	0.00	7.11	
	453.493	-8.600	9.600	48.31	0.00	5.03	
	458.078	-8.700	9.650	44.25	0.10	4.59	
	463.196	-8.800	9.750	49.90	0.10	5.12	
	469.347	-8.800	9.800	60.28	0.00	6.15	
	474.745	-8.800	9.800	52.90	0.00	5.40	

479.239	-8.800	9.800	44.04	0.00	4.49	
483.411	-8.800	9.800	40.89	0.00	4.17	
487.980	-8.800	9.800	44.78	0.00	4.57	
494.517	-8.800	9.800	64.06	0.00	6.54	
499.561	-8.800	9.800	49.43	0.00	5.04	
521.849	2.090	4.355	0.00	10.89	0.00	
		Area =	3950.17	P =	169.93	



1.3 Calculation of velocity of Estuary at Bridge location

Q = Discharge at Estuary location = 8657 cumecs

A= Area of c/s at estuary location = 3950 sqm

v= Velocity of flow at estuary location = Q/A = 2.19 m/sec

2.0 Calculations of Afflux and scour depth

Length of Cable stayed bridge = 100+200+100

= 400 m

Discharge of River = 8657 cumecs

2.1 Estimation of Linear Waterway

Effective Linear Waterway provided = Length of Waterway - Obstruction

Length of waterway = 521.849 m

Width of pylon = 6 m

No. of Pylons = 2 Nos

Effective Linear Waterway Provided, L =521.849-2×6= 509.849 m

2.2 Scour Depth Calculations :

Effective Linear Watreway (L) = 509.85 m

Discharge (Q) = 8657 Cumecs

High Tide Level (HTL) = 1.000 m

Lowest Bed Level (BL) = -8.800 m

Silt Factor (K_{sf}) = 1.76 x $\sqrt{d_m}$

Where, dm = Mean Diameter of particles

Mean Dia of Particles for Pier = 0.081

Silt Factor (K_{sf}) for Pier = 0.501 (From soil report)

Mean Scour Depth

$$d_{sm} = 1.34 * \left(\frac{D_b^2}{K_{sf}} \right)^{(1/3)}$$

[As per Cl.110.1.3 & 110.1.4.1 of IRC 5:1998]

Where D_b = 1.2192* Q/L = 20.70 cumecs/m

As per IRC: 78-2014, clause 703.3 for foundations without any floor protections, Maximum Scour depth below HFL shall be taken as : (1) For abutments : 1.27*dsm (2) For Piers : 2.0*dsm

d_{sm} = 12.721 m

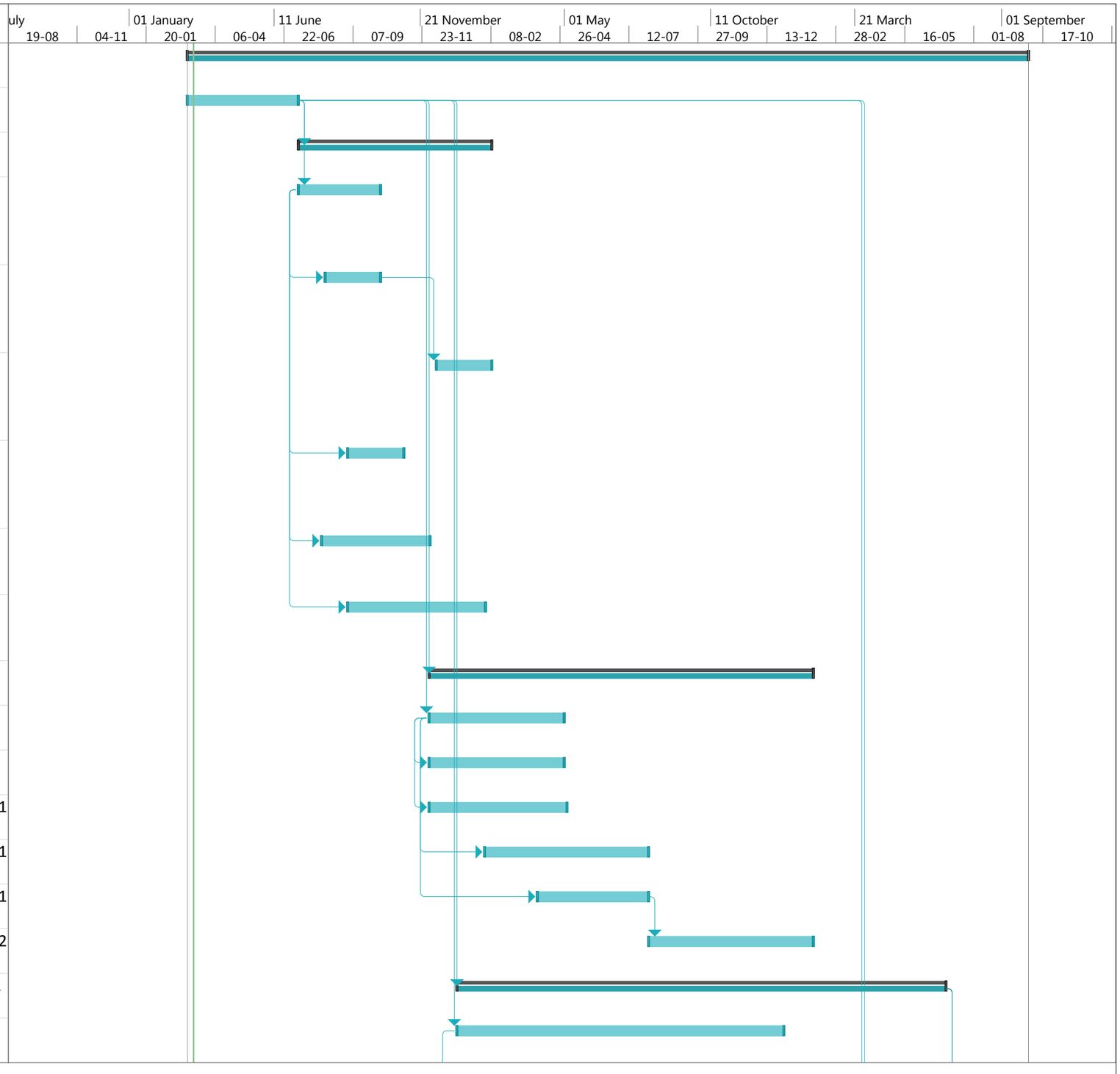
Max Scour Depth at Pier, $2.0*d_{sm}$ = 25.441 m

Max Scour Level (Pier), HFL - $2.00*d_{sm}$ = -24.441 m

ANNEXURE-5

(WORK BREAKDOWN SCHEDULE OF CONSTRUCTION ACTIVITIES)

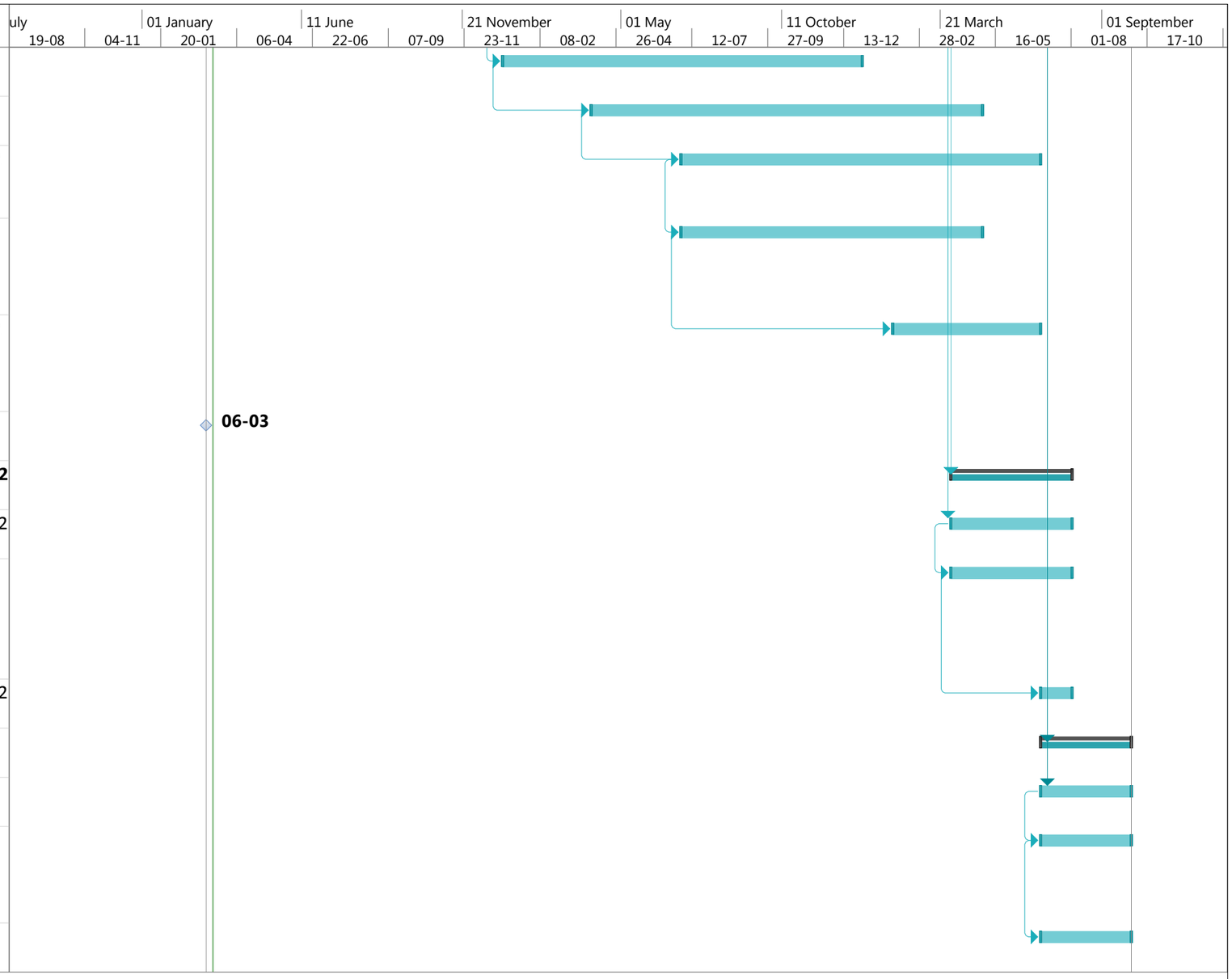
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Start of Project**	**671 days?**	**Fri 06-03-20**	**Fri 30-09-22**
2		Tendering process and Award of	88 days	Fri 06-03-20	Tue 07-07-20
3		**Mobilisation, Prework**	**154 days**	**Wed 08-07-20**	**Mon 08-02-21**
4		Setting up site office,obtaining clearances, land possession	66 days	Wed 08-07-20	Wed 07-10-20
5		Setting up casting yard and batching plants	44 days	Fri 07-08-20	Wed 07-10-20
6		Mobilisation of Rigs and all construction equipments	44 days	Wed 09-12-20	Mon 08-02-21
7		Initial surveys and fixing BM & Fixing alignment	45 days	Tue 01-09-20	Mon 02-11-20
8		Appointment of DDC & initiate designs	87 days	Mon 03-08-20	Tue 01-12-20
9		Soil investigation and	110 days	Tue 01-09-20	Mon 01-02-21
10		**Foundation / Piling / Piers**	**307 days**	**Tue 01-12-20**	**Wed 02-02-22**
11		Foundation / Pil	109 days	Tue 01-12-20	Fri 30-04-21
12		Piling of Approaches	109 days	Tue 01-12-20	Fri 30-04-21
13		Piling in water	110 days	Tue 01-12-20	Mon 03-05-21
14		Piers in land	131 days	Mon 01-02-21	Mon 02-08-21
15		Lower Pylon	88 days	Thu 01-04-21	Mon 02-08-21
16		Upper pylon	132 days	Tue 03-08-21	Wed 02-02-22
17		**Superstructure**	**390 days?**	**Fri 01-01-21**	**Thu 30-06-22**
18		Superstructure	261 days	Fri 01-01-21	Fri 31-12-21



Project: Ponnani Project
Date: Fri 13-03-20

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

ID	Task Mode	Task Name	Duration	Start	Finish
19		Casting of girder in precast	261 days	Fri 01-01-21	Fri 31-12-21
20		Erection of girders	283 days	Thu 01-04-21	Mon 02-05-22
21		Diaphragm and deck slab casting	261 days	Thu 01-07-21	Thu 30-06-22
22		Casting of segments for cable stayed portion	218 days	Thu 01-07-21	Mon 02-05-22
23		Erecction, stressing cables and stays	108 days	Tue 01-02-22	Thu 30-06-22
24		RE wall approaches	0 days		
25		**Appurtenances**	**87 days**	**Fri 01-04-22**	**Mon 01-08-22**
26		Appurtenances	87 days	Fri 01-04-22	Mon 01-08-22
27		Finishes, Wearing coat, Ejs, Crassh barrier, Downtakes,	87 days	Fri 01-04-22	Mon 01-08-22
28		Open to traffic	22 days	Fri 01-07-22	Mon 01-08-22
29		**Amenities**	**66 days?**	**Fri 01-07-22**	**Fri 30-09-22**
30		Amenities	66 days	Fri 01-07-22	Fri 30-09-22
31		Footpath, Walways, Park, escalator, cafetaria,	66 days	Fri 01-07-22	Fri 30-09-22
32		Bridge complete	66 days	Fri 01-07-22	Fri 30-09-22



Project: Ponnani Project
Date: Fri 13-03-20

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
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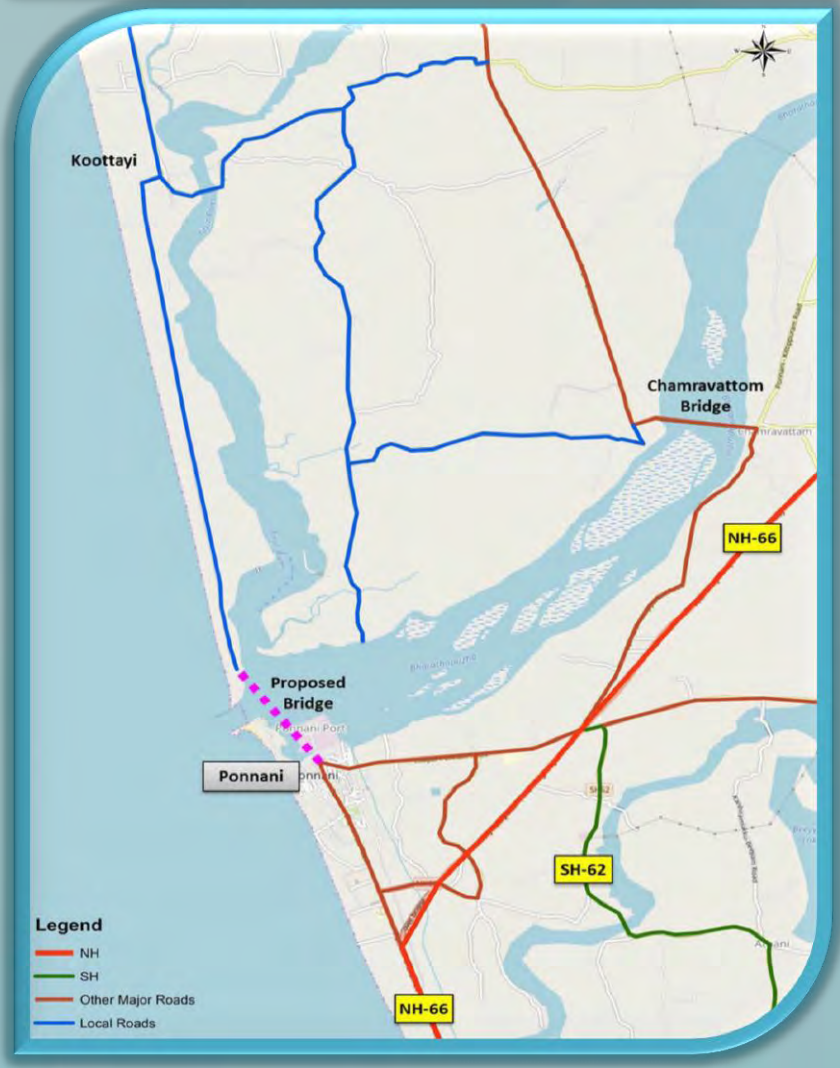
Roads and Bridges Development Corporation of Kerala Limited (RBDCK)

Kerala Infrastructure Investment Fund Board (KIIFB)

Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches



Detailed Project Report
(Volume-II: Design Report)
February 2020

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PART-I

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

Client: **Roads and Bridges Development Corporation of Kerala Limited (RBDCK)**
(A Government of Kerala Undertaking)

Project:	**Project No.:**
Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches	C1193601

Title:	**Document No.:**	**Rev.:**
Design of Cable Stayed Bridge and Viaduct	DN101	0

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Notes:

1.

Revision Details:

Rev.	Date	Details	Prepared Init.	Prepared Sign.	Checked Init.	Checked Sign.	Approved Init.	Approved Sign.
0	12/03/2020	First Submission	AGS		NRY		PML	

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LIST OF ENCLOSURES

1 Introduction

Roads and Bridges Development Corporation of Kerala Limited (RBDCK) (the "Client/Authority") has been entrusted with the assignment of ***'Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala'.*** In this context, the Client has appointed **L&T Infrastructure Engineering (L&TIEL) (the "Consultant")** for carrying out Feasibility Study, to establish the technical, economic and financial viability of the aforesaid project and to prepare Detailed Project Report.

This report is prepared highlighting the proposed design parameters and methodology to be adopted for the viaduct and cable stayed portion of this project.

2 Project Description

The proposed Cable Stayed Bridge across Ponnani Estuary in Malappuram Distric. The project is 4 lane elevated road from Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) and ends at Padinjarekara beach. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock. The alignment of the Cable stayed bridge is shown in the figure-1.

Figure 2-1 Alignment along the Project Stretch

3 General Arrangement

3.1 Approaches and Cable Stayed Bridge

Approach to the main bridge starts at ch:2+920 and ends at ch:4+410 comprising total length as 1.49km crossing bharathapuzah river. Approach viaduct is proposed as 4/5 span integral structure with 1 module of 120m (4 spans of 30m) each (ej to ej). Superstructure for the approach portion is proposed as RCC I-girder with 13.0m wide deck integrated with pier and foundation. The proposed main bridge is 400m in length with two end spans of 100.0m and interior span of 200.0m. The main bridge superstructure consists of 23.0m wide three cell PSC segmental concrete box girder, with dual carriageway of 2x9.5m with 3.0m wide median at centre. The box girder will be supported by stay cables which will be anchored in the pylon and stressed diaphragm wall inside the box girder. Internal diaphragms are proposed wherever stay cables are anchored to the box. The cable stays will be arranged in a semi harp layout with provision for the planned replacement or accidental removal of any one cable taken into account in the design. The precast segments will be erected in balanced cantilever construction method using a beam and winch erection system. The bridge substructure consists of cast-in-place concrete vertical pylons supported on pile foundations at bottom and Inclined pylon at top as shown in the general arrangement drawing.

3.1.1 Geometry

Description	**Approaches**	**Main Bridge**
Start and end Chainage (km)	2+920 to 3+480 3+880 to 4+410	3+480 to 3+880
Length(m)	1090	400
Overall deck width (m)	13	23
Clear carriageway width	9.5	2x9.5
Central median(m)	-	3
Type of structure	RCC-Integral	Cable stayed bridge
Superstructure	RCC I-girder	PSC Box girder
Substructure	Rectangular Pier	Two legged vertical Pylon
Foundation	Pile	Pile
Type of Expansion Joint	Single strip seal	Modular type

For details of span configuration for approach and cable stayed bridge refer general arrangement drawings listed below,

DDG 501 to DDG 506 – General Arrangement Drawing for approach and Cable Stayed Bridge

4 Materials

The different materials for the construction and their properties envisaged for the design are described in the following sections.

4.1 Units

The main units used for design shall be

(t), (m), (mm), (KN), (KN/m^2), (MPa), (^{0}C), (rad)

4.2 Unit weight

The unit weight of various materials is considered as per Clause 203 of IRC: 6 – 2017 as listed below:

Table 4-1 Unit Weights of Materials

Description of Materials	Unit Weight (kN/m^3)
Pre-Stressed Concrete	25
Reinforced Concrete	25
Plain Concrete	25
Structural Steel	78.5
Asphalt	22

4.3 Concrete

4.3.1 Concrete Grades

The following concrete grades are used for various design of structural members.

Description	Viaduct	Main Bridge
Superstructure	M45	M60
Substructure	M35	M50 / M55
Foundation	M35	M40

Modulus of elasticity of concrete for various grades shall be taken as per table 6.5 of IRC: 112. The Poisson's ratio of un-cracked concrete is taken as 0.2 and that of cracked as zero as per Clause 6.4.2.5 (4) (ii) of IRC: 112.

4.3.2 Co-efficient of Thermal Expansion

The co-efficient of thermal expansion for reinforced as well as pre-stressed concrete is taken as $\varepsilon = 1.2 \times 10^{-5}$ /°C as per cl: 215.4 in IRC: 6-2017.

4.4 Reinforcement

High yield strength corrosion resistance steel of grade CRS 500D conforming to IS: 1786 will be considered for steel reinforcement with the following material properties:

Young's Modulus (E) : 200,000 MPa

Yield Strength (f_y) : 500 MPa

As per clause 18.2.3.2 of IRC:112-2011, reinforcement bars where fusion bond epoxy coat is used as a measure for corrosion resistance, lap length is increased by 25 percent on account of lower bond strength between concrete and epoxy coated reinforcement.

4.5 Pre-stressing Steel

Pre-stressing steel shall be stress relieved Class II 7 ply strands of low relaxation type conforming to IS: 14268. The characteristics of stress relieved strands are as follows,

Young's Modulus (E)	-	195000 MPa
Pre-stressing strands Nominal dia.	-	15.24 and Area – 140 mm^2
Ultimate Tensile Strength	-	1860 MPa
0.1% Proof stress	-	87% of minimum ultimate tensile strength (Clause 6.3.5 IRC: 112)
Maximum Jacking force	-	78.3% of UTS

Strand relaxation Loss shall not be more than 2.5% of 0.7 UTS tested at 1000 hours.

Density	-	78.5 kN/m^3
Coefficient of Friction	-	0.17/radian
Wobble effect	-	0.002/m
Anchorage Slip	-	6 mm

For Design purpose coefficient of friction and wobble effect shall be as per Table 7.1 of IRC: 112.

Thickness of Sheathing: The wall thickness will be as per clause 13.4.3 in IRC:112-2011

Sheathing: For internal longitudinal cables, Double Corrugated HDPE duct shall be used as per cl: 13.4.3 of IRC: 112-2011. For transverse prestressing steel corrugated flat ducts shall be used.

4.5.1 Young's Modulus

The Young's Modulus for the pre-stressing strands is taken as $E = 1.95 \times 10^5$ MPa

4.5.2 Elastic Shortening Loss

The loss due to elastic shortening will be computed as half the product of modular ratio and stress in concrete adjacent to the tendons averaged along the length of girder.

4.5.3 Losses due to Shrinkage, Creep and Relaxation

The shrinkage, creep and relaxation losses are calculated as per cl: 6.4.2.6, 6.4.2.7 and 6.3.6 of IRC: 112-2011.

4.5.4 Stay Cables

The stay cables are proposed as seven wire strands, coated (waxed and HDPE sheathed), low relaxation, grade 1860 MPa, weldless, conforming to EN 10138, with the following properties:

Nominal size (diameter)	: 15.7mm
Nominal mass	: 1.172 kg/m
Nominal area	: 150.0 mm^2
Nominal tensile strength	: 1860 N/mm^2
Relaxation	: 2.5% at 70% UTS
Apparent modulus of elasticity	: 195.0 kN/mm^2

The stay cable units will be 34T15 to 114T15 based on the design requirement.

The stay cables would be installed strand by strand and stressed in the same manner. With the longer stay lengths, greater consideration would need to be given to the provision of secondary cables and damping devices to limit possible wind/rain induced cable oscillations and deck movements due to vortex shedding.

4.5.5 Exposure Condition

The exposure condition is decided based on Table 14.1 of IRC: 112-2011. The exposure conditions for the structures is considered as “Severe”.

4.5.6 Concrete cover

The minimum clear cover to the reinforcement for various structural elements has been taken as listed below:

Pile, pile cap	: 75 mm (as per Cl. 14.3.2.1 (7) of IRC:112)
Pylons (below superstructure)*	: 75 mm
Pylons (above superstructure)*	: 45 mm
Superstructure*	: 45 mm
Crash barrier, median*	: 45 mm

* as per table 14.2 of IRC:112-2011.

5 Loads

5.1 Dead Load

The dead load includes self weight of the members estimated on the basis of unit weight of the material specified in cl: 4.2 of this report.

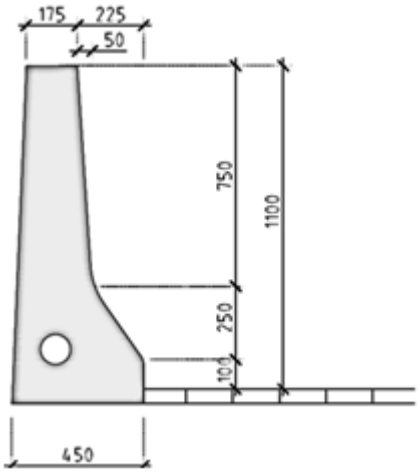
5.2 SIDL

5.2.1 Wearing Course

The wearing coat over the superstructure will consist of 65 mm thick bituminous concrete. An equivalent UDL of 1.36 kN/m^2 is considered as superimposed dead load due to wearing coat. 1.10 kN/m^2 is considered for future overlay.

5.2.2 Crash Barrier

New Jersey type crash barriers as per details in IRC: 5 [Fig. 4 (a)] (P1 type -"Normal containment category) are provided on the flyovers and along the ramps. These crash barriers are designed as per table 9 of IRC: 6-2017.



Weight of crash barriers = 0. 325 x 25 = 8.125kN/m.

Total weight of crash barriers = 8.125 **= 8.125 kN/m on each side**

5.2.3 Median Crash Barrier

3.0m wide median provided with New Jersey type crash barrier on either side to protect the stay cables.

5.2.4 Other Service facilities

Loads of service facilities such as electrical cables and telephone cables are considered as

Electrical cables - 1kN/RM per cable duct on either side

Telephone cables - 1kN/RM per cable duct on either side

Construction stage load of 1.5kN/m2 has been considered.

Walkway Load = 10kN/m on each side of carriageway.

5.3 Live Load

Live load is applied on the structure as per the influence surface for the critical live load positions.

Considering the carriageway to be three-lane carriageway for approach and four lane for main bridge, no of lanes and critical positions of live load on the bridge are considered as per cl:204.3 of IRC:6-2017 and governing of all these are considered in the design.

The cases for one carriageway loaded and both carriageways loaded shall be considered in the analysis.

Each of two traffic lanes within four lane carriageway will operate in opposite directions. Reduction as specified in cl: 205 of IRC: 6-2017 for multi lane loading shall be followed.

Minimum clear distance between the outer edges of passing vehicles shall be 1.2m in case of two class A vehicles or between Class A and Class70R vehicles.

Class 70R shall be considered for every two traffic lane width and no other live load shall be considered on any part of said two lane wide carriageway of the bridge.

5.3.1 Impact Factor (Q_{im})

Impact factor shall be considered for the Longitudinal and Transverse Design of Superstructure as per Clause 208 of IRC: 6-2017.

Full impact shall be considered up to top of pier cap only, thus bearing and pier cap shall be design for live load with full impact factor. For design of pier and foundation impact factor shall be multiplied by appropriate factors as in Clause 208.7 of IRC: 6-2017.

5.3.2 Congestion factor

Congestion factor shall be considered as per Table 7 of IRC: 6-2017. Under this condition, horizontal force due to braking/acceleration, centrifugal action, temperature effect and effect of transverse eccentricity of live load shall not be considered as per Clause 204.4 of IRC:6-2017.

5.3.3 Special Vehicle

Special vehicle as given in Clause 204.5 will be considered. Only one Special vehicle is considered to travel throughout the length of the bridge with a maximum eccentricity of 300mm from the centre of the carriage way and no successive vehicles shall be considered for design.

As per Sl. No. 3 of Amendment No 2/IRC:6/November 2017, wind, seismic, temperature gradient, braking force and dynamic impact on the live load need not be considered along with Special vehicle. The special vehicle shall move at a speed not exceeding 5kmph over the bridge.

For the load combination with Special vehicle, the partial safety factor on SV load for verification of equilibrium and structural strength under ULS and SLS Rare combination shall be taken as 1.15 and 1.0 respectively.

5.3.4 Dynamic allowance

For design of substructure and superstructure, impact or dynamic action is considered as per cl: 208 of IRC:6-2017.

5.3.5 Braking/Traction Force

Braking force is considered as per cl.211.2 and 211.3 of IRC: 6-2017.

5.3.6 Centrifugal force

Wherever the bridge is proposed along horizontal curve, the centrifugal force shall be calculated as per IRC: 6-2017.

5.4 Prestressing Force

(i) As per clause 7.9.2 of IRC: 112-2011, Jacking force is limited to 90 percent of 0.1 percent of proof stress

= 0.9 x (0.87 of UTS) = 0.783% of UTS.

(ii) The maximum prestressing force (after losses due to elastic shortening and anchorage slip) shall not be greater than 75 percent of UTS or 0.85 of 0.1 percent of proof stress whichever is less.

= (0.75 of UTS) or (0.85 x 0.87 of UTS = 0.7395 UTS).

Partial factors for prestressing force will be considered as per cl: 7.9.5 of IRC:112-2011.

5.5 Temperature Load

5.5.1.1 Superstructure

As per the maximum and minimum temperature Isopleths in latest amendments of IRC: 6 – 2017, the temperature range in Ponnani (Karipur) is 38.6^0C to 11.2^0 C.

- Highest maximum bridge temperature = 38.6^0C
- Lowest minimum bridge temperature = 11.2^0C
- Total variation of temperature = 38.6^0C – 11.2^0C = 27.4^0C
- Mean variation of temperature = 27.4^0C/2 = 13.7^0C

= ± (Mean variation of temperature + 10^0C)

= ± (13.7^0C +10^0C)

= ± 23.7^0C

However the linear temperature variation shall be considered as ± 25^0C.

Temperature gradient as shown in Fig. 17(a) of IRC: 6-2017 shall be considered for the design of superstructure.

The forces due to linear temperature variation shall be derived based on long term modulus of elasticity where as the effect of temperature gradient shall be assessed using short term modulus of elasticity.

5.5.1.2 Stay Cables

Uniform temperature differential of ± 8.0°C between stay cables and concrete structure (deck, pylons, end piers) shall be considered as per PTI recommendations for stay cable design, testing and installation.

5.5.1.3 Pylons

Linear temperature difference of ± 10.0°C shall be considered between the opposite faces of pylon.

5.5.2 Differential Temperature

Temperature gradient within the superstructure shall be derived from two cases,

a) Positive temperature difference due to solar radiation and other effects causes gain in heat through top surface of superstructure.
b) Negative temperature differences due to re-radiation and other effect causes loss of heat from top surface of bridge deck.

The temperature differences shall be assumed as shown in Fig. 10 of IRC: 6.

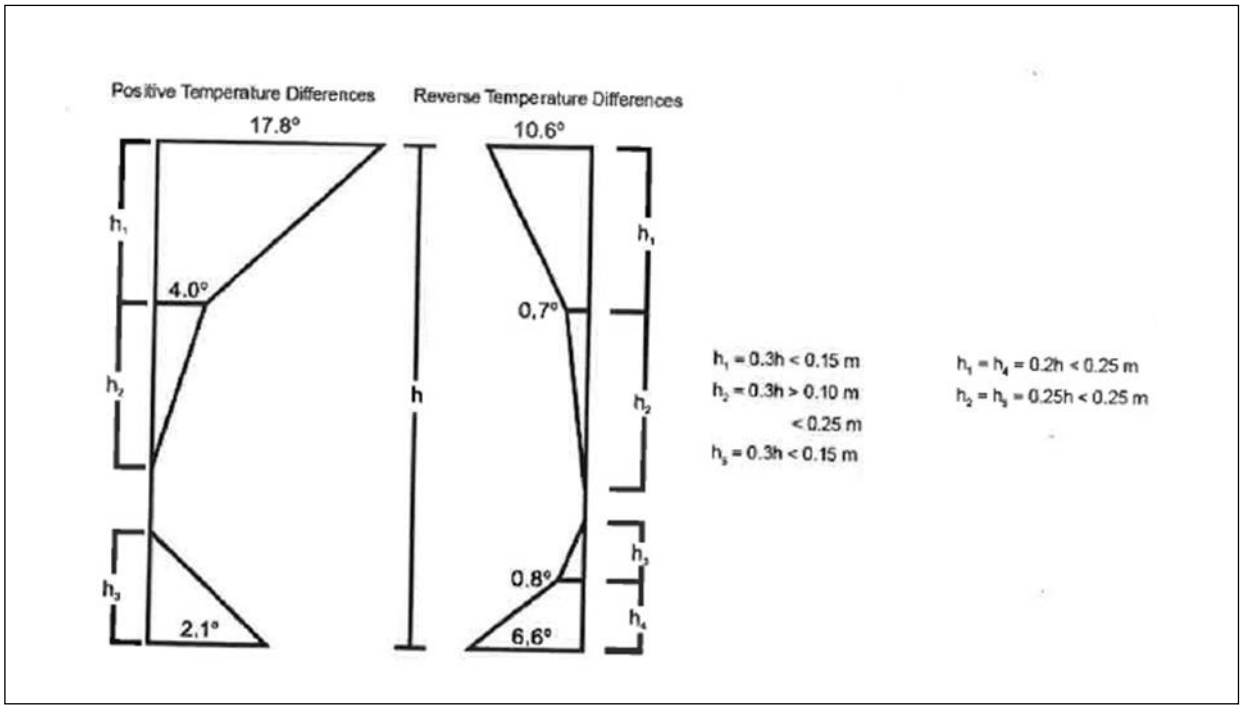


Figure 5-1 Design Temperature differences for Concrete Bridge Decks

Instantaneous modulus of elasticity of concrete shall be used for calculation of forces under temperature gradient (diurnal variation). Coefficient of thermal expansion for concrete is taken as 12 x 10^{-6}/°C as per Clause 215.4 of IRC: 6.

5.6 Wind Load

Wind loading acting on exposed areas of superstructure, substructure and live load is calculated in accordance with the clause 209 of IRC: 6-2017. The basic wind speed is considered as 39 m/s as per figure 10 of IRC: 6-2017

The intensity of wind force is based on hourly mean wind speed and pressure corresponding to plain terrain as shown in table below. This table corresponds to basic wind speed of 33 m/s.

Table 1 Hourly mean wind speed and wind pressures for 33m/s

H (m)	V_z (m/s)	P_z (N/m^2)
Upto 10	27.80	463.7
15	29.20	512.5
20	30.30	550.6
30	31.40	590.2
50	33.10	659.2
60	33.60	676.3
70	34.00	693.6

Hourly mean wind speeds mentioned in table above is modified by multiplying a factor 39/33 to obtain corresponding hourly mean wind speeds for basic wind speed of 39 m/s.

Hourly mean wind pressure mentioned in table above is modified by multiplying a factor $39^2/33^2$ to obtain corresponding hourly mean wind pressure for basic wind speed of 39 m/s. Thus, hourly mean wind speeds and pressures at different heights for plain terrain having basic wind speed of 39 m/s is as per the following table.

Table 2 Hourly mean wind speed and wind pressures for 39m/s

H (m)	V_z (m/s)	P_z (N/m^2)
Upto 10	32.85	647.64
15	34.50	715.80
20	35.81	769.02
30	37.10	824.32
50	39.11	920.70
60	39.70	944.58
70	40.18	968.74

For construction stage, the hourly mean wind speed and pressures will be taken as 70 percent of the value calculated above as per cl: 209.2 pt. (6) of IRC: 6-2014

In addition to clause 209 of IRC: 6-2017, wind forces are considered in following two ways for design

1. Full wind force at right angles to superstructure.
2. 65 % of wind force as calculated in (1) above acting perpendicular to the superstructure

   35 % acting in traffic direction.

Wind forces on stay cables will be considered as per the guideline given in PTI Recommendations for Stay Cable Design, Testing and Installation.

As per cl:209.3.7 of IRC:6-2017, The bridges shall not be considered to be carrying any live load when the wind speed at deck level exceeds 36 m/s.

5.7 Seismic Force

Seismic force shall be considered as per cl. 219 of IRC: 6-2017. The project site is located in zone III. Considering the complexities of the structural system elastic response spectrum method is used to assess the seismic response. This load will be considered on completed structure and also on partially completed constructed structure.

F_{eq} = A_h x (Dead Load + Appropriate Live Load)

Where, F_{eq} = Seismic force to be resisted

$$A_h = \frac{\left(\frac{Z}{2}\right)\left(\frac{Sa}{g}\right)}{\left(\frac{R}{I}\right)}$$

Z = Zone factor shall be as per Table 16 of IRC: 6-2017, equals to 0.16

I = Importance factor shall be 1.5.

T = Fundamental Period of Bridge Member for Horizontal Vibrations

R= Response Reduction Factor (4) without ductile detailing for substructure design. R=2.0 for superstructure and bearing designs.

$\left(\frac{Sa}{g}\right)$ = Average Response Acceleration Coefficient for 5% damping and function of the fundamental Period, T

For superstructure design, damping will be 2% and elastic spectra will be magnified by 1.4.

For design of foundations, the seismic force shall be taken as 1.25 times the forces transmitted to it by substructure.

For medium soil sites,
Type II soil with 10 < N ≤30

$$\frac{S_a}{g} = \begin{cases} 1 + 15\,T, & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.55 \\ 1.36/T & 0.55 \le T \le 4.00 \end{cases}$$

While calculating the effect of vertical seismic force on prestressed bridge superstructure, Sa/g obtained for 5 % damping is multiplied by 1.4.

Design seismic force resultants in all three orthogonal directions are combined as per rule defined in clause 219.3 of IRC: 6-2017

± r1 ± 0.3 r2 ± 0.3 r3

± 0.3r1 ± r2 ± 0.3r3

± 0.3r1 ± 0.3r2 ± r3

Where, r1, r2 and r3 are force resultant due to full design seismic force in longitudinal, transverse and vertical directions, respectively.

Live Load Components:

Seismic force due to live load shall not be considered when acting in the direction of traffic, but shall be considered in the direction perpendicular to the traffic as per clause 219.5.2 of IRC: 6-2017

The horizontal seismic force in the direction perpendicular to the traffic shall be calculated using 20% of live load (excluding impact factor).

Vertical seismic force is calculated using 20 % of live load excluding impact factor as per clause 219.5.2 of IRC: 6-2017.

5.8 Differential Settlement

The differential settlement shall be 50% of the gross settlement used to calculate safe bearing capacity. This shall be worked out from the soil parameters encountered at pile founding level. While deriving the effect of differential settlement, long term modulus of concrete of superstructure (half the short term modulus of concrete) shall be taken.

5.9 Water Current Forces

Effect of water currents shall be considered as per clause 210 of IRC: 6-2017. Design mean velocity for water current is 3m/s shall be considered in design.

5.10 Barge Impact

The substructure and foundations for all piers in the river portion shall be designed for barge impact as per cl:220 in IRC:6-2017. The design impact force is considered as 250 t acting at 1m above HFL/HTL.

5.11 Fatigue for Stay Cables

Fatigue criteria for stay cables shall be based on SETRA Stay Cable Recommendations of French Interministerial Commission on Pre-stressing, but the fatigue load shall be a as per Cl. 204.6 of IRC:6-2017 occupying a single lane in each traffic lane, with 50% dynamic load allowance.

5.11.1 Stay Cable Replacement

The structure and stay cables shall be designed to allow for removal of any one of the cable stays under service conditions. The strands shall be replaced one by one in the cable group. The live load on lanes on either side of the stay cable plane shall be closed during replacement. Loads and load factors to be considered during stay cable replacement of the main bridge shall be as per Cl.C.5.4 of PTI recommendations for stay cable design, testing and installation.

5.11.2 Cable Stay Loss

The main bridge structure shall be designed for the loss of a stay as per Cl.C.5.5 of PTI recommendations for stay cable design, testing and installation. This effect shall be considered by considering 1.5 times the force in the stay in the opposite direction of break. This shall be checked under ULS accidental combination.

5.12 Erection Forces and Effects

The weight of all permanent and temporary materials together with all other forces and effects which can operate on any part of structure during erection has been taken into account. Allowance has been made in the design for stresses caused in any member that may occur during erection and construction.

6 Load Combinations

The load combinations for the design of various structural elements are taken as per Annex B of IRC: 6-2017 for Limit State of Design.

7 Design Basis

7.1 Superstructure-Cable stayed bridge

Three cell PSC segmental box girder is used for the superstructure of the main cable stayed bridge. The length of typical segment will be limited to about 3.0m to control the weight of the segments during handling. Pier table at the pylon locations provide integral connection of substructure and superstructure.

The box girders will be erected segment by segment by balanced cantilever construction method with epoxy joints. Adequate internal post-tensioning is provided for both service & ultimate load conditions.

segments shall be cast using short line method. The analyses of the box girder will be carried out on following basis.

Longitudinal effects such as dead loads, post-tensioning, creep, shrinkage, steel relaxation, construction effects (locked-in moments) shall be determined using staged/phased construction analysis programs in MIDAS civil software. This software accounts for staged construction features such as addition of segments, stressing of tendons & stays, support movements in each erection phase. This software has capability to determine the time dependent effects such as creep, shrinkage and steel relaxation.

2D analysis with beam elements shall be used for longitudinal analysis to account the global effect due to permanent/transient loads. To assess the transverse local effects in the box girder 2D analysis shall be followed.

Ultimate resistance of the box girder in flexure is determined in accordance with Section 8 of IRC: 112-2011.

Shear Resistance of the Box-girder shall be in accordance with IRC 112 Section 10

Permissible Stress in segment joints during service are in accordance with Clause 12.2 of IRC: 112-2011:

The compressive stresses in concrete under service (rare) load combinations shall not exceed 0.48 f_{ck}

The stresses at the least compressive face under Rare Combination of Loads shall be limited to minimum residual compression of 0.5 MPa in case of epoxy jointed precast segments as per Clause 3.2 of IRC:SP: 65.

Where compressive stresses in concrete under quasi-permanent load combination exceeds 0.36 f_{ck}, non-linear creep shall be considered as per A-2 of IRC 112.

In case of precast segmental elements joined by pre-stressing, the stresses in the extreme fibre of concrete shall always be compressive and minimum compressive stress shall not be less than 5% of maximum permanent compressive stress of the section.

Permissible Stress in segment joints during construction:

The compressive stress in concrete during construction shall not exceed 0.48 f_{ck},

At initial transfer, the cube strength of concrete shall not be less than 0.8 f_{ck}.

No tensile stress is permitted in concrete.

7.2 Superstructure-Approach

7.2.1 Longitudinal Action:

The method of analysis of RCC T-beam girder for various structural behaviours is explained in following steps:

1. The piers and continuous span unit is modelled as a grillage in STAAD. The RCC T-beam girder /composite long/short term, section properties are considered for the loads.
2. The moment and shear forces are calculated from the grillage model at critical sections.

7.2.2 Transverse Action:

Deck slab is analyzed, as a continuous slab of unit width and reinforcement shall be provided for the same. The continuity reinforcement shall be provided on the deck slab at the location of continuous supports/piers. The same shall be designed as per stress limitation.

7.3 Stay Cables

Design of Stay Cables for this bridge shall satisfy both strength and service (rare) load combinations of IRC-6-2017 Appendix B. Fatigue criteria shall follow the guidelines provided in SETRA Stay Cable Recommendations of French Interministerial Commission on Prestressing to verify that fatigue in stay cables does not govern.

Stay Cable stresses at the factored load (ultimate) and service (rare) load conditions shall satisfy the following, as per SETRA Stay Cable Recommendations of French Interministerial Commission on Pre-stressing for ductile Bridges:

Ultimate Limit States: $F_{ULS} \leq 0.70\ F_{GUTS}$

Provided that stay cable system shall satisfy Category B mechanical tests as defined in Chapter 11 of SETRA Stay Cable Recommendations or Appendix Schedule D of the tender specifications.

Serviceability Limit State: $F_{SLS} \leq 0.50\ F_{GUTS}$

In the absence of detailed fatigue analysis it is recommended to limit the service stress in stay cable as $0.45F_{GUTS}$

Free length of stay cables shall consist of parallel strands, and strands shall have minimum two layers of nested protection against corrosion in the form of

Coated strands, filled with microcrystalline wax and individually sheathed with HDPE

External, continuous, light coloured, weather resistant HDPE stay pipe

It is envisioned that no external damping is required for the stay cables due to their short lengths. This shall be confirmed by a vibration analysis by the stay supplier to achieve minimum performance criteria established by the designer.

7.4 Pylons

The boat shape of pylon is proposed as rectangular two leg tower with rounded corners to improve aesthetics and to reduce wind and water current force. The pylons shall be of cast in place reinforced concrete have integral connection with the deck and pile cap.

Seismic design of pylon will be in accordance with both IRC: 112 and IRC: 6-2017 for seismic zone III.

The response acceleration coefficient will be based on the hard soil site conditions, for both no-scour or seismic scour conditions as average N within first 30m (or 100ft) soil strata exceeds 30. Response reduction factor shall be used as 4.0 (with ductile detailing) for substructure design. For superstructure & bearing designs, response reduction factor or ductility shall be 2.0. The importance factor shall be 1.5 for this project and I/R shall not be greater than 1.0. Global Response spectrum analyses will be performed using cracked sections, and moment of inertia of cracked sections shall be limited to 75% of gross sectional properties of the pylons and deck as per IRC: 6-2017.

Pylon sections shall be designed for ULS load combinations and shall be checked for serviceability for limits of crack width and material stresses as per Section 12 of IRC: 112-2011.

Limiting crack width considered for the design is as shown below,

- Crack width = 0.3 mm above H.T.L+1.5m for ‘severe’ exposure condition.

7.5 Design of Pile Foundation

The design principles for piles and pile cap for the Cable stayed Bridge is described in the following sections. The general arrangement and layout of piles and pile cap will be in accordance with cl: 709.1 of IRC: 78-2014.

Seismic design approach of the project shall be based on weak column/strong foundations in order not to have any damage in the foundations during a seismic event. For foundations, seismic loads from all sources shall be increased by 25% (over strength factor of 1.35) as per section 219.8 of IRC: 6-2017.

7.5.1 Estimation of Pile Capacity

The static vertical capacity of pile is estimated in accordance with cl. 709.3.1 and Appendix 5 of IRC: 78-2014 and Annex B of IS: 2911 (Part 1/Sec 2)-2010. The ultimate static vertical

capacity of the pile is estimated as the sum of end bearing and skin friction and the factor of safety for working out the safe working load will be as per cl. 709.3.2 of IRC: 78-2014.

The lateral load capacity of pile is estimated in accordance with cl. 709.3.5 of IRC: 78-2014 and cl. 6.5.2 and Annex C of IS: 2 911 (Part 1/Sec 2)-2010. Maximum lateral load on any pile under normal conditions shall not exceed the value corresponding to horizontal deflection (produced at the scour level) of 1% of diameter of pile.

The uplift capacity of pile is estimated in accordance with cl. 709.3.6 of IRC: 78-2014.

Under wind and seismic conditions the maximum vertical force acting on pile shall not exceed 125% of load carrying capacity. Under temperature conditions the maximum vertical force acting on pile shall not exceed 115% of vertical load carrying capacity as per cl: 706.1.2 in IRC: 78-2014.

7.5.2 Pile Load Test

The initial load tests for piles shall be suggested in accordance with cl. 709.2 of IRC: 78-2014. The safe load shall be taken from the initial test. Initial test shall be conducted for a load of 2.5 times the safe vertical load, based on static formula.

The working load on pile shall be checked by conducting routine tests. Routine tests shall be conducted for checking vertical load carrying capacity of the working piles. Vertical load test shall be conducted for a load of 1.5 times for allowable load.

7.5.3 Structural Design of Pile and Pile Cap

The structural design of pile and pile cap will be carried out under limit state method in accordance with cl. 709.4 and cl. 709.5 respectively of IRC: 78-2014 and the relevant clauses of IRC: 112-2011.

For the computation of bending moments along the pile length, due to horizontal forces, the pile cap will be assumed as rigid. Pile will be considered as having fixed head.

Bending moment shall be worked out by soil pile interaction analogy.

Pile cap shall be designed based on bending theory as per IRC: 112, soil structure interaction will be ignored for the design of pile cap.

Serviceability limit state checks on permissible stresses and crack width are done as per Section 12 of IRC: 112 – 2011. Limiting crack width considered for the design is 0.2mm corresponding to ‘very severe’ exposure condition.

8 Construction Methodology

The basis of design outlined here has been formulated in line with the methodology for construction of the main bridge and approach envisaged and described in the following sections.

8.1 Superstructure –Cable stayed bridge

Balanced cantilever construction combined with stay cable erection is proposed for the superstructure of the Cable stayed Bridge. In the balanced cantilever method of construction the superstructure of bridge is built from one or more pylons by means of lifting frame. In this method the structure advances from a short stub on top of a pylon symmetrically in segments

of about 3.0m length to the mid span or to an end pier. The pylon segment needs to be constructed prior to the start of cantilevering to provide a working platform from which the two lifting frames can start launching. It also includes diaphragms that facilitate the flow of forces from the cantilever arms into the pylon. The details of construction stages are given in the are described below.

1. Pile and pile cap shall be casted first.
2. The lower pylon will be cast up to bottom of pier table by leaving dowels for casting superstructure.
3. Cast the superstructure on either side of pylon monolithically on staging from pile cap for a length specified in the detailed drawings.
4. Assemble the segment erector on constructed superstructure.
5. Upper pylon is cast simultaneously with the superstructure errection activities.
6. Bring the precast segment and keep under the proposed bridge from where it to be lifted.
7. Lift the precast segment on either side of the pylon and align to do the stitch concrete between precast and cast in situ face.
8. Complete the longitudinal prestressing to release the segment from segment erector.
9. Place the next two precast segments on either side of pylon and do the temporary prestressing.
10. Place the next two precast segments on either side of pylon and do the internal prestress to release the segment from the erector.
11. Place the next two precast segments on either side of pylon and do the temporary stressing to hold the segment in position, and then do the stressing of stay cables from the internal diaphragm of the segment.
12. Repeat stage 8 & 9 until it completes the total span on either side.
13. Keep the key segment and do the internal prestressing to make the whole span continuous.
14. Stress the stay cables for final force.
15. Apply other SIDL loads.

8.2 Superstructure – Approach Portion

Structural concept adopted for straight spans (two lane carriageway) is pre-cast I girder with cast in-situ deck slab. The following construction methodology has been considered in the analysis and design of various structural elements.

- Stage 1 (At casting yard)
  - The girders are cast at the casting yard and brought to the site after achieving the specified age and strength.
- Stage 2 (At site)
  - The girders are supported on temporary supports.
  - The diaphragms and part of in situ portion of deck slab over the diaphragms are cast.

- Temporary supports are removed to make the girder integral with diaphragms after the structure becomes monolithic, after achieving strength of 35MPa.
- Remaining portion of cast-in-situ deck slab is cast in one go.
- The wearing coat, median and crash barriers are cast.

8.3 Substructure and Foundation

Pier and pylon are constructed as in-situ concrete sections monolithic with rigid deck. Pile foundation is proposed for the new bridge with 1.5m diameter bored cast-in-situ piles.

9 Analysis and Design

The analysis of the whole structure has been done by modelling the structure using beam elements in Midas Civil software. The sectional properties of the beam elements has been given corresponds to the actual geometry of the proposed structure. The model is made assuming a fixed support at the top of the pilecap. The analysis has been divided into construction stage and service stage. The in-built module in the software is used for the construction stage analysis which take care the age effect of the material, sequential stressing of the stay and internal pre-stress cables, change in the static system of the structure etc. The model used for the analysis is shown in Figure 9-1. *It is observed that the secondary effects due to age effect are insignificant until the key segment is attached. Hence the analysis is done for the superstructure at 2 pylons simultaneously.*

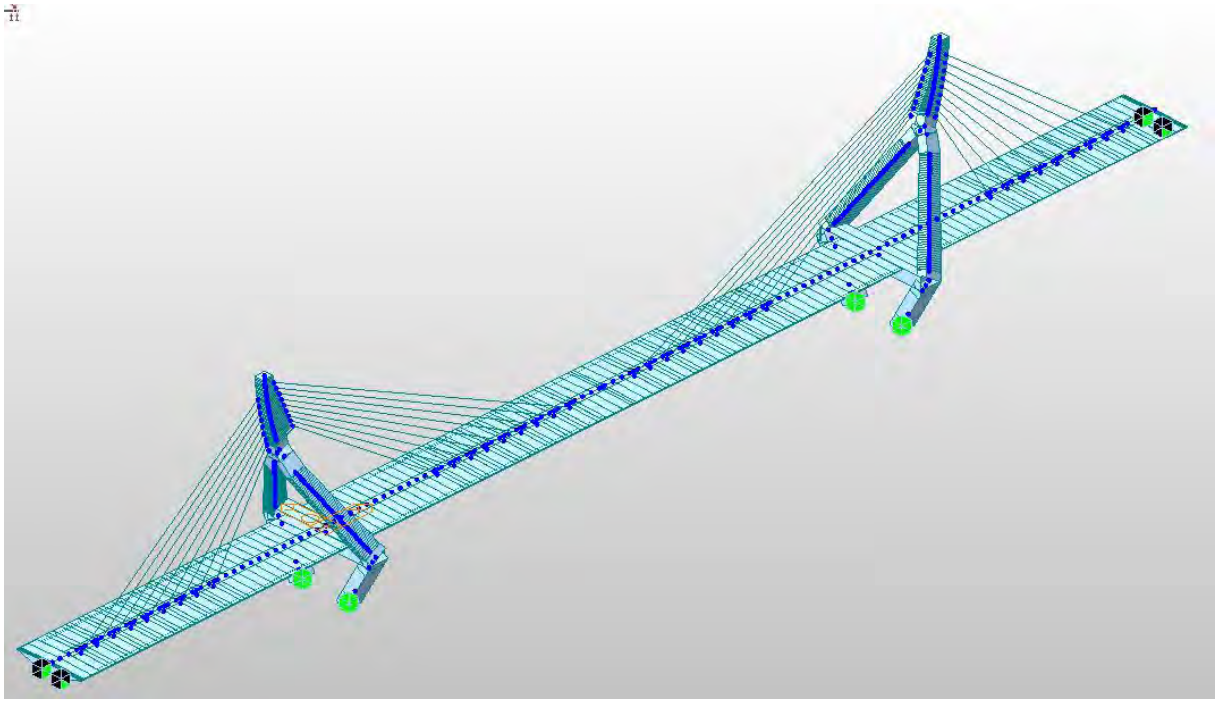


Figure 9-1: Model for the longitudinal analysis

9.1.1 Superstructure - SLS

The maximum compression in concrete during construction and service is limited to $0.48f_{ck}$ (28.8 MPa). In segmental joint no tensile stress is permitted during construction whereas in the cast in-situ portion the tensile stress is limited to tensile strength of concrete (f_{ctm}). During service condition the minimum compressive stress in segment joint is maintained as 0.5 Mpa

and no tensile stress in the cast in-situ portion. The top and bottom fibre stress during construction and service in SLS Rare combination for each activity are shown below.

9.1.2 Construction Stage Stress Plots

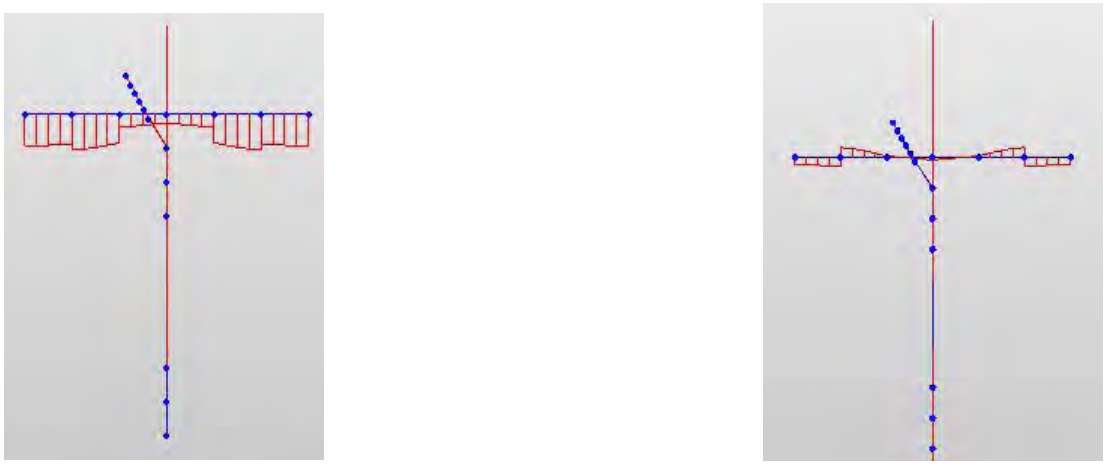


Figure 9-2: Stress plot at top and bottom after erection of S1 Segment respectively.

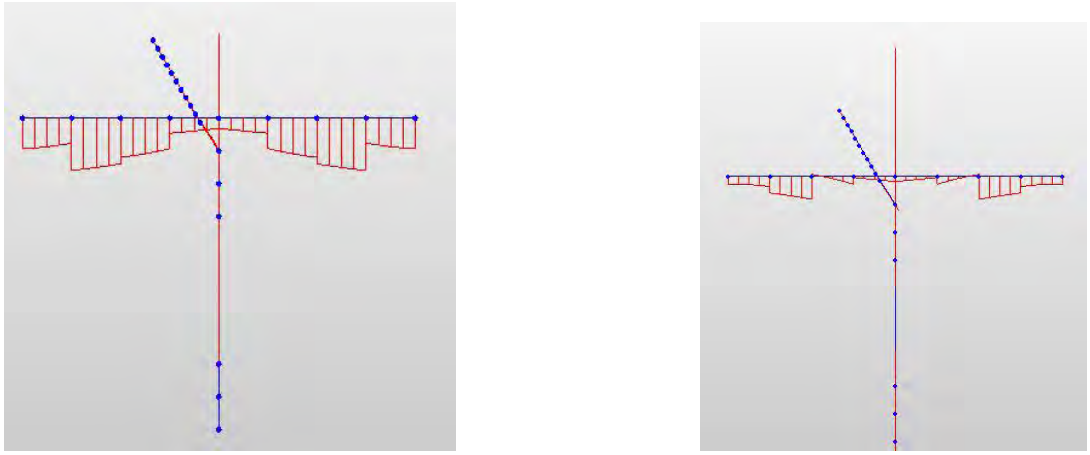


Figure 9-3: Stress plot at top and bottom after erection of S2 Segment respectively.

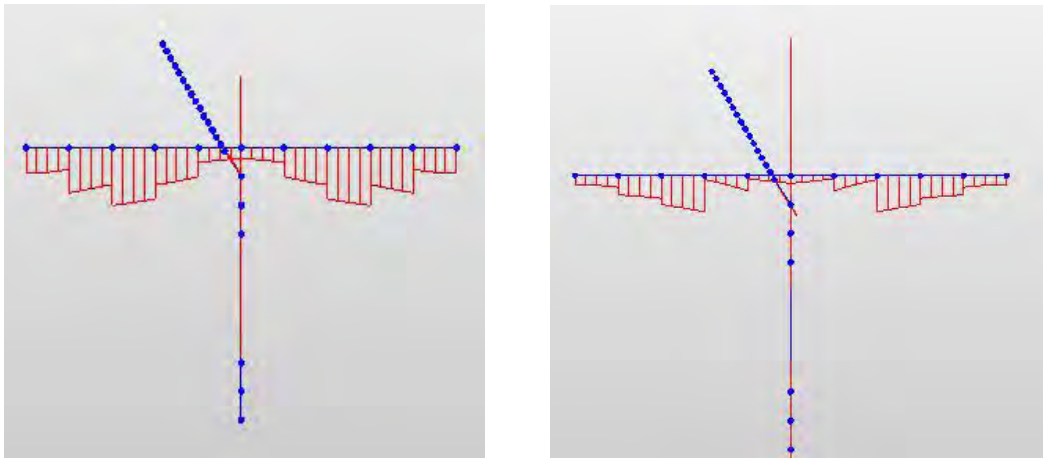


Figure 9-4: Stress plot at top and bottom after erection of S3 Segment respectively.

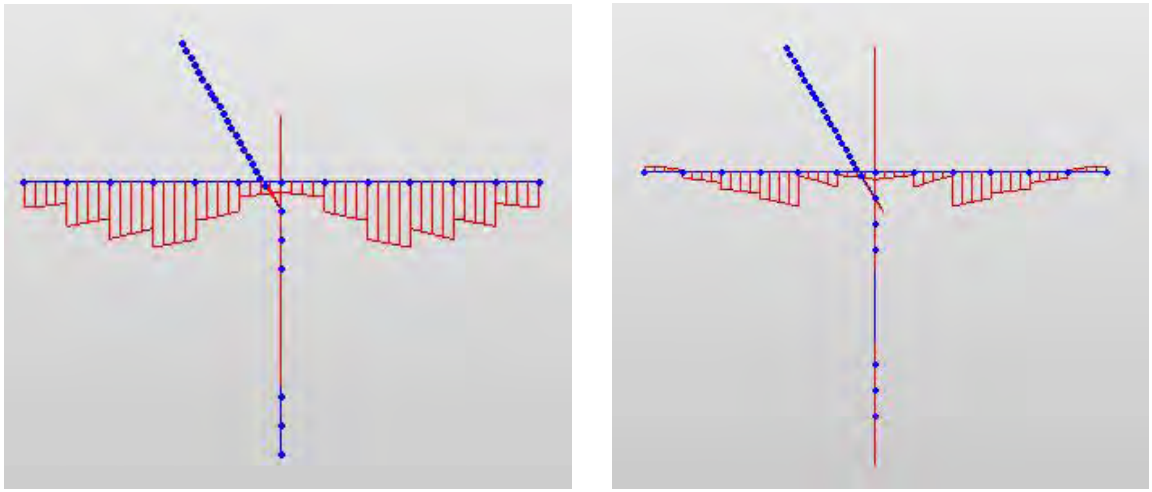


Figure 9-5: Stress plot at top and bottom after erection of S4 Segment respectively.

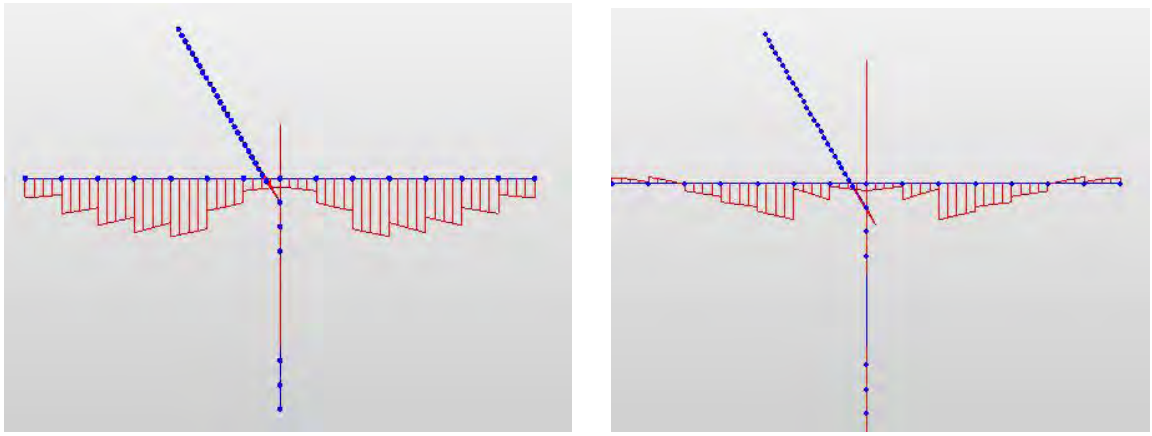


Figure 9-6: Stress plot at top and bottom after erection of S5 Segment respectively.

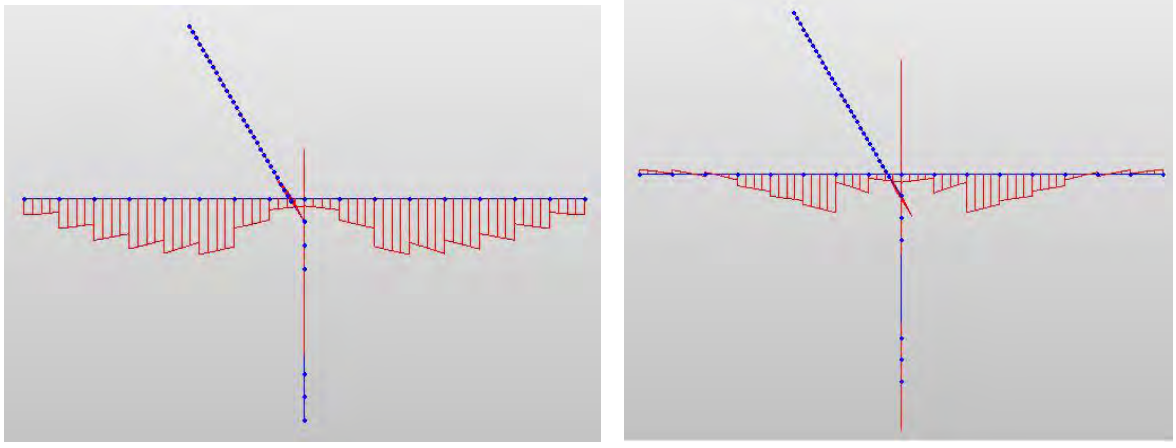


Figure 9-7: Stress plot at top and bottom after erection of S6 Segment respectively.

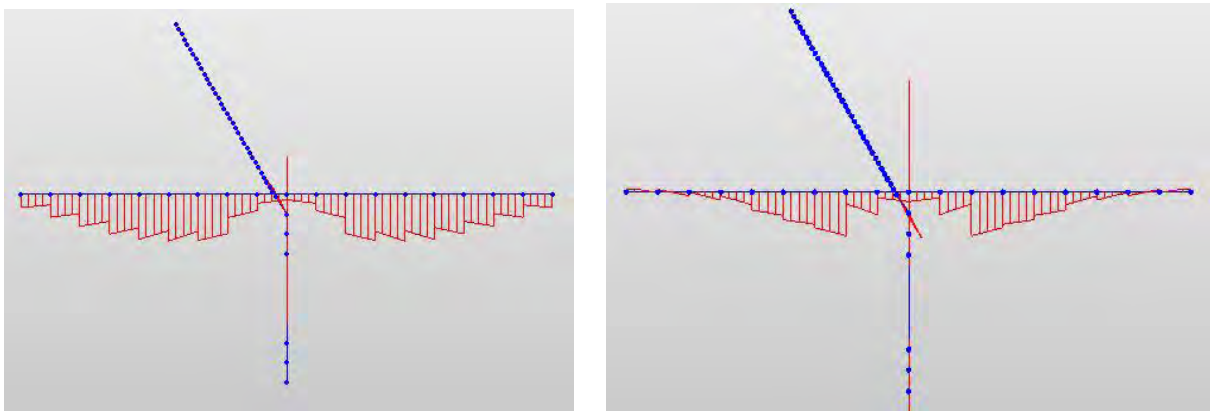


Figure 9-8: Stress plot at top and bottom after erection of S7 Segment respectively.

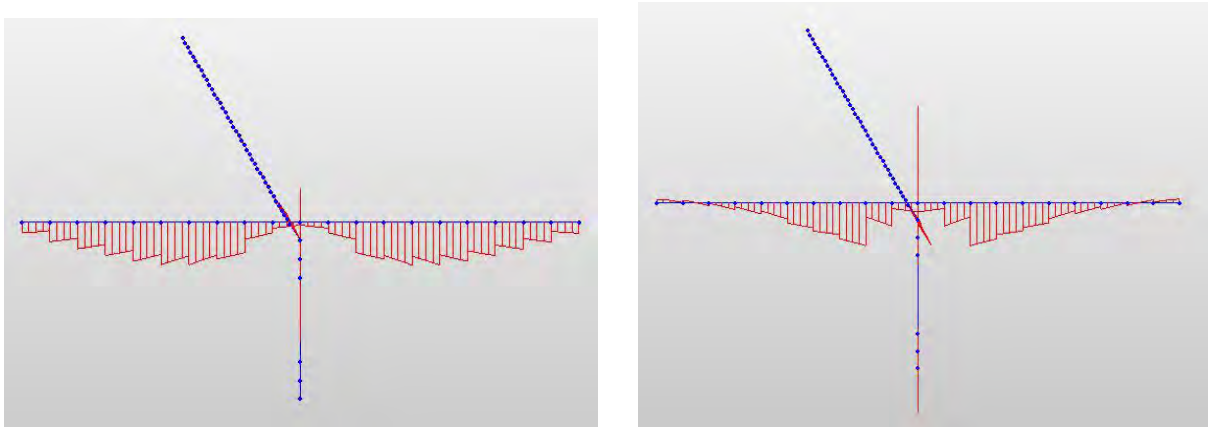


Figure 9-9: Stress plot at top and bottom after erection of S8 Segment respectively.

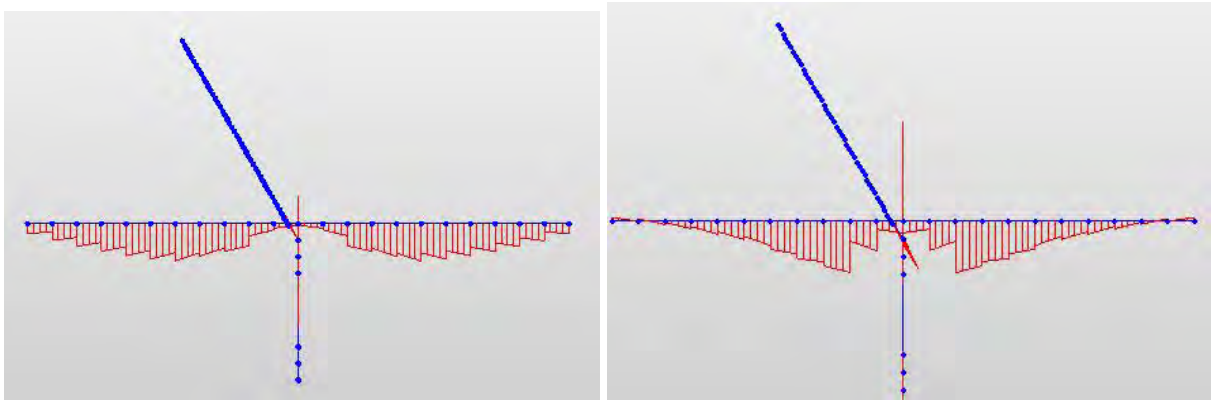


Figure 9-10: Stress plot at top and bottom after erection of S9 Segment respectively.

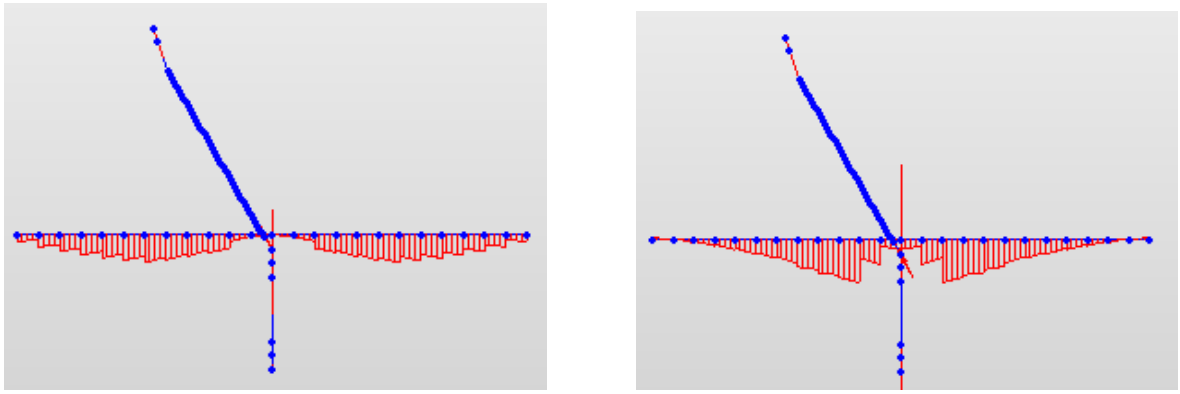


Figure 9-11: Stress plot at top and bottom after erection of S10 Segment respectively.

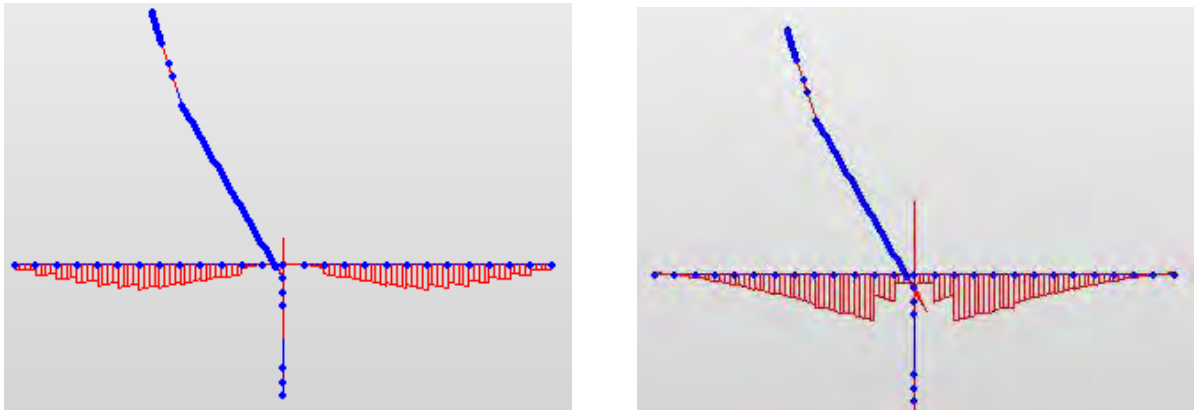


Figure 9-12: Stress plot at top and bottom after erection of S11 Segment respectively.

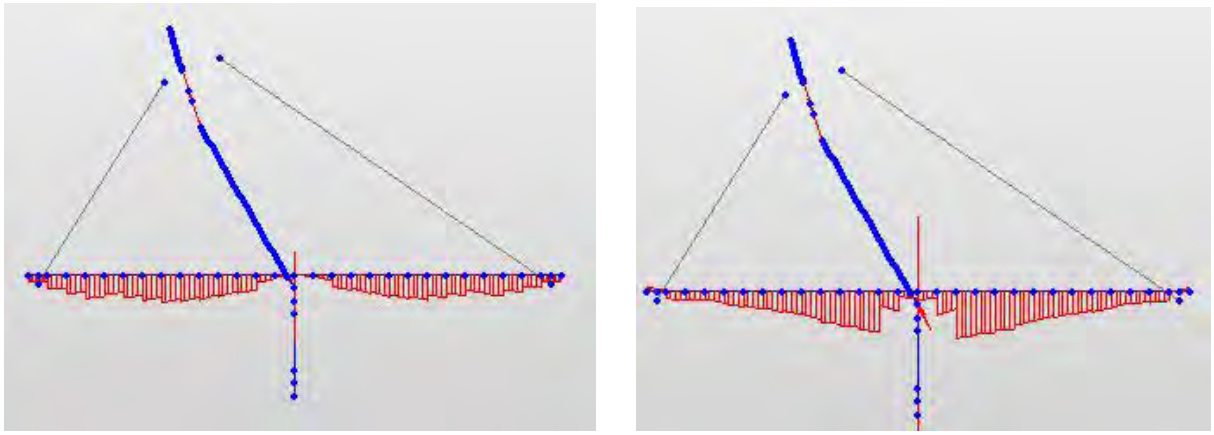


Figure 9-13: Stress plot at top and bottom after erection of S12 Segment respectively.

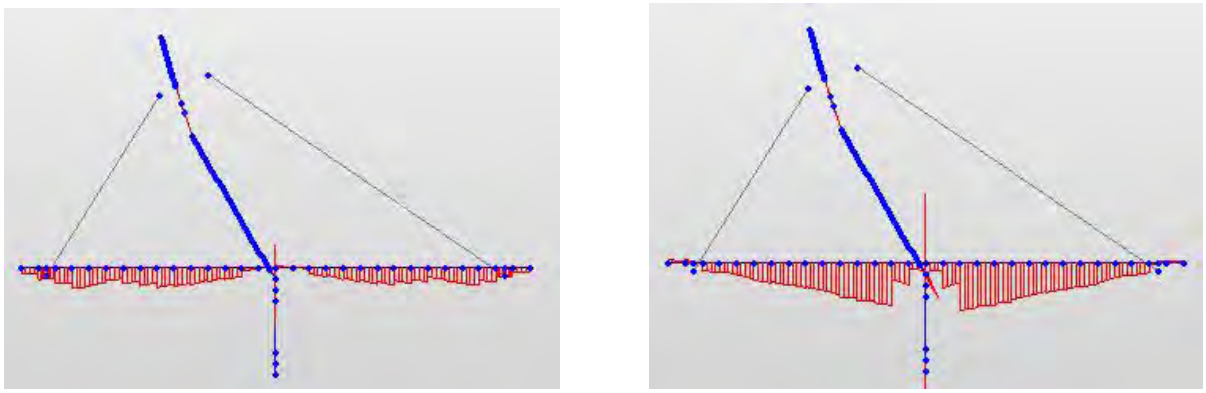


Figure 9-14: Stress plot at top and bottom after erection of S13 Segment respectively.

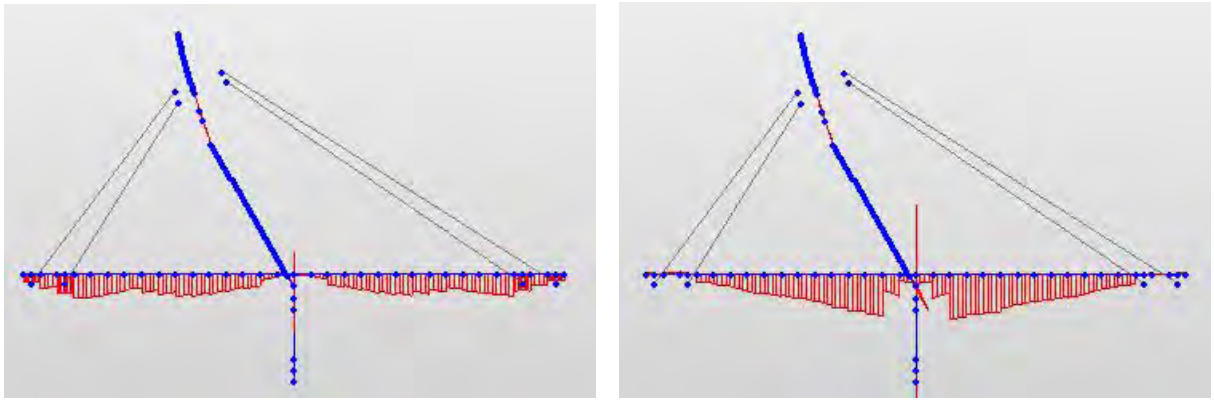


Figure 9-15: Stress plot at top and bottom after erection of S14 Segment respectively.

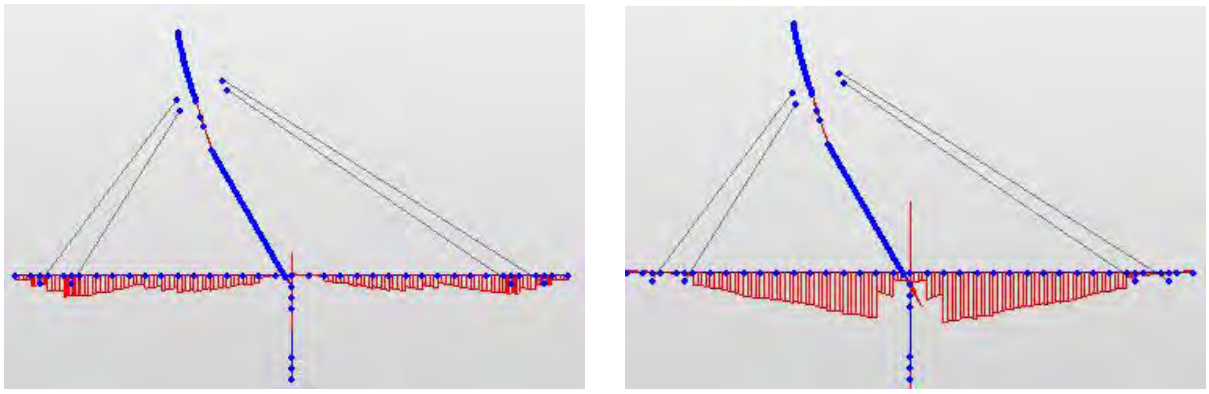


Figure 9-16: Stress plot at top and bottom after erection of S15 Segment respectively.

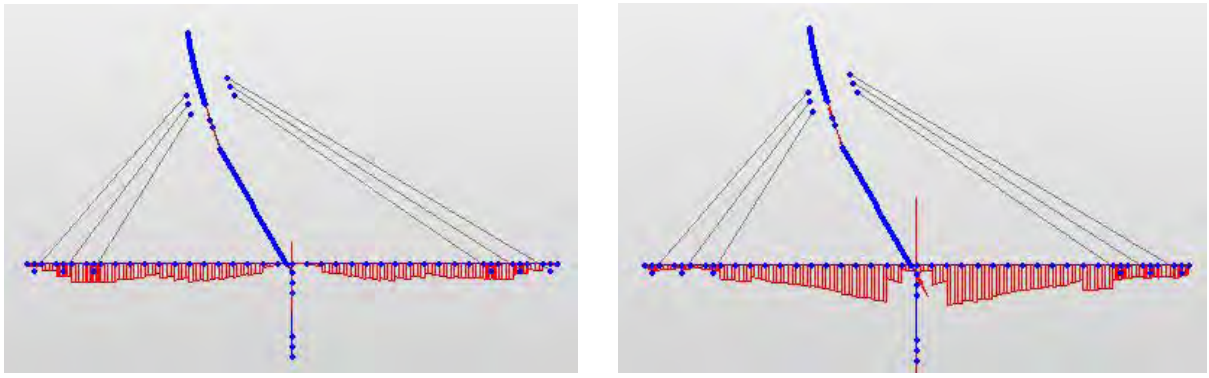


Figure 9-17: Stress plot at top and bottom after erection of S16 Segment respectively.

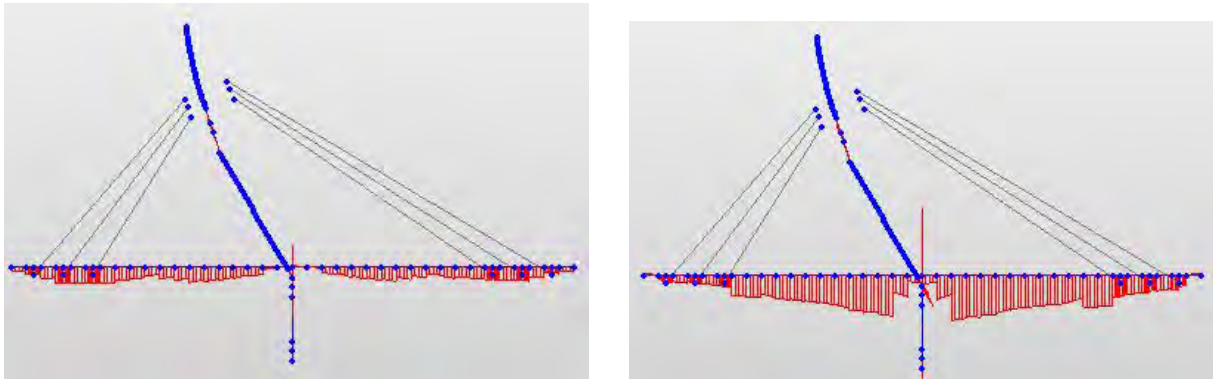


Figure 9-18: Stress plot at top and bottom after erection of S17 Segment respectively.

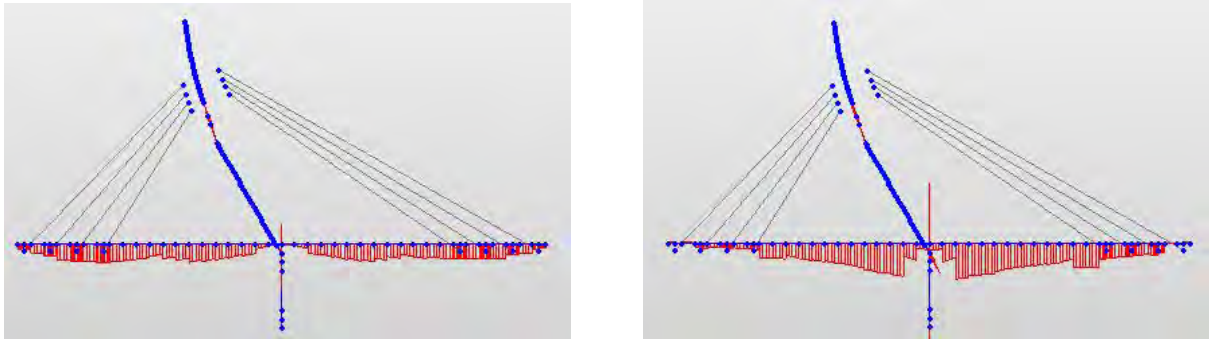


Figure 9-19: Stress plot at top and bottom after erection of S18 Segment respectively.

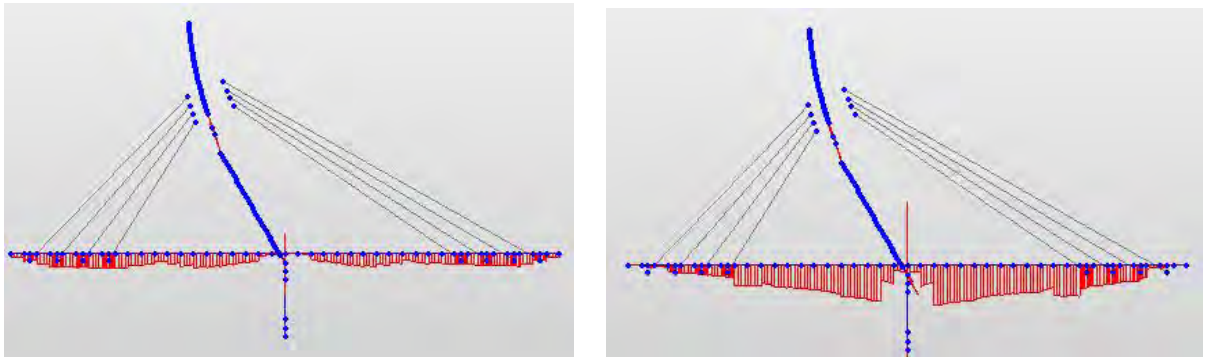


Figure 9-20: Stress plot at top and bottom after erection of S19 Segment respectively.

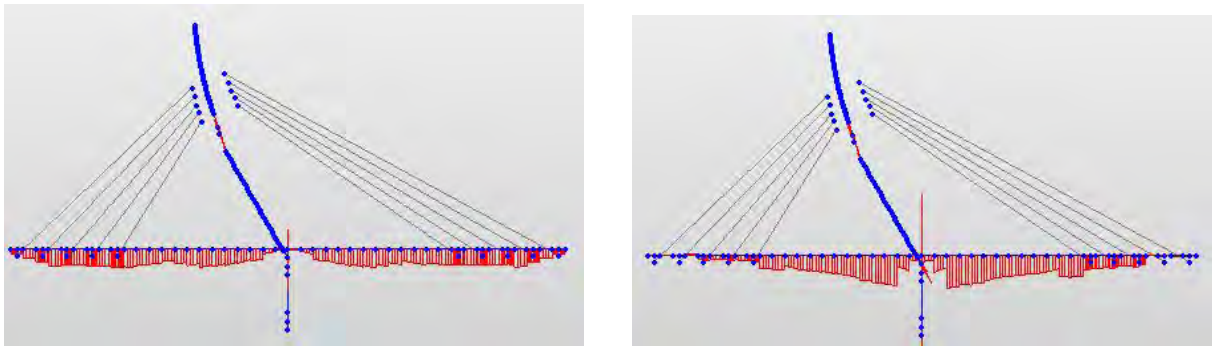


Figure 9-21: Stress plot at top and bottom after erection of S20 Segment respectively.

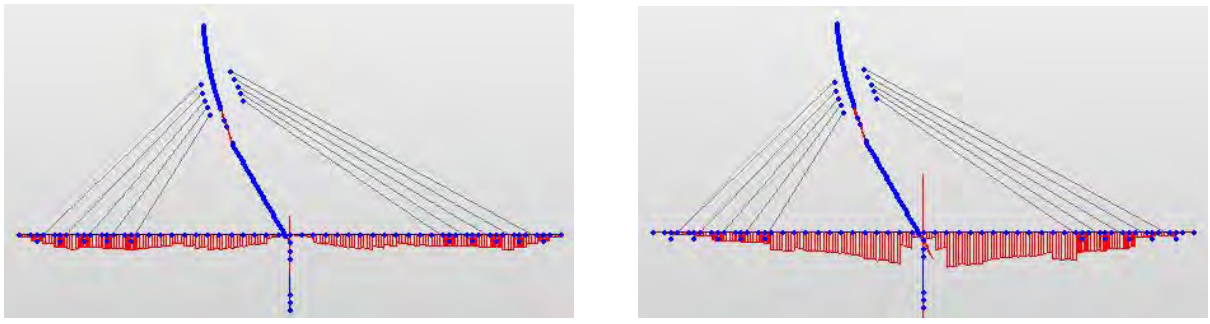


Figure 9-22: Stress plot at top and bottom after erection of S21 Segment respectively.

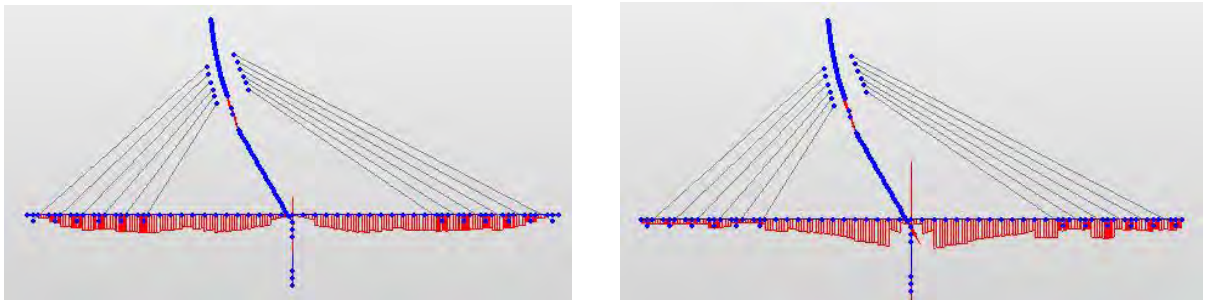


Figure 9-23: Stress plot at top and bottom after erection of S22 Segment respectively.

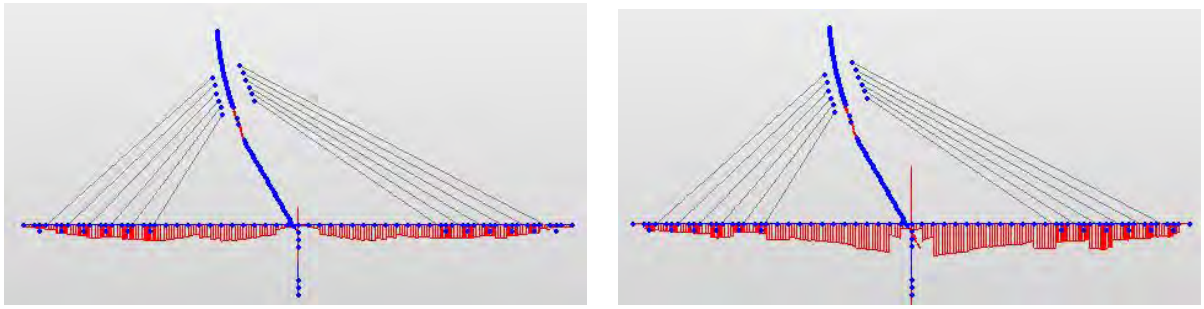


Figure 9-24: Stress plot at top and bottom after erection of S23 Segment respectively.

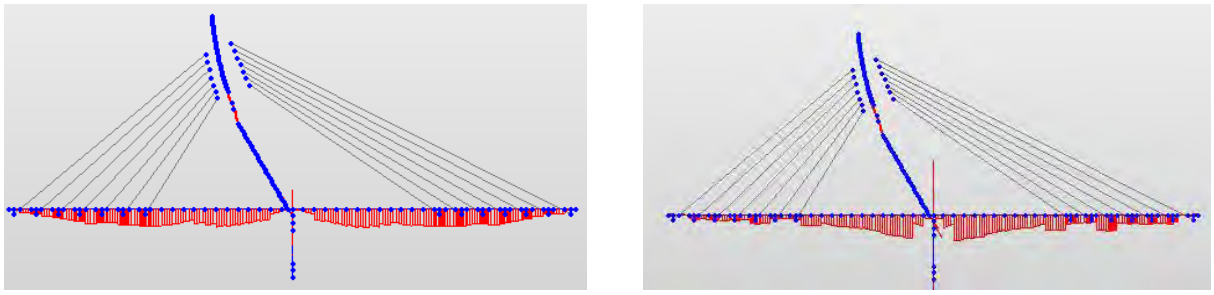


Figure 9-25: Stress plot at top and bottom after erection of S24 Segment respectively.

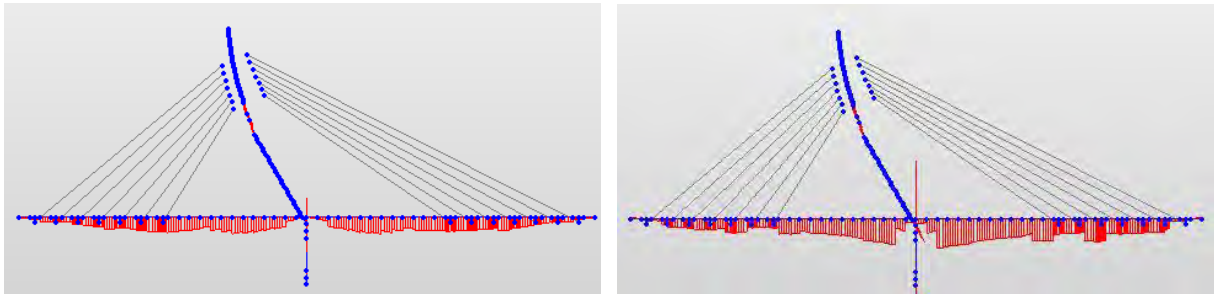


Figure 9-26: Stress plot at top and bottom after erection of S25 Segment respectively.

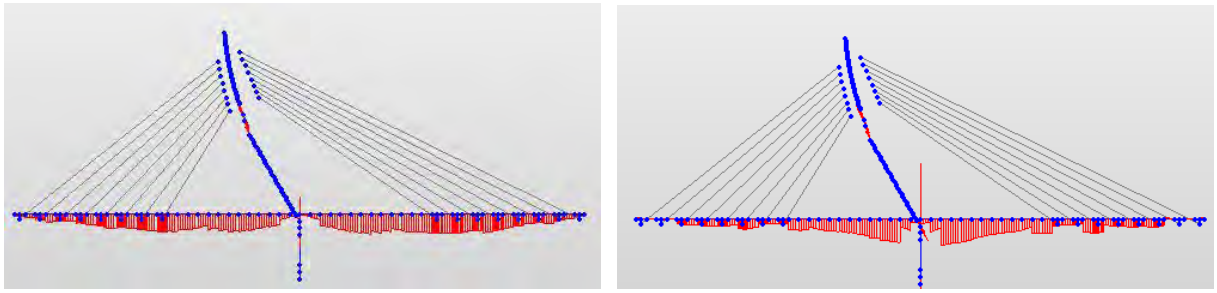


Figure 9-27: Stress plot at top and bottom after erection of S26 Segment respectively.

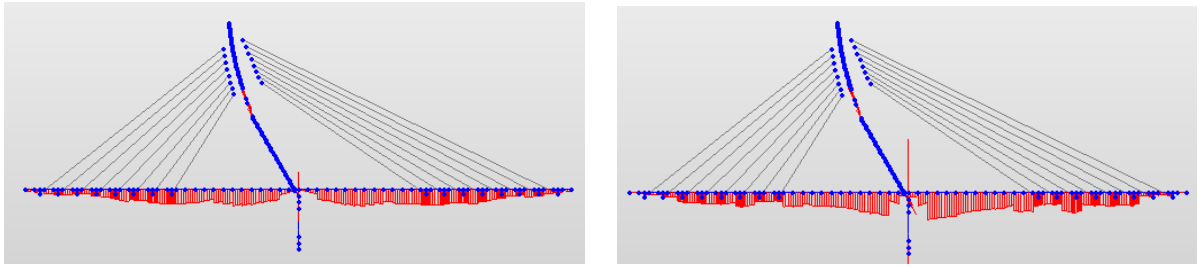


Figure 9-28: Stress plot at top and bottom after erection of S27 Segment respectively.

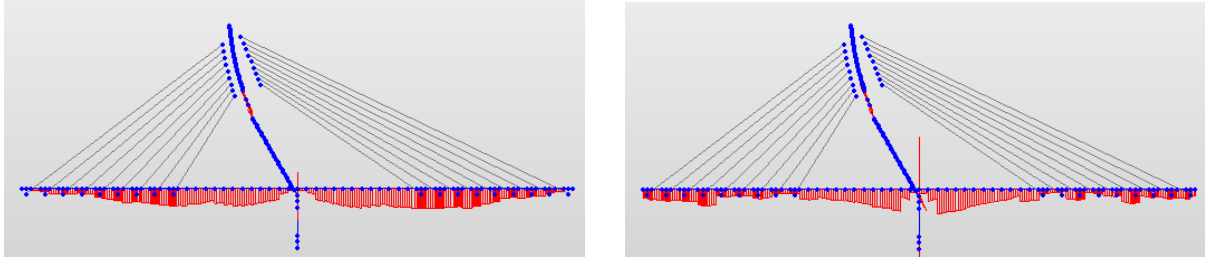


Figure 9-29: Stress plot at top and bottom after erection of S28 Segment respectively.

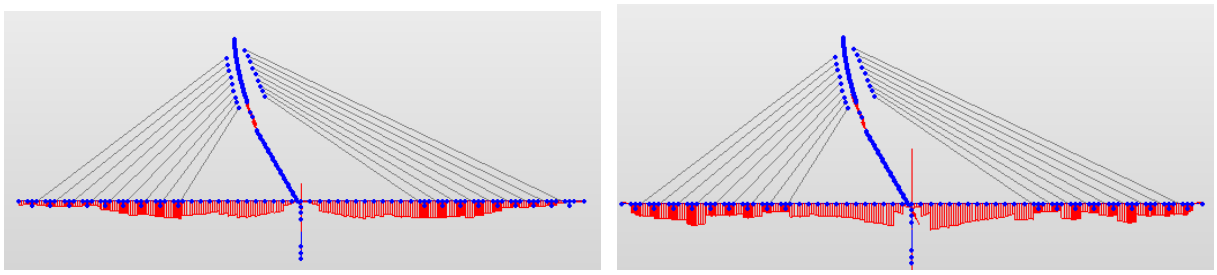


Figure 9-30: Stress plot at top and bottom after erection of S29 Segment respectively.

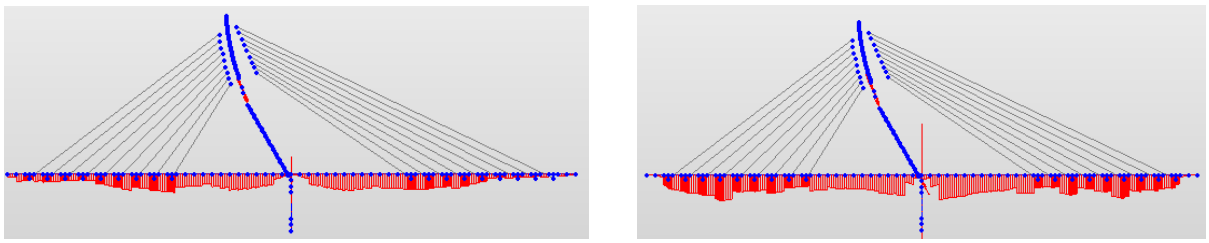


Figure 9-31: Stress plot at top and bottom after erection of S30 Segment respectively.

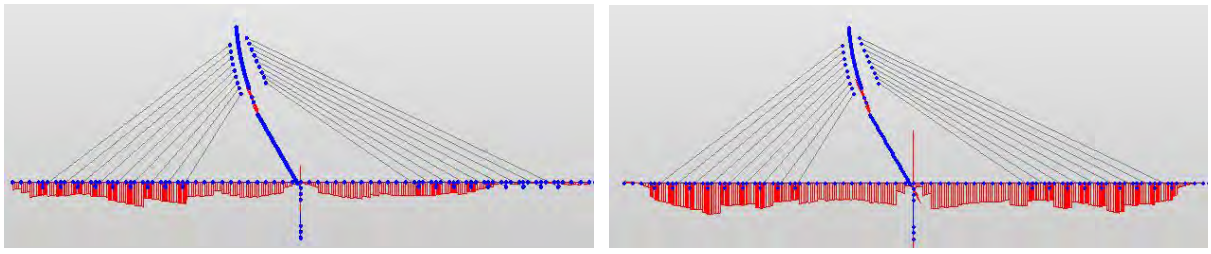


Figure 9-32: Stress plot at top and bottom after erection of S31 Segment respectively.

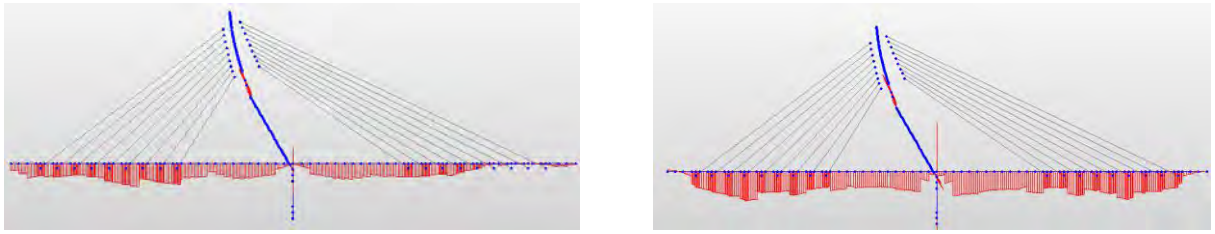


Figure 9-33: Stress plot at top and bottom after placing 10T arrangement respectively.

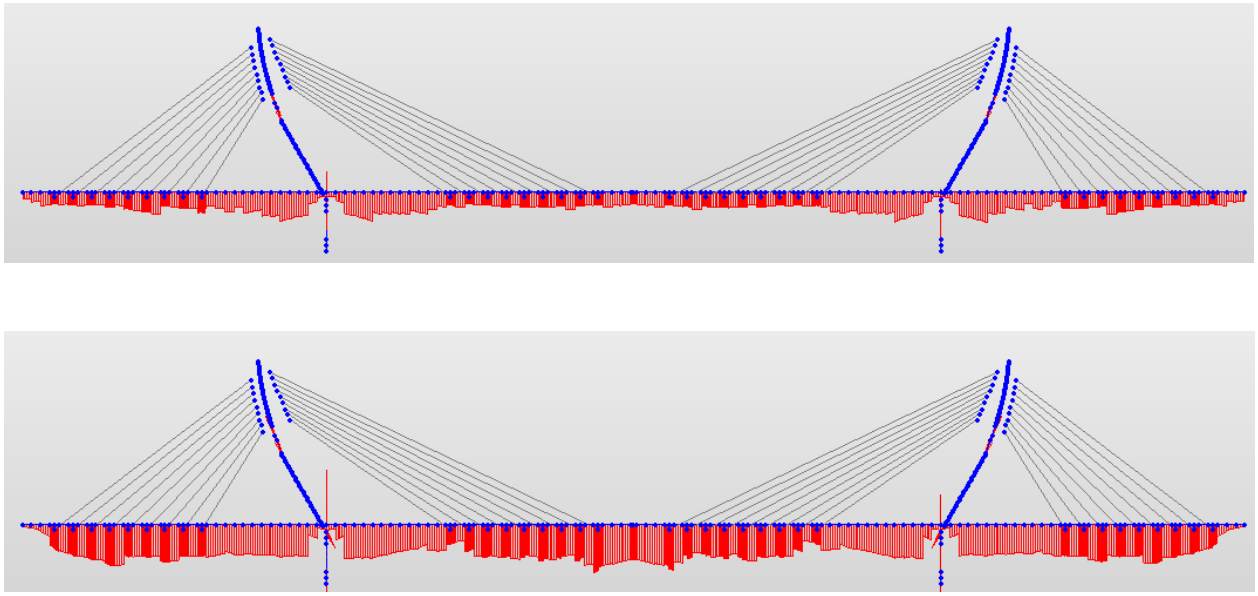


Figure 9-34: Stress plot at top and bottom after erection of Key Segment respectively.

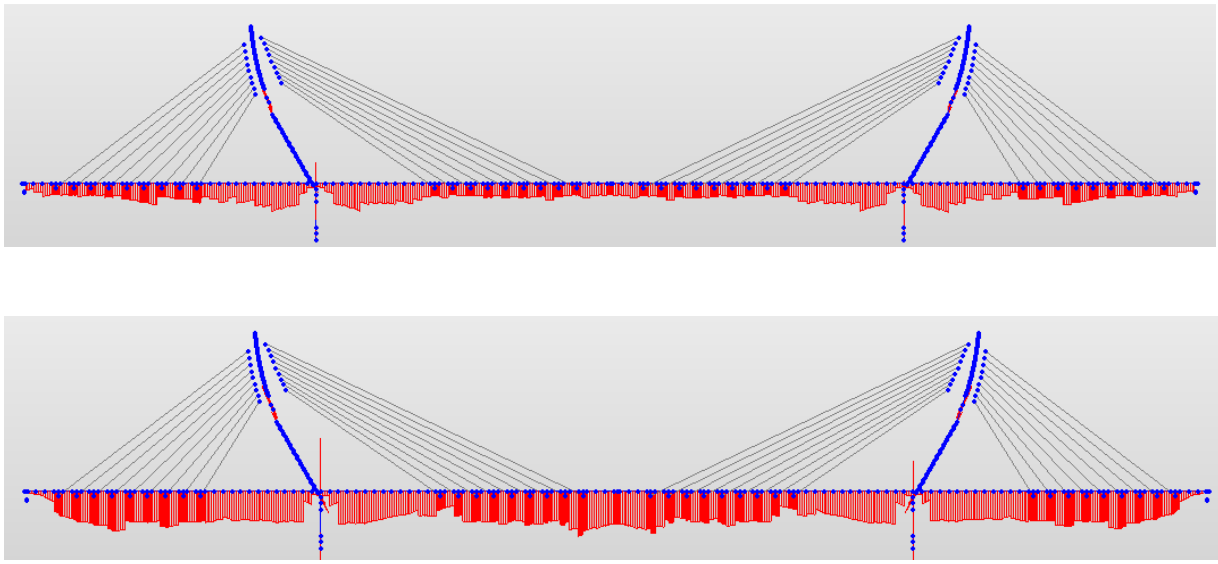


Figure 9-35: Stress plot at top and bottom after placing sidespan support respectively.

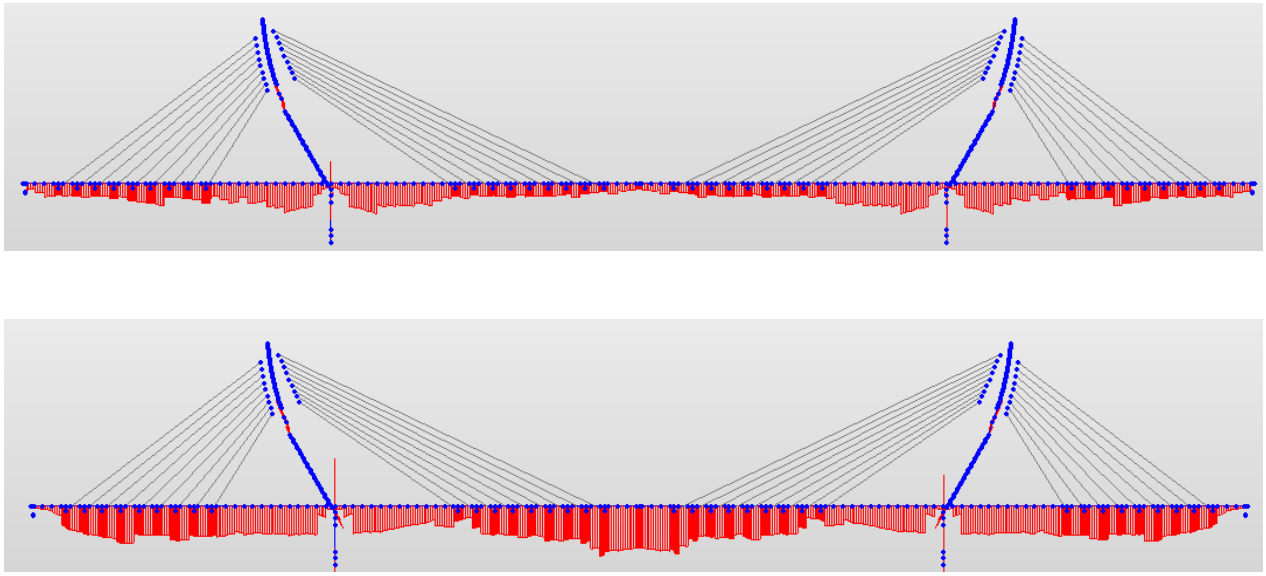


Figure 9-36: Stress plot at top and bottom after second stage stressing of CR1 and CL1 Stay Cables respectively.

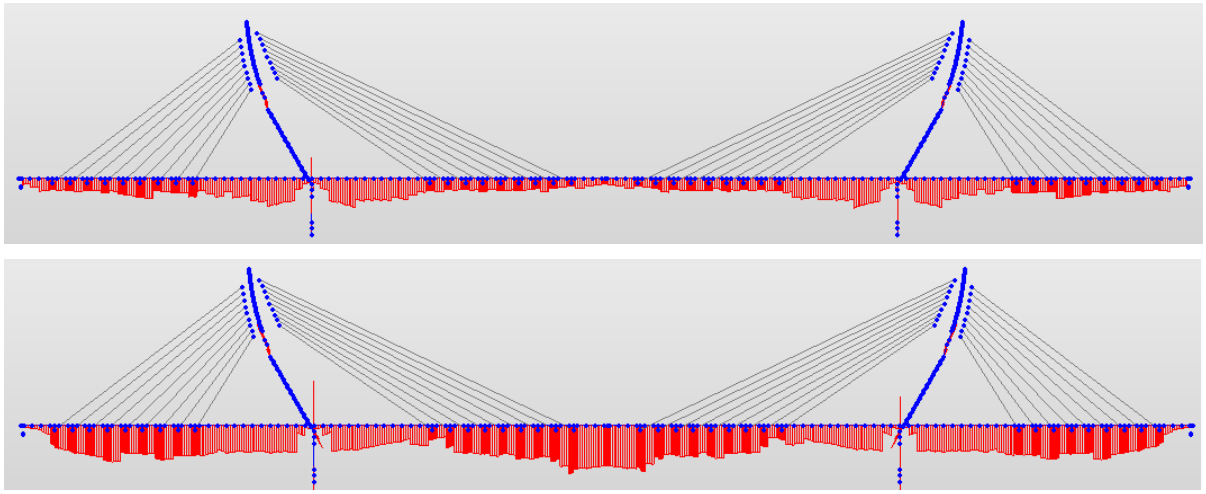
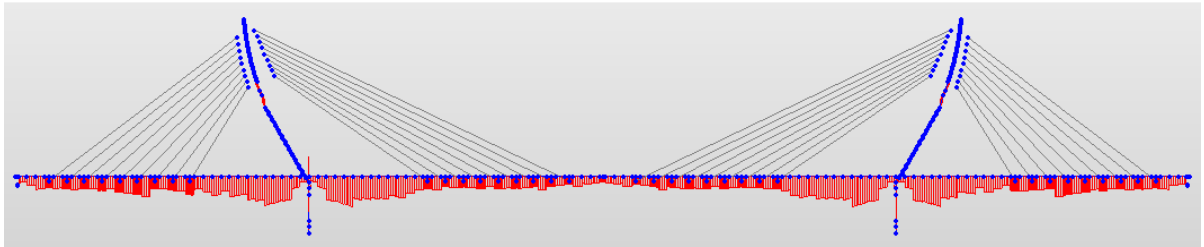


Figure 9-37: Stress plot at top and bottom after second stage stressing of CR2 and CL2 Stay Cables respectively.



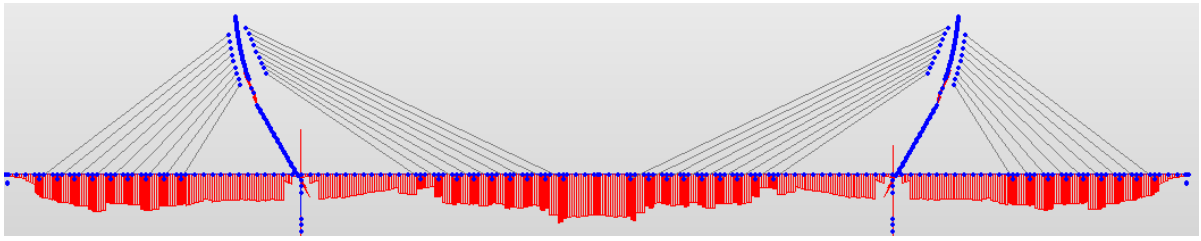


Figure 9-38: Stress plot at top and bottom after second stage stressing of CR3 and CL3 Stay Cables respectively.

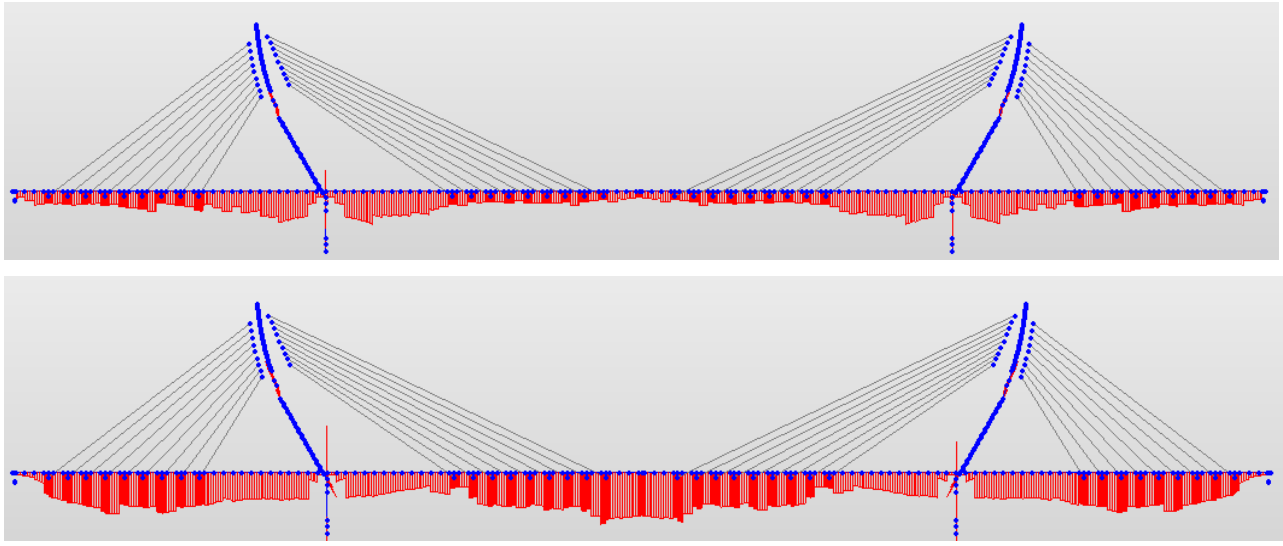


Figure 9-39: Stress plot after at top and bottom second stage stressing of CR4 and CL4 Stay Cables respectively.

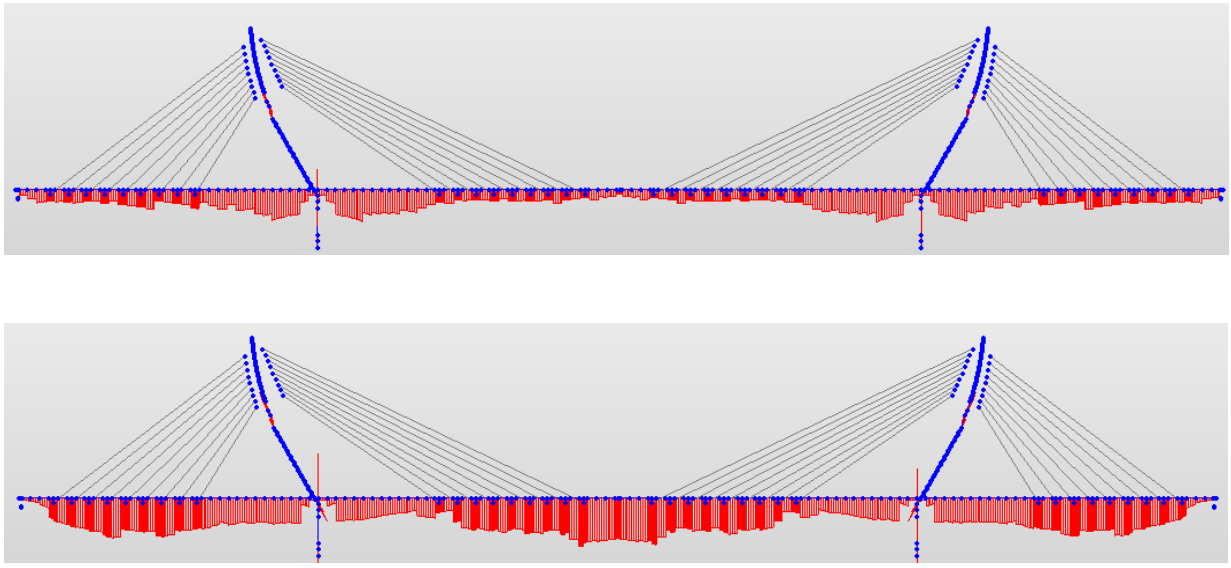


Figure 9-40: Stress plot at top and bottom after second stage stressing of CR5 and CL5 Stay Cables respectively.

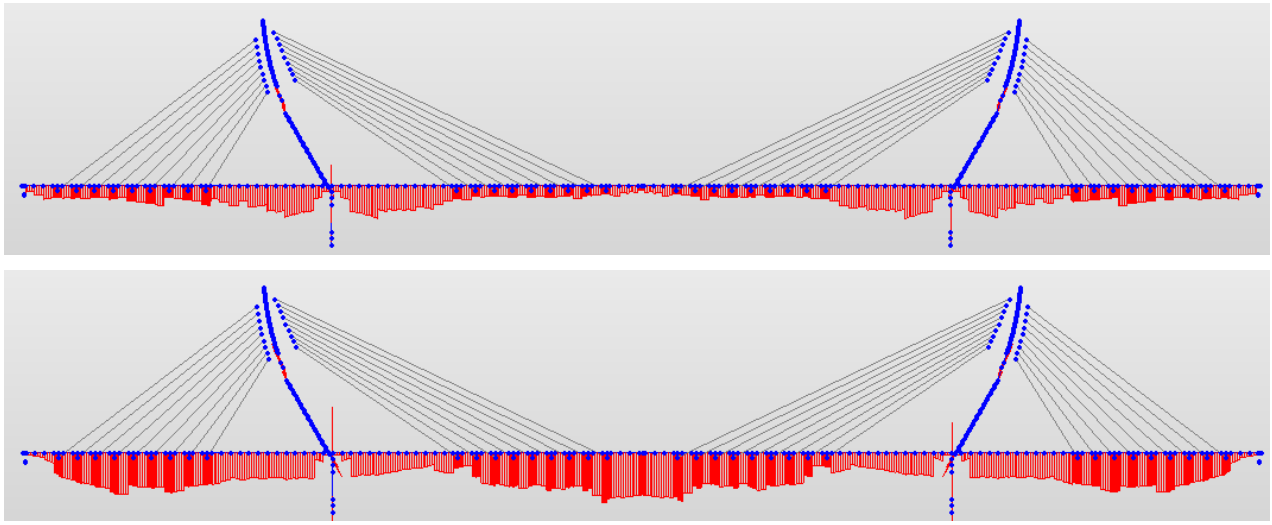


Figure 9-41: Stress plot at top and bottom after second stage stressing of CR6 and CL6 Stay Cables respectively.

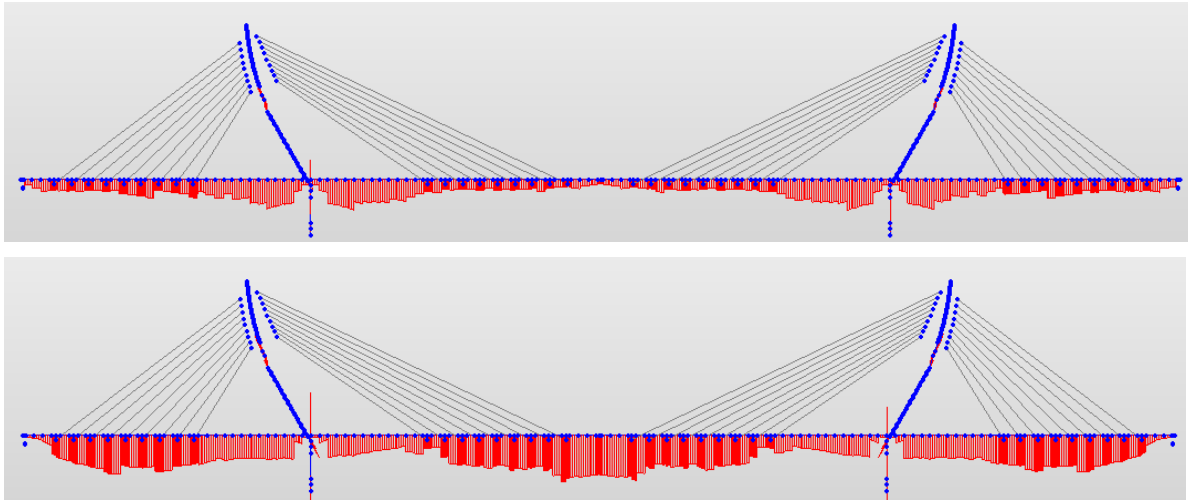


Figure 9-42: Stress plot at top and bottom after second stage stressing of CR7 and CL7 Stay Cables respectively.

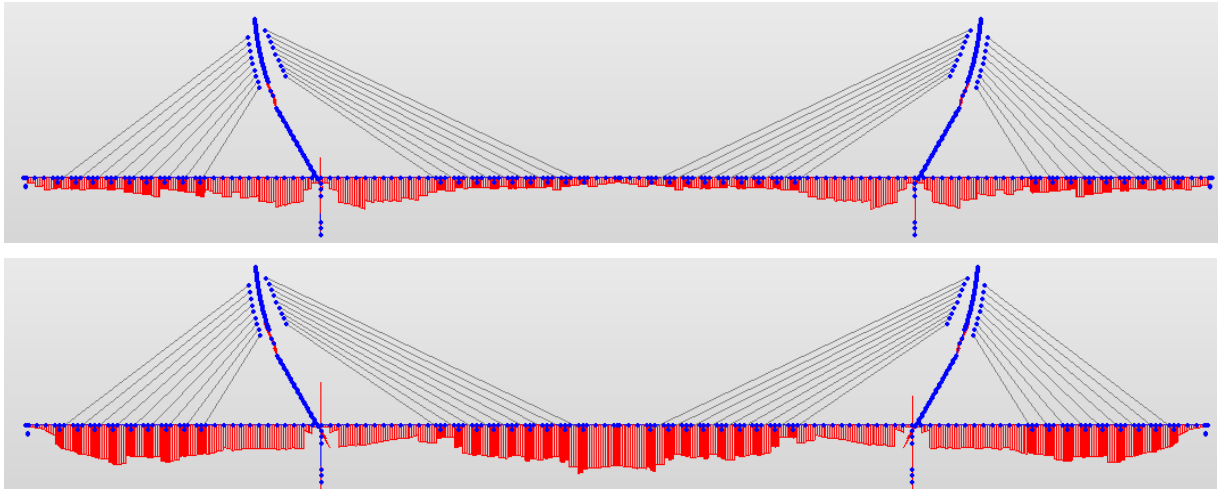


Figure 9-43: Stress plot at top and bottom after second stage stressing of CR8 and CL8 Stay Cables respectively.

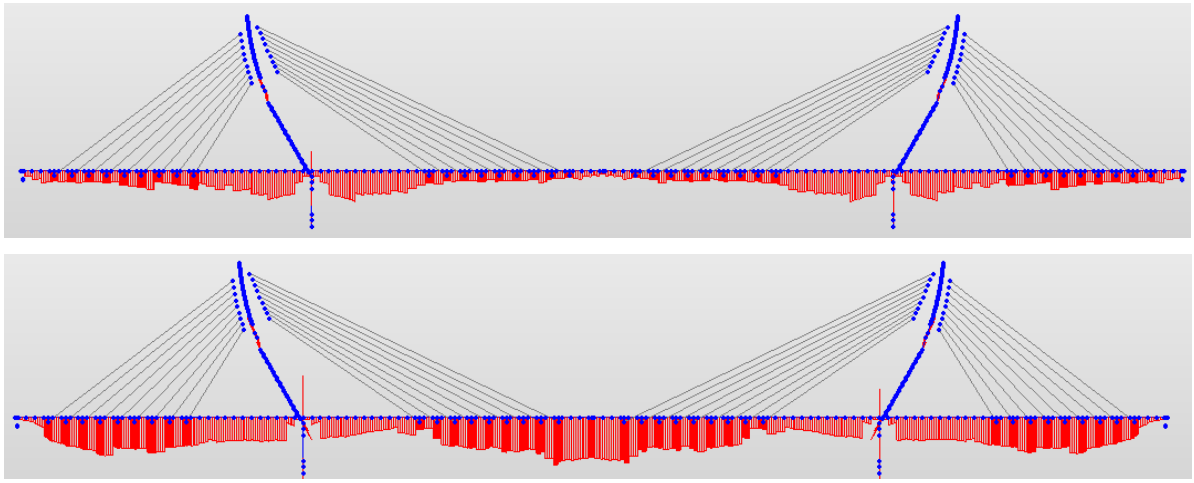


Figure 9-44: Stress plot at top and bottom after second stage stressing of CR9 And CL9 Stay Cables respectively.

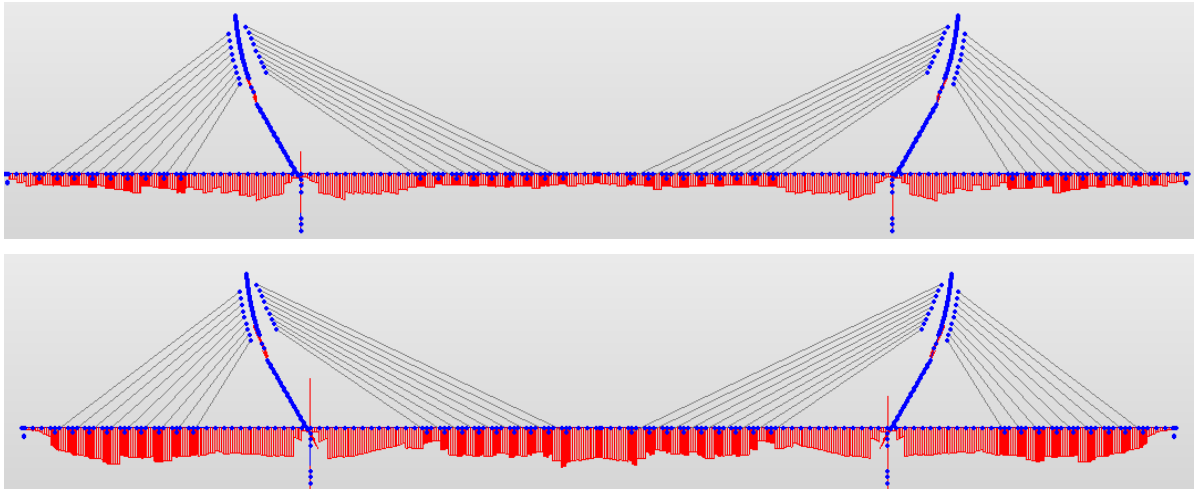


Figure 9-45: Stress plot at top and bottom after placing of SIDL-Fixed respectively.

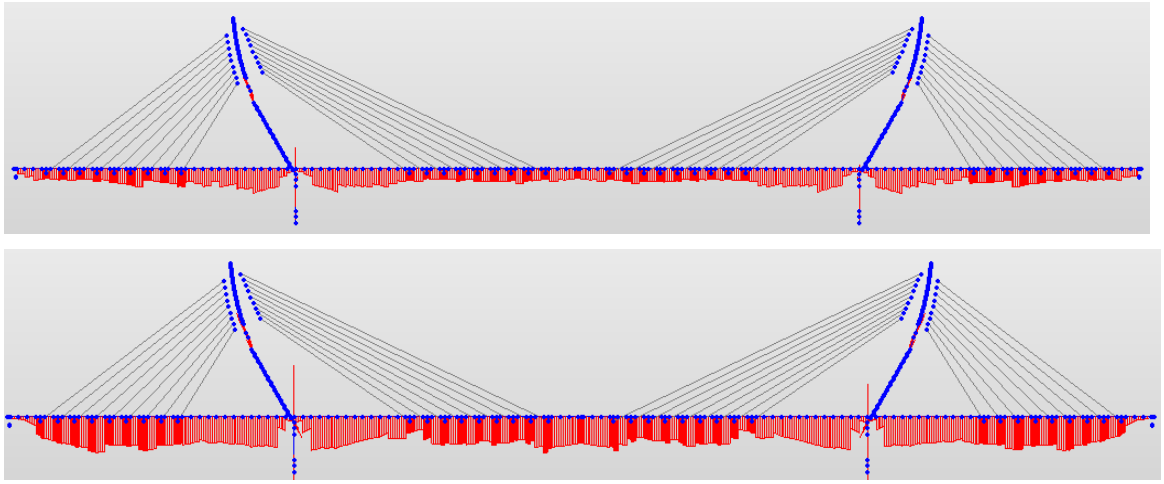


Figure 9-46: Stress plot at top and bottom after placing of SIDL-Variable respectively.

9.1.3 Service Stage Stress Plots

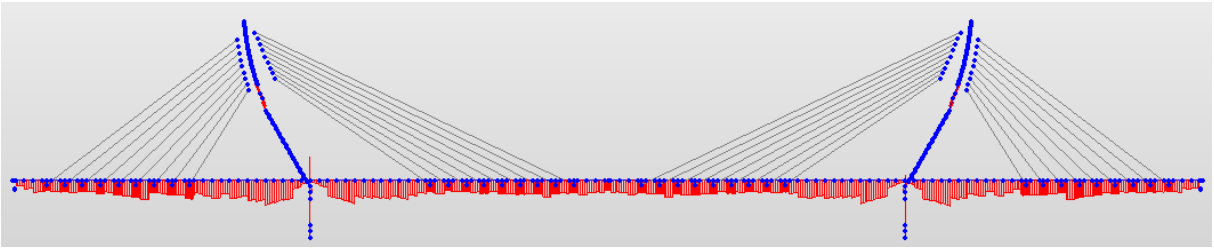


Figure -9-47: Stress at Top at Service stage

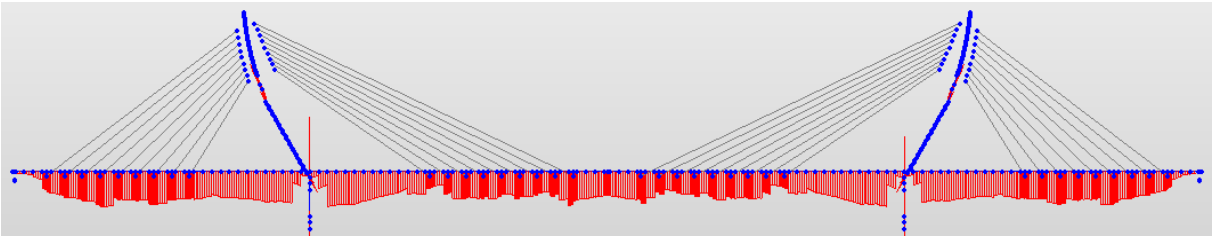


Figure 9-48: Stress at Bottom at Service stage

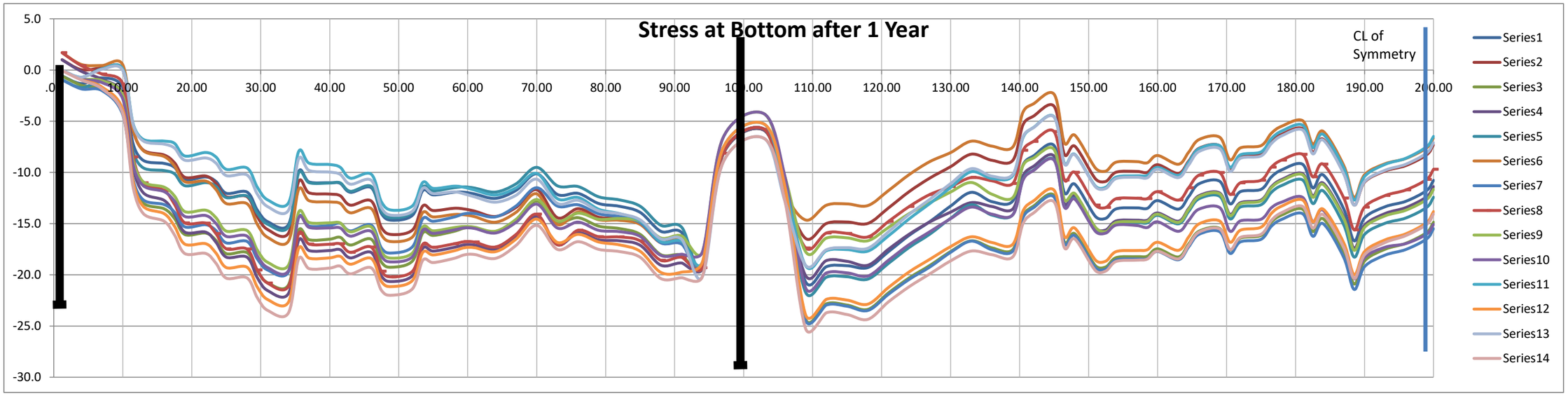
9.1.4 SLS stress graph:

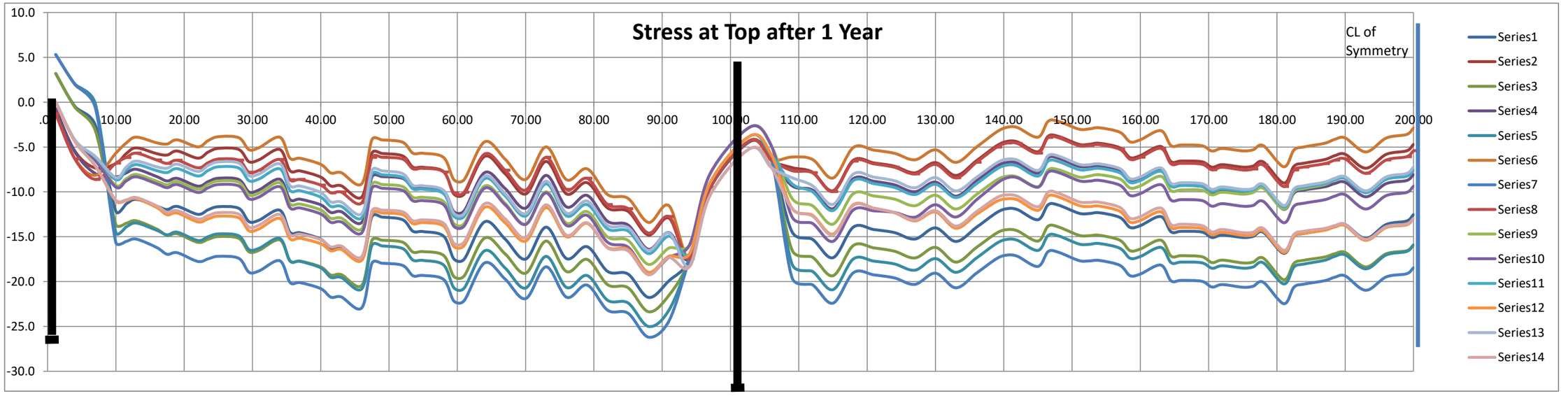
Rare Combinations:

Combination-1	Summation+SIDL+LL max +0.6 Temp pos.
Combination-2	Summation+SIDL+LL max +0.6 Temp neg.
Combination-3	Summation+SIDL+LL min +0.6 Temp pos.
Combination-4	Summation+SIDL+LL min +0.6 Temp neg.
Combination-5	Summation+SIDL+0.75 LL max +Temp pos.
Combination-6	Summation+SIDL+0.75 LL max +Temp neg.
Combination-7	Summation+SIDL+0.75 LL min +Temp pos.
Combination-8	Summation+SIDL+0.75 LL min +Temp neg.
Combination-9	Summation+SIDL+Wind max
Combination-10	Summation+SIDL+Wind min
Combination-11	Summation+SIDL+SV max
Combination-12	Summation+SIDL+SV min
Combination-13	Summation+SIDL+LL max Congestion
Combination-14	Summation+SIDL+LL min Congestion
Summation:	DL-CS + Pretension + Creep-secondary + shrinkage-secondary + tendon-primary + tendon-secondary+Walkway

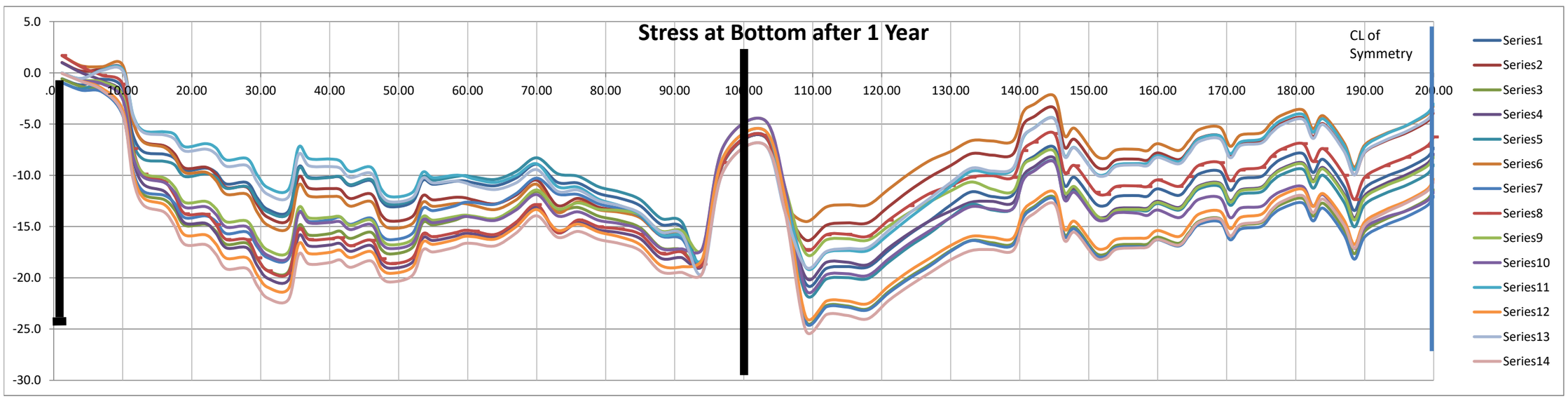
Note: Superior and inferior effects of Tendon Prestress is considered as per IRC: 112-2011.

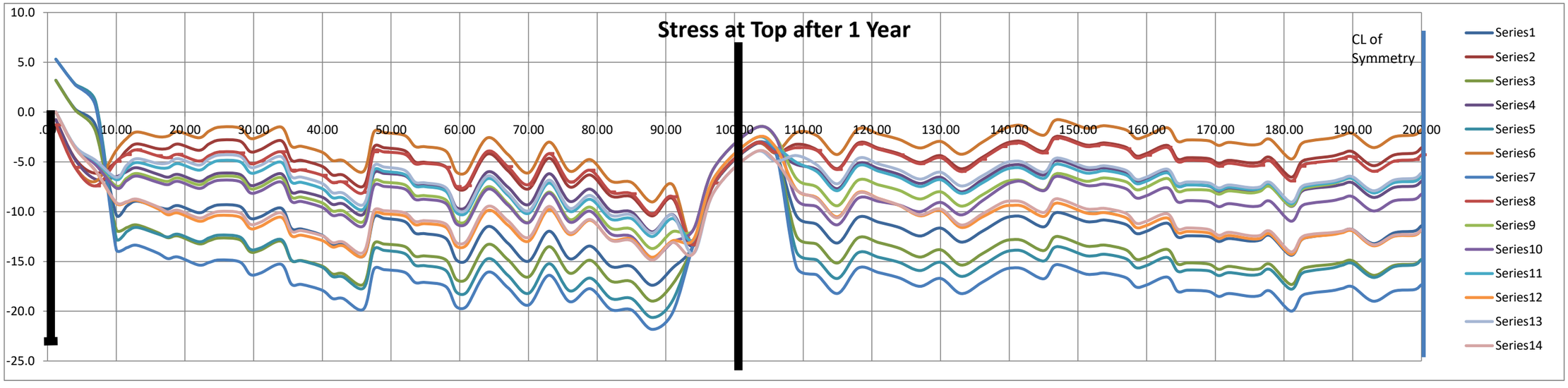
9.1.4.1- Stress after 1 Year with PT superior



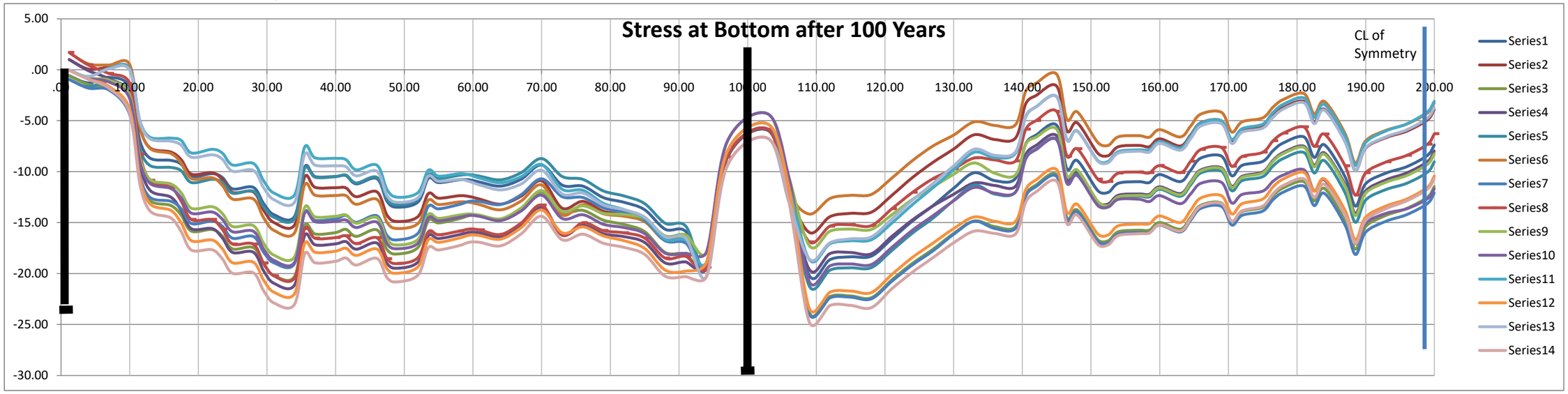


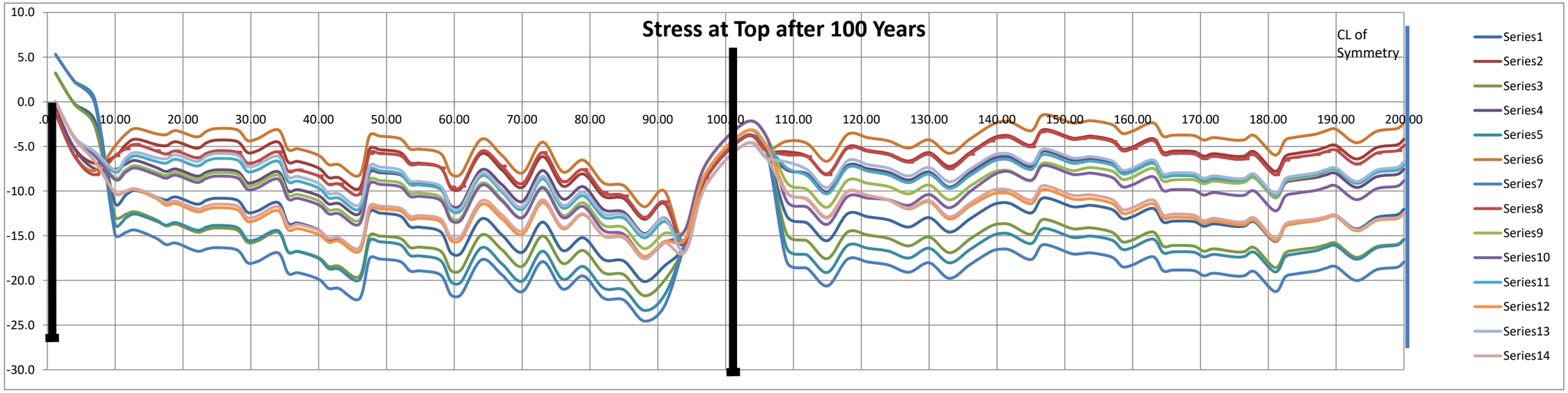
9.1.4.2- Stress after 1 Year with PT Inferior



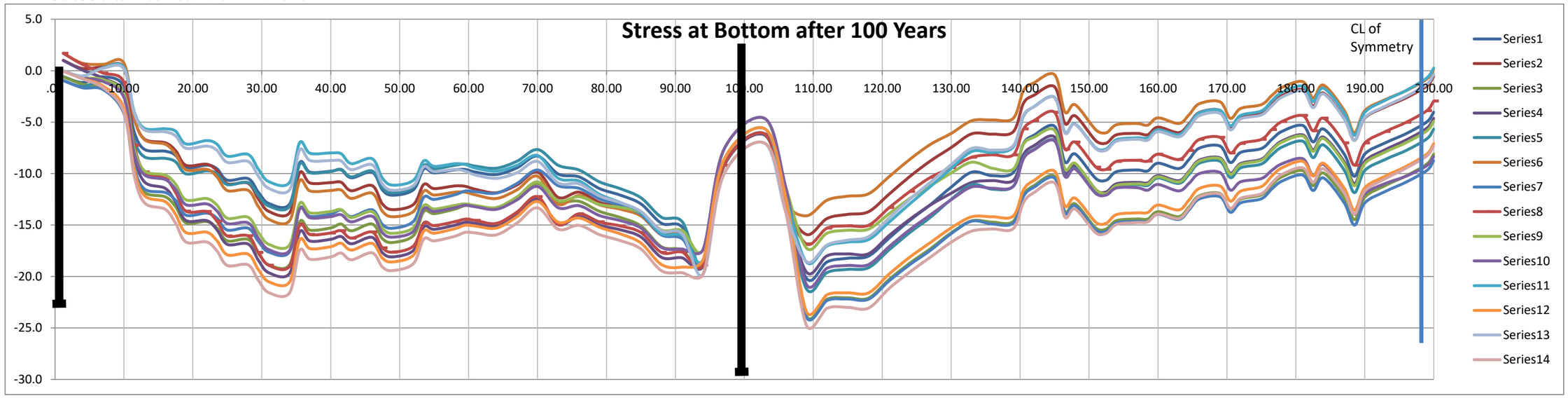


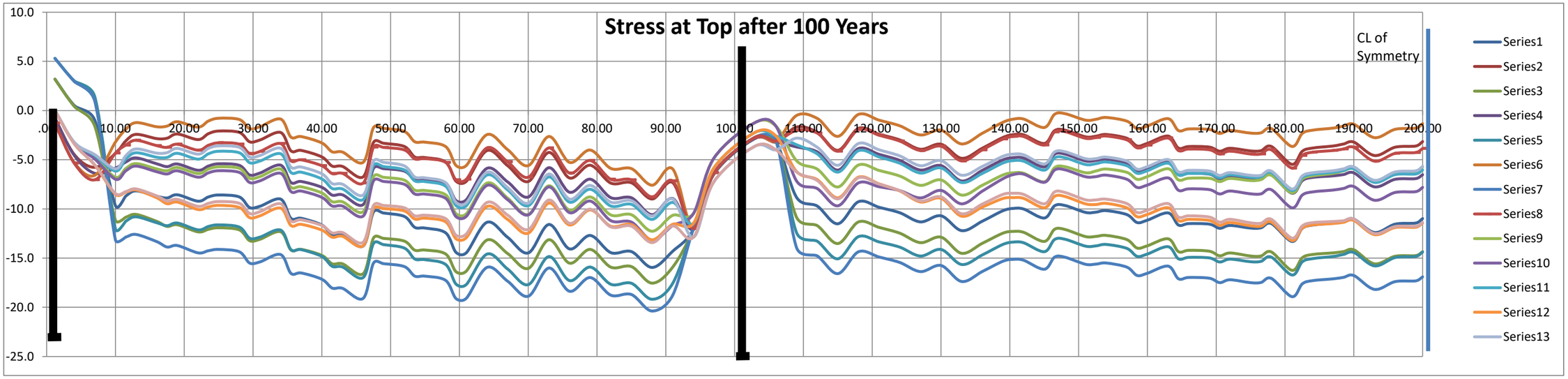
9.1.4.3- Stress after 100 Year with PT Superior





9.1.4.4- Stress after 100 Year with PT Inferior





9.1.5 Superstructure – ULS

The design of superstructure for flexure, shear and torsion in ultimate limit state has been done as per the guide lines given in IRC: 112-2011. The design is done for axial compression with bending as per the Basic load combination given in IRC: 6-2017.

9.1.5 ULS Check:

Details of the concrete properties

Grade of the Concrete	=	M	60		
Young Modulus of Elasticity	=		37000	N/mm^2	
Age of concrete at transfer	=		28	days	
Grade of the Concrete at Transfer	=	M	60		
Young Modulus of Elasticity at Transfer	=	Ecm	37000	N/mm^2	*Table 6.5 of IRC 112*

Details of the Prestressing cables (As per Design Basis Report, cl: 5.4)

(Low Relaxtion steel confirming to IS: 14268)

UTS of 1K15	=	260.4	kN

Jack force applied as per IRC:18-2000 cl.

Jack force applied.	=	0.783	UTS	
for 22K15	=	4486	kN	per cable

Area of the single strand	=	140	mm^2
Total area of the cable	=	3080	mm^2
Maximum number of strand per cable	=	22	No.s
Stress in strand	=	1860	N/mm^2
Slip of anchorages	=	6	mm
Young's Modulus of steel	=	1.95E+05	N/mm^2
Coeffiecient of the Friction μ	=	0.17	
Wobbling Effect k	=	2.00E-03	per m run

	Distance from CL of pier	**X (m)**	**-99.2**	**-96**	**-93**	**-90**	**-87**	**-84**	**-81**	**-78**	**-75**	**-72**	**-69**	**-66**	**-63**	**-60**	**-57**	**-54**	**-51**	**-48**	**-45**	**-42**	**-39**	**-36**	**-33**	**-30**
	Distance between the sections	(m)	0.00	3.200	3.000	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	3.000	3.000
9.1.5.1	**Sectional Properties**																									
			2042	2041	2040	2039	2037	2036	2034	2033	2031	2030	2028	2027	2025	2024	2022	2021	2019	2018	2016	2015	2013	2012	2011	2010
	Overall depth of girder d		2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.76	2.79	2.79
	Area	(m^2)	16.301	16.301	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.592	14.927	15.296	15.296
	Y_t	(m)	1.106	1.106	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.030	1.064	1.103	1.103
	Yb	(m)	1.644	1.644	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.720	1.696	1.688	1.688
	Icg	(m^4)	13.219	13.219	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.624	13.382	14.355	14.355
	Z_t	(m^3)	11.952	11.952	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.253	12.574	13.009	13.009
	Z_b	(m^3)	8.041	8.041	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.341	7.892	8.506	8.506
	Ultimate Design Moment with LL sagging		1671	12573	15252	10863	422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	797	3859	10877	12108	3784
	Ultimate Design Moment with LL Hogging		-1952	-12711	-31052	-56221	-81217	-95916	-111463	-119906	-129529	-133481	-137957	-135806	-134802	-129900	-125412	-116208	-108562	-98787	-91921	-85335	-80024	-72284	-71819	-80861
9.1.5.2	**For Sagging Moment (Top Compression)**																									
	Width of the Web	mm	1200	1200	900	900	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Width of the top Slab	mm	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000
	Depth of top Deck Slab, Df	mm	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	Effective Depth d	mm	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2610	2641	2641
	Area of HT Steel Ap	mm^2	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600
	UTS of HT steel fp	Mpa	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	Stress in steel at ultimate	Mpa	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407
	Design Mult req.	kNm	1671	12573	15252	10863	422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	797	3859	10877	12108	3784
	Mult capacity	kNm	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**198124**	**200543**	**200543**
	Remark		safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe
9.1.5.3	**For Hogging Moment (Bottom Compression)**																									
	Width of the Web	mm	1200	1200	900	900	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Width of the bottom Slab	mm	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
	Thickness of the bottom Slab	mm	250	250	500	500	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	Effective Depth d	mm	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2260	2291	2291
	Area of HT Steel Ap	mm^2	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400
	UTS of HT steel fp	Mpa	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	Total strain in steel at ultimate		0.001	0.010	0.011	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.014	0.014	0.015	0.015	0.014	0.014	0.014	0.014	0.014	0.012	0.012	0.013	0.012
	Stress in steel at ultimate	Mpa	145	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407
	Design Mult req.	kNm	1952	12711	31052	56221	81217	95916	111463	119906	129529	133481	137957	135806	134802	129900	125412	116208	108562	98787	91921	85335	80024	72284	71819	80861
	Mult capacity	kNm	**146424**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**228977**	**276600**	**318900**
	Remark		safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe
9.1.5.4	**Ultimate Strength capactiy check for S.F**																									
	Design Shear force	kN	8469	9016	9742	10755	5079	5958	3019	3611	3273	2999	4628	3166	5892	4571	7247	6460	7612	6733	7459	6710	8764	7838	7255	6236
	Corresponding Ultimate BM	kNm	21139	29101	23705	-20449	-31399	-40270	-43483	-46375	-49143	48283	53322	96299	92958	26217	30842	89134	46400	55023	129589	137396	71455	80448	162950	75357
	Min Top Stress ULS	N/mm^2	1.77	2.44	1.94	-1.67	-1.86	-2.58	-2.28	-2.51	-2.25	5.71	6.62	10.13	10.28	4.83	5.61	10.38	7.16	7.87	14.14	14.78	9.59	10.08	16.11	9.39
	Min Bottom Stress ULS	N/mm^2	-2.63	-3.62	-3.24	2.80	5.00	6.21	7.22	7.62	8.48	-4.84	-5.03	-10.90	-10.02	-0.89	-1.12	-9.09	-2.97	-4.15	-14.15	-15.22	-5.97	-6.52	-15.57	-5.26
	Axial stress	(N/mm^2)	0.00	0.00	0.00	0.00	0.71	0.71	1.28	1.28	1.76	1.76	2.26	2.26	2.69	2.69	3.10	3.10	3.37	3.38	3.56	3.56	3.76	3.68	3.59	3.60

	Distance from CL of pier	**X (m)**	**-99.2**	**-96**	**-93**	**-90**	**-87**	**-84**	**-81**	**-78**	**-75**	**-72**	**-69**	**-66**	**-63**	**-60**	**-57**	**-54**	**-51**	**-48**	**-45**	**-42**	**-39**	**-36**	**-33**	**-30**
	Distance between the sections	(m)	0.00	3.200	3.000	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	3.000	3.000
	Shear Resistance without Shear Reinforcement																									
	Min. breadth of the section over depth, bw		1200	1200	900	900	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Overall depth of member	mm	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2760	2791	2791
	Effective Depth d	mm	2250	2250	2250	2600	2600	2600	2600	2600	2600	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2260	2291	2291
	K_1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	K		1.30	1.30	1.30	1.28	1.28	1.28	1.28	1.28	1.28	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	v_{min}	$0.031 * K^{3/2} * fck^{1/2}$	0.36	0.36	0.36	0.35	0.35	0.35	0.35	0.35	0.35	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.35	0.35
	ρ_1		0.023	0.023	0.030	0.039	0.059	0.059	0.059	0.059	0.059	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.045	0.045	0.045
	Mean Compressive Stress, σ_{cp}		2.49	3.66	5.40	7.17	7.75	8.19	8.16	8.10	8.15	9.40	9.40	8.74	9.14	9.62	10.03	8.57	8.60	8.20	8.28	8.40	6.42	6.61	7.06	6.15
	$V_{Rd.c} = I\, b_{wc}/s * \sqrt{(f_{ctd}^2 \pm k_1\sigma_{cp} f_{ctd})}$		1557	1763	1548	2898	1995	2040	2038	2032	2036	1292	1291	1252	1276	1304	1328	1242	1244	1220	1224	1232	1108	1178	1272	1205
	$V_{Rd.c} = 0.12K(80\rho 1.f_{ck})^{0.33} + 0.15\sigma_{cp})b_w d$		2988	3462	3274	4540	3357	3458	3452	3439	3449	3149	3148	3014	3096	3193	3277	2980	2987	2906	2921	2946	2545	2593	2713	2526
	Condition of section (cracked or uncracked)		Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked
	Design Shear Capacity of the section, $V_{Rd,c}$		1557	1763	1548	2898	1995	2040	2038	2032	2036	1292	1291	1252	1276	1304	1328	1242	1244	1220	1224	1232	1108	1178	1272	1205
	Design Shear Force, V_{Ed}		8469	9016	9742	10755	5079	5958	3019	3611	3273	2999	4628	3166	5892	4571	7247	6460	7612	6733	7459	6710	8764	7838	7255	6236
	Max. permissible shear force = 0.5 * bw * d * v * fcd		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Maximum Shear Stresses (for vertical shear force)																									
	Vertical component of prestresses(before losses)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vertical component of prestresses(after losses)		1196	757	779	920	0	0	0	0	0	348	0	0	0	0	0	364	0	0	0	0	349	902	462	1885
	Maximum Shear force , Vns		7273	8259	8963	9835	5079	5958	3019	3611	3273	2651	4628	3166	5892	4571	7247	6097	7612	6733	7459	6710	8415	6936	6792	4352
	Design Shear force		7273	8259	8963	9835	5079	5958	3019	3611	3273	2651	4628	3166	5892	4571	7247	6097	7612	6733	7459	6710	8415	6936	6792	4352
	Depth of the webs upto CG of Cables in Tensile zone, d		2600	2600	2600	2600	2600	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2600	2600	2610	2641	2641
	α_{cw}		1.09	1.14	1.20	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.24	1.25	1.25	1.23
	$V_{Rd.max}$	$= \alpha_{cw} * b_w * z * v_1 * f_{cd} / (\cot\Theta + \tan\Theta)$	22203	23091	18309	19049	12699	10990	10990	10990	10990	10990	10990	10990	10990	10990	10990	10990	10990	10990	10990	12699	12593	12714	12899	12689
	Remarks		Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe
	Shear Reinforcement Required		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Total Shear reinf. needed for flexure Asv/Sv (mm^2 / m)		2859	3247	3524	3867	1997	2707	1372	1641	1487	1204	2102	1438	2677	2077	3293	2770	3479	3059	3389	2638	3308	2717	2629	1684
	Shear reinf. needed per web Asv/Sv (mm^2 / m)		1430	1624	1762	1933	999	1353	686	820	744	602	1051	719	1338	1038	1646	1385	1739	1529	1694	1319	1654	1358	1315	842
	Minumum reinforcement Asv/Sv (mm^2 / m)per web		669	669	502	502	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335	335
9.1.5.5	**Check for Torsion**																									
	Ultimate Torsional moment		22830	21908	21111	20340	19679	19001	18263	17678	17294	16728	15777	15565	15147	14661	14781	15231	15655	16062	16834	17399	17939	18422	19261	19858
	$t_{ef,i}$ of web		600	600	450	450	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Ak - Area enclosed by centre line of box girder mm2		1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07
	Design shear corresponding to max torsion		3873	5601	5957	6939	3162	4109	1302	1906	1580	1018	2933	1427	3824	2618	5213	3992	5360	4558	5358	4658	5828	3686	4515	-127
	$T_{Rd,max} = 2v\alpha_{cw}f_{cd}A_k t_{ef,i} \sin\theta\cos\theta$ kNm		143095	148817	117995	122764	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843	81159	81625	81843	80508
	$T_{Ed}/T_{Rd.max} + V_{Ed}/V_{Rd.max} \le 1$		0.334	0.390	0.504	0.530	0.489	0.606	0.342	0.389	0.355	0.297	0.460	0.320	0.533	0.417	0.655	0.549	0.679	0.611	0.693	0.579	0.684	0.516	0.585	0.237
	Remarks		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

	Distance from CL of pier	**X (m)**	**-27**	**-24**	**-21**	**-18**	**-15**	**-12**	**-9**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**33**	**36**	**39**	**40.5**	**45**	**46.5**	**51**	**52.5**
	Distance between the sections	(m)	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	1.500	3.000	1.500	3.000	1.500
9.1.5.1	**Sectional Properties**																								
			2009	2008	2007	2006	2005	2004	2003	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1016	1017	1019	1020
	Overall depth of girder d		2.92	3.01	3.12	3.26	3.41	3.59	3.78	4.00	3.78	3.59	3.41	3.26	3.12	3.01	2.92	2.79	2.79	3.00	3.00	2.75	2.75	2.75	2.75
	Area	(m^2)	15.808	16.272	16.768	17.296	17.849	19.858	22.400	23.054	22.400	19.858	17.849	17.296	16.768	16.272	15.808	15.296	15.296	14.927	14.595	14.595	14.595	14.595	14.595
	Y_t	(m)	1.174	1.234	1.302	1.377	1.431	1.527	1.621	1.708	1.621	1.527	1.431	1.377	1.302	1.234	1.174	1.103	1.103	1.064	1.028	1.028	1.028	1.028	1.028
	Yb	(m)	1.741	1.774	1.820	1.879	1.980	2.060	2.162	2.292	2.162	2.060	1.980	1.879	1.820	1.774	1.741	1.688	1.688	1.696	1.722	1.722	1.722	1.722	1.722
	Icg	(m^4)	16.593	18.534	20.925	23.839	26.939	32.015	38.247	44.137	38.247	32.015	26.939	23.839	20.925	18.534	16.593	14.355	14.355	13.382	12.593	12.593	12.593	12.593	12.593
	Z_t	(m^3)	14.132	15.019	16.077	17.313	18.826	20.969	23.600	25.847	23.600	20.969	18.826	17.313	16.077	15.019	14.132	13.009	13.009	12.574	12.247	12.247	12.247	12.247	12.247
	Z_b	(m^3)	9.531	10.447	11.495	12.686	13.605	15.540	17.687	19.253	17.687	15.540	13.605	12.686	11.495	10.447	9.531	8.506	8.506	7.892	7.314	7.314	7.314	7.314	7.314
	Ultimate Design Moment with LL sagging		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	871	4278	9695	9256
	Ultimate Design Moment with LL Hogging		-93260	-114528	-144299	-181464	-231232	-288808	-355609	-591355	-501670	-424824	-356995	-293399	-242189	-197837	-162325	-136336	-111922	-99005	-93115	-83848	-79319	-74432	-74684
9.1.5.2	**For Sagging Moment (Top Compression)**																								
	Width of the Web	mm	600	600	900	900	900	900	2000	2000	1400	1400	1400	1200	1200	1200	900	900	600	600	600	600	600	600	600
	Width of the top Slab	mm	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000
	Depth of top Deck Slab, Df	mm	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	Effective Depth d	mm	2765	2858	2972	3106	3261	3437	3633	3850	3633	3437	3261	3106	2972	2858	2765	2641	2641	2850	2850	2600	2600	2600	2600
	Area of HT Steel Ap	mm^2	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600
	UTS of HT steel fp	Mpa	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	Stress in steel at ultimate	Mpa	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407
	Design Mult req.	kNm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	871	4278	9695	9256
	Mult capacity	kNm	**210216**	**217471**	**226365**	**236818**	**248910**	**262640**	**277930**	**294859**	**277930**	**262640**	**248910**	**236818**	**226365**	**217471**	**210216**	**200543**	**200543**	**216847**	**216847**	**197344**	**197344**	**197344**	**197344**
	Remark		safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe
9.1.5.3	**For Hogging Moment (Bottom Compression)**																								
	Width of the Web	mm	600	600	900	900	900	900	2000	2000	1400	1400	1400	1200	1200	1200	900	900	600	600	600	600	600	600	600
	Width of the bottom Slab	mm	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
	Thickness of the bottom Slab	mm	250	250	250	250	250	250	250	250	250	250	250	250	250	250	325	325	375	375	500	500	500	500	500
	Effective Depth d	mm	2415	2508	2622	2756	2911	3087	3283	3500	3283	3087	2911	2756	2622	2508	2415	2291	2291	2500	2500	2250	2250	2250	2250
	Area of HT Steel Ap	mm^2	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400
	UTS of HT steel fp	Mpa	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	Total strain in steel at ultimate		0.015	0.016	0.018	0.019	0.022	0.023	0.025	0.026	0.024	0.022	0.019	0.018	0.016	0.015	0.013	0.013	0.012	0.013	0.012	0.011	0.011	0.012	0.012
	Stress in steel at ultimate	Mpa	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407
	Design Mult req.	kNm	93260	114528	144299	181464	30573	288808	355609	591355	501670	424824	356995	293399	242189	197837	162325	136336	111922	99005	93115	83848	79319	74432	74684
	Mult capacity	kNm	**361200**	**403500**	**445800**	**488100**	**530400**	**572700**	**615000**	**615000**	**572700**	**530400**	**488100**	**445800**	**403500**	**361200**	**318900**	**276600**	**232605**	**257061**	**257061**	**227807**	**227807**	**227807**	**227807**
	Remark		safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe
9.1.5.4	**Ultimate Strength capactiy check for S.F**																								
	Design Shear force	kN	7575	10151	12691	15913	17932	20845	24093	43301	38368	34512	27757	25453	21480	18176	14927	11473	10189	8998	8475	7796	8735	9432	9167
	Corresponding Ultimate BM	kNm	64838	45632	20179	-12448	-52912	-97155	-148043	-155242	-99918	-55196	-50795	-19123	-20994	2073	8013	-30944	12729	20913	31540	46373	40284	28354	21604
	Min Top Stress ULS	N/mm^2	8.07	6.43	4.55	2.48	0.30	-1.83	-3.79	-3.33	-1.49	0.46	0.72	2.43	2.33	3.88	4.42	1.58	4.94	5.72	6.72	7.53	7.03	5.65	5.10
	Min Bottom Stress ULS	N/mm^2	-3.32	-0.98	1.54	4.18	7.00	9.05	10.86	10.73	8.40	6.65	7.15	5.04	5.46	3.54	3.01	7.60	2.47	1.41	-0.16	-2.60	-1.76	-0.54	0.38
	Axial stress	(N/mm^2)	3.49	3.39	3.30	3.19	3.11	2.80	2.49	2.67	2.75	3.10	3.42	3.53	3.64	3.74	3.85	3.96	3.97	4.06	4.15	3.74	3.74	3.33	3.33

	Distance from CL of pier	**X (m)**	**-27**	**-24**	**-21**	**-18**	**-15**	**-12**	**-9**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**33**	**36**	**39**	**40.5**	**45**	**46.5**	**51**	**52.5**
	Distance between the sections	(m)	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	1.500	3.000	1.500	3.000	1.500
	Shear Resistance without Shear Reinforcement																								
	Min. breadth of the section over depth, bw		600	600	900	900	900	900	2000	2000	1400	1400	1400	1200	1200	1200	900	900	600	600	600	600	600	600	600
	Overall depth of member	mm	2915	3008	3122	3256	3411	3587	3783	4000	3783	3587	3411	3256	3122	3008	2915	2791	2791	3000	3000	2750	2750	2750	2750
	Effective Depth d	mm	2415	2508	2622	3106	3261	3437	3633	3850	3633	3437	3261	3106	2972	2508	2415	2641	2291	2500	2500	2250	2250	2250	2250
	K_1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	K		1.29	1.28	1.28	1.25	1.25	1.24	1.23	1.23	1.23	1.24	1.25	1.25	1.26	1.28	1.29	1.28	1.30	1.28	1.28	1.30	1.30	1.30	1.30
	v_{min}	$0.031 * K^{3/2} * fck^{1/2}$	0.35	0.35	0.35	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.34	0.34	0.35	0.35	0.35	0.35	0.35	0.35	0.36	0.36	0.36	0.36
	ρ_1		0.043	0.041	0.026	0.033	0.031	0.030	0.013	0.012	0.018	0.019	0.020	0.025	0.026	0.020	0.028	0.039	0.045	0.041	0.041	0.046	0.046	0.046	0.046
	Mean Compressive Stress, σ_{cp}		7.72	8.20	9.45	9.96	11.75	11.21	10.56	10.31	10.10	10.71	9.85	9.35	8.09	7.63	6.59	6.83	6.47	6.40	4.84	5.53	5.06	6.66	6.75
	$V_{Rd.c} = I\, b_{wc}/s * \sqrt{(f_{ctd}^2 \pm k_1\sigma_{cp} f_{ctd})}$		1431	1562	2656	3967	4489	4403	9514	10020	6531	6713	6469	5147	4640	3033	2013	2881	1228	1163	990	1042	1007	1120	1126
	$V_{Rd.c} = 0.12K(80\rho1.f_{ck})^{0.33} + 0.15\sigma_{cp})b_w d$		2973	3174	5125	6417	7475	7573	15694	16235	10995	10916	9837	7941	6976	5550	3849	4479	2591	2761	2409	2366	2269	2593	2612
	Condition of section (cracked or uncracked)		Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked
	Design Shear Capacity of the section, $V_{Rd,c}$		1431	1562	2656	3967	4489	4403	9514	10020	6531	6713	6469	5147	4640	3033	2013	2881	1228	1163	990	1042	1007	1120	1126
	Design Shear Force, V_{Ed}		7575	10151	12691	15913	17932	20845	24093	43301	38368	34512	27757	25453	21480	18176	14927	11473	10189	8998	8475	7796	8735	9432	9167
	Max. permissible shear force = 0.5 * bw * d * v * fcd		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Maximum Shear Stresses (for vertical shear force)																								
	Vertical component of prestresses(before losses)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vertical component of prestresses(after losses)		2124	2656	3755	2807	6572	6872	6777	8059	7017	6714	2871	3827	2721	2182	2135	468	1675	703	0	0	0	807	0
	Maximum Shear force , Vns		5451	7495	8935	13106	11361	13973	17316	35243	31351	27798	24886	21626	18758	15993	12791	11005	8514	8295	8475	7796	8735	8626	9167
	Design Shear force		5451	7495	8935	13106	11361	13973	17316	35243	31351	27798	24886	21626	18758	15993	12791	11005	8514	8295	8475	7796	8735	8626	9167
	Depth of the webs upto CG of Cables in Tensile zone, d		2415	2508	2622	2756	2911	3087	3283	3500	3283	3087	2911	2756	2622	2508	2415	2291	2291	2500	2500	2600	2600	2600	2600
	α_{cw}		1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.24	1.24	1.18	1.21	1.19	1.25	1.25
	$V_{Rd.max}$	$= \alpha_{cw} * b_w * z * v_1 * f_{cd} / (\cot\Theta + \tan\Theta)$	11796	12250	19210	20192	21327	22617	53451	56984	37415	35182	33176	26922	25613	24500	17637	16785	11112	12103	11531	12257	12077	12682	12699
	Remarks		Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe
	Shear Reinforcement Required		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Total Shear reinf. needed for flexure Asv/Sv (mm^2 / m)		2307	3055	3484	4861	3989	4627	5392	10293	13229	11273	9865	10095	7966	6519	5814	4910	4431	3392	3794	3065	3674	3391	3844
	Shear reinf. needed per web Asv/Sv (mm^2 / m)		1154	1527	1742	2431	1995	2313	2696	5147	6615	5636	4932	5048	3983	3259	2907	2455	2215	1696	1897	1532	1837	1696	1922
	Minumum reinforcement Asv/Sv (mm^2 / m)per web		335	335	502	502	502	502	1115	1115	781	781	781	669	669	669	502	502	335	335	335	335	335	335	335
9.1.5.5	**Check for Torsion**																								
	Ultimate Torsional moment		20513	21047	21917	22576	23258	23692	24403	34807	33012	32096	32063	31019	29753	28651	28681	27806	27032	26064	26180	25280	24869	24030	24276
	$t_{ef,I}$ of web		300	300	450	450	450	450	1000	1000	700	700	700	600	600	600	450	450	300	300	300	300	300	300	300
	Ak - Area enclosed by centre line of box girder mm2		1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07
	Design shear corresponding to max torsion		463	1595	1468	6834	-23	1953	5457	31533	27671	24534	21733	18563	15956	13428	10302	8206	6286	5857	6244	5443	6760	6144	7104
	$T_{Rd,max} = 2v\alpha_{cw}f_{cd}A_k t_{ef,I}\,\mathrm{Sin}\theta\mathrm{Cos}\theta$ kNm		81843	81843	122764	122764	122764	122764	272809	272809	190966	190966	190966	163685	163685	163685	122372	122764	81270	81117	77289	78996	77832	81735	81843
	$T_{Ed}/T_{Rd.max} + V_{Ed}/V_{Rd.max} \le 1$		0.290	0.387	0.255	0.522	0.188	0.279	0.192	0.681	0.912	0.865	0.823	0.879	0.805	0.723	0.818	0.715	0.898	0.805	0.880	0.764	0.879	0.778	0.856
	Remarks		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

	Distance from CL of pier	**X (m)**	**57**	**58.5**	**63**	**64.5**	**69**	**70.5**	**75**	**76.5**	**81**	**82.5**	**87**	**88.5**	**93**	**96**	**99**
	Distance between the sections	(m)	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	3.000	3.000
9.1.5.1	**Sectional Properties**																
			1022	1023	1025	1026	1028	1029	1031	1032	1034	1035	1037	1038	1040	1041	1042
	Overall depth of girder d		2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
	Area	(m^2)	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595	14.595
	Y_t	(m)	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028
	Yb	(m)	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722	1.722
	Icg	(m^4)	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593	12.593
	Z_t	(m^3)	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247	12.247
	Z_b	(m^3)	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314	7.314
	Ultimate Design Moment with LL sagging		13376	11580	15615	14447	18788	17103	23045	25198	32689	36519	49948	60201	84625	104861	118308
	Ultimate Design Moment with LL Hogging		-71476	-72086	-68863	-69431	-65421	-66128	-60500	-58565	-50289	-45990	-31815	-21747	0	0	0
9.1.5.2	**For Sagging Moment (Top Compression)**																
	Width of the Web	mm	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Width of the top Slab	mm	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000	23000
	Depth of top Deck Slab, Df	mm	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
	Effective Depth d	mm	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
	Area of HT Steel Ap	mm^2	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600	61600
	UTS of HT steel fp	Mpa	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	Stress in steel at ultimate	Mpa	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407
	Design Mult req.	kNm	13376	11580	15615	14447	18788	17103	23045	25198	32689	36519	49948	60201	84625	104861	118308
	Mult capacity	kNm	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**	**197344**
	Remark		safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe
9.1.5.3	**For Hogging Moment (Bottom Compression)**																
	Width of the Web	mm	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Width of the bottom Slab	mm	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
	Thickness of the bottom Slab	mm	375	325	250	250	250	250	250	250	250	250	250	250	250	250	250
	Effective Depth d	mm	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250
	Area of HT Steel Ap	mm^2	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400	92400
	UTS of HT steel fp	Mpa	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
	Total strain in steel at ultimate		0.011	0.012	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.014	0.014	0.015	0.014	0.014
	Stress in steel at ultimate	Mpa	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407	1407
	Design Mult req.	kNm	71476	72086	68863	69431	65421	66128	60500	58565	50289	45990	31815	21747	0	0	0
	Mult capacity	kNm	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**	**227807**
	Remark		safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe	safe
9.1.5.4	**Ultimate Strength capactiy check for S.F**																
	Design Shear force	kN	7402	8307	7509	8090	7579	8267	7066	6808	4802	6249	7812	5363	11822	8473	5996
	Corresponding Ultimate BM	kNm	47595	51325	38438	33061	17555	4961	7101	-327	17210	7091	-6937	-25770	-580	-39	5592
	Min Top Stress ULS	N/mm^2	6.66	6.96	5.26	4.82	2.90	1.87	1.29	0.69	1.48	0.66	0.47	-1.07	2.17	2.21	2.67
	Min Bottom Stress ULS	N/mm^2	-3.74	-4.25	-3.13	-2.40	-0.94	0.79	-0.26	0.76	-2.28	-0.89	1.98	4.56	2.30	2.22	1.45
	Axial stress	(N/mm^2)	2.77	2.77	2.12	2.12	1.46	1.46	0.71	0.71	0.08	0.08	1.04	1.04	2.22	2.22	2.22

	Distance from CL of pier	**X (m)**	**57**	**58.5**	**63**	**64.5**	**69**	**70.5**	**75**	**76.5**	**81**	**82.5**	**87**	**88.5**	**93**	**96**	**99**
	Distance between the sections	(m)	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	1.500	3.000	3.000	3.000
	Shear Resistance without Shear Reinforcement																
	Min. breadth of the section over depth, bw		600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
	Overall depth of member	mm	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
	Effective Depth d	mm	2250	2250	2250	2250	2250	2250	2250	2600	2250	2250	2600	2600	2600	2600	2250
	K_1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	K		1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.28	1.30	1.30	1.28	1.28	1.28	1.28	1.30
	v_{min}	$0.031 * K^{3/2} * fck^{1/2}$	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.36	0.36	0.35	0.35	0.35	0.35	0.36
	ρ_1		0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.059	0.046	0.046	0.059	0.059	0.059	0.059	0.046
	Mean Compressive Stress, σ_{cp}		5.85	6.28	6.24	5.97	6.42	7.42	7.45	7.44	8.33	8.96	10.08	11.23	11.66	10.94	10.50
	$V_{Rd.c} = I\, b_{wc}/s * \sqrt{(f_{ctd}^2 \pm k_1\sigma_{cp} f_{ctd})}$		1064	1094	1092	1073	1104	1171	1172	1961	1227	1266	2227	2334	2373	2308	1354
	$V_{Rd.c} = 0.12K(80\rho 1.f_{ck})^{0.33} + 0.15\sigma_{cp})b_w d$		2429	2516	2509	2454	2546	2749	2754	3283	2931	3060	3901	4170	4271	4102	3371
	Condition of section (cracked or uncracked)		Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked	Uncracked
	Design Shear Capacity of the section, $V_{Rd,c}$		1064	1094	1092	1073	1104	1171	1172	1961	1227	1266	2227	2334	2373	2308	1354
	Design Shear Force, V_{Ed}		7402	8307	7509	8090	7579	8267	7066	6808	4802	6249	7812	5363	11822	8473	5996
	Max. permissible shear force = 0.5 * bw * d * v * fcd		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Maximum Shear Stresses (for vertical shear force)																
	Vertical component of prestresses(before losses)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vertical component of prestresses(after losses)		0	0	199	0	589	432	826	0	0	401	796	768	751	0	0
	Maximum Shear force , Vns		7402	8307	7309	8090	6990	7835	6240	6808	4802	5847	7016	4594	11071	8473	5996
	Design Shear force		7402	8307	7309	8090	6990	7835	6240	6808	4802	5847	7016	4594	11071	8473	5996
	Depth of the webs upto CG of Cables in Tensile zone, d		2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600	2600
	α_{cw}		1.22	1.23	1.23	1.22	1.24	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
	$V_{Rd.max}$	$= \alpha_{cw} * b_w * z * v_1 * f_{cd} / (\cot\Theta + \tan\Theta)$	12375	12539	12525	12422	12594	12699	12699	12699	12699	12699	12699	12699	12699	12699	12699
	Remarks		Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe	Safe
	Shear Reinforcement Required		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Total Shear reinf. needed for flexure Asv/Sv (mm^2 / m)		2910	3266	2874	3181	2748	3080	2453	2677	1888	2299	2758	1806	6368	3331	2357
	Shear reinf. needed per web Asv/Sv (mm^2 / m)		1455	1633	1437	1590	1374	1540	1227	1338	944	1149	1379	903	3184	1666	1179
	Minumum reinforcement Asv/Sv (mm^2 / m)per web		335	335	335	335	335	335	335	335	335	335	335	335	335	335	335
9.1.5.5	**Check for Torsion**																
	Ultimate Torsional moment		23469	23265	22636	22892	22282	22127	21625	21581	21279	21020	21027	20921	20814	20499	20540
	$t_{ef,I}$ of web		300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Ak - Area enclosed by centre line of box girder mm2		1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07	1.87E+07
	Design shear corresponding to max torsion		5123	6118	4952	6040	4673	5612	3874	4678	2284	3470	4490	2110	8020	5563	3279
	$T_{Rd,max} = 2v\alpha_{cw}f_{cd}A_k t_{ef,I}\,\mathrm{Sin}\theta\mathrm{Cos}\theta$ kNm		79755	80808	80718	80054	81168	81843	81843	81843	81843	81843	81843	81843	81843	81843	81843
	$T_{Ed}/T_{Rd.max} + V_{Ed}/V_{Rd.max} \le 1$		0.708	0.776	0.676	0.772	0.646	0.712	0.569	0.632	0.440	0.530	0.610	0.422	0.886	0.689	0.509
	Remarks		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK

9.1.6 Design of Stay Cable-SLS

The stay cable stress in serviceability state FSLS ≤ 0.5 FGUTS during service and FSLS ≤ 0.55FGUTS during construction. The summary of stay cable forces is presented below for SLS combinations.

Cable Nos	Service Comb				Service Max	Cable Nos	Perm. Force (0.45 x UTS)	Service Max	Interaction Ratio
	LL leading (Superior)	Temp. Leading (Superior)	LL leading (Inferior)	Temp. Leading (Inferior))					
10101	5138	5106	5166	5134	5166	P1-CR1	5999	5166	0.43
10102	4807	4733	4960	4886	4960	P1-CR2	5999	4960	0.41
10103	6501	6395	6704	6598	6704	P1-CR3	8231	6704	0.41
10104	7105	6892	7444	7231	7444	P1-CR4	8928	7444	0.42
10105	7225	6982	7545	7302	7545	P1-CR5	9207	7545	0.41
10106	8149	7863	8577	8291	8577	P1-CR6	10184	8577	0.42
10107	8523	8198	9019	8694	9019	P1-CR7	10881	9019	0.41
10108	10304	9905	10946	10547	10946	P1-CR8	13253	10946	0.41
10109	12497	12055	13467	13025	13467	P1-CR9	15903	13467	0.42
10201	3728	3608	3950	3829	3950	P1-CL1	4743	3950	0.42
10202	3189	3047	3350	3207	3350	P1-CL2	4743	3350	0.35
10203	4358	4187	4529	4358	4529	P1-CL3	5441	4529	0.42
10204	5996	5824	6166	5994	6166	P1-CL4	7394	6166	0.42
10205	6048	5937	6177	6065	6177	P1-CL5	7394	6177	0.42
10206	6689	6635	6912	6858	6912	P1-CL6	8091	6912	0.43
10207	6320	6304	6584	6567	6584	P1-CL7	8091	6584	0.41
10208	7146	7137	7468	7459	7468	P1-CL8	8649	7468	0.43
10209	8413	8394	9079	9060	9079	P1-CL9	10881	9079	0.42
20101	4926	4892	5067	5032	5067	P2-CL1	5999	5067	0.42
20102	4840	4765	4981	4905	4981	P2-CL2	5999	4981	0.42
20103	6532	6425	6722	6615	6722	P2-CL3	8231	6722	0.41
20104	7153	6940	7472	7260	7472	P2-CL4	8928	7472	0.42
20105	7272	7030	7574	7332	7574	P2-CL5	9207	7574	0.41
20106	8206	7922	8612	8328	8612	P2-CL6	10184	8612	0.42
20107	8582	8260	9056	8734	9056	P2-CL7	10881	9056	0.42
20108	10358	9954	10980	10576	10980	P2-CL8	13253	10980	0.41
20109	12559	12109	13501	13052	13501	P2-CL9	15903	13501	0.42
20201	3683	3561	3915	3792	3915	P2-CR1	4743	3915	0.41
20202	3192	3049	3347	3203	3347	P2-CR2	4743	3347	0.35
20203	4395	4224	4548	4378	4548	P2-CR3	5441	4548	0.42
20204	6068	5895	6207	6035	6207	P2-CR4	7394	6207	0.42
20205	6129	6015	6225	6111	6225	P2-CR5	7394	6225	0.42
20206	6775	6717	6964	6906	6964	P2-CR6	8091	6964	0.43
20207	6385	6366	6622	6603	6622	P2-CR7	8091	6622	0.41
20208	7179	7167	7486	7474	7486	P2-CR8	8649	7486	0.43
20209	8482	8458	9107	9083	9107	P2-CR9	10881	9107	0.42

9.1.7 Design of Stay Cable-ULS

The design of stay cables has been done as per the guide lines given in Setra Specification for Stay cable design. As per Cl. 14.4.1 of the specification, the ultimate stress in the cable FULS ≤ 0.7FGUTS in service conditions and FULS ≤ 0.75FGUTS in construction and accidental situations. The summary of stay cable forces is presented below for ULS combinations.

Cables	Comb-1	Comb-2	ULS Max		No. of Strands	Perm. Force (0.7 x UTS)
	LL-Leading + Temp	LL-Leading-Wind		Interaction Ratio		
10101	6613	6630.032008	6630	0.55	43	8398
10102	6671	6724.788581	6725	0.56	43	8398
10103	9169	9252.064253	9252	0.56	59	11523
10104	10423	10594.86433	10595	0.59	64	12499
10105	10660	10858.77037	10859	0.59	66	12890
10106	12167	12402.89491	12403	0.61	73	14257
10107	12870	13140.22535	13140	0.60	78	15233
10108	15707	16039.0933	16039	0.61	95	18554
10109	19506	19864.55354	19865	0.62	114	22264
10201	6337	6413.424041	6413	0.68	34	6640
10202	5154	5259.931025	5260	0.55	34	6640
10203	6710	6848.154809	6848	0.63	39	7617
10204	8964	9104.587194	9105	0.62	53	10351
10205	8825	8913.649307	8914	0.60	53	10351
10206	9738	9775.372185	9775	0.60	58	11327
10207	9161	9143.079999	9161	0.57	58	11327
10208	10239	10163.13195	10239	0.59	62	12109
10209	12410	12247.26014	12410	0.57	78	15233
20101	6623	6642.128951	6642	0.55	43	8398
20102	6685	6740.032163	6740	0.56	43	8398
20103	9182	9265.841104	9266	0.56	59	11523
20104	10446	10617.08118	10617	0.59	64	12499
20105	10683	10881.46088	10881	0.59	66	12890
20106	12193	12427.4852	12427	0.61	73	14257
20107	12897	13164.22723	13164	0.60	78	15233
20108	15722	16059.09778	16059	0.61	95	18554
20109	19522	19887.73285	19888	0.63	114	22264
20201	6326	6404.107575	6404	0.68	34	6640
20202	5159	5265.864906	5266	0.56	34	6640
20203	6728	6865.806644	6866	0.63	39	7617
20204	8993	9135.290304	9135	0.62	53	10351
20205	8855	8946.7148	8947	0.61	53	10351
20206	9766	9808.039644	9808	0.61	58	11327
20207	9181	9168.243915	9181	0.57	58	11327
20208	10245	10176.20123	10245	0.59	62	12109
20209	12434	12281.47773	12434	0.57	78	15233

9.2 Design of Pylons

9.2.1 Structural Design of Pylon

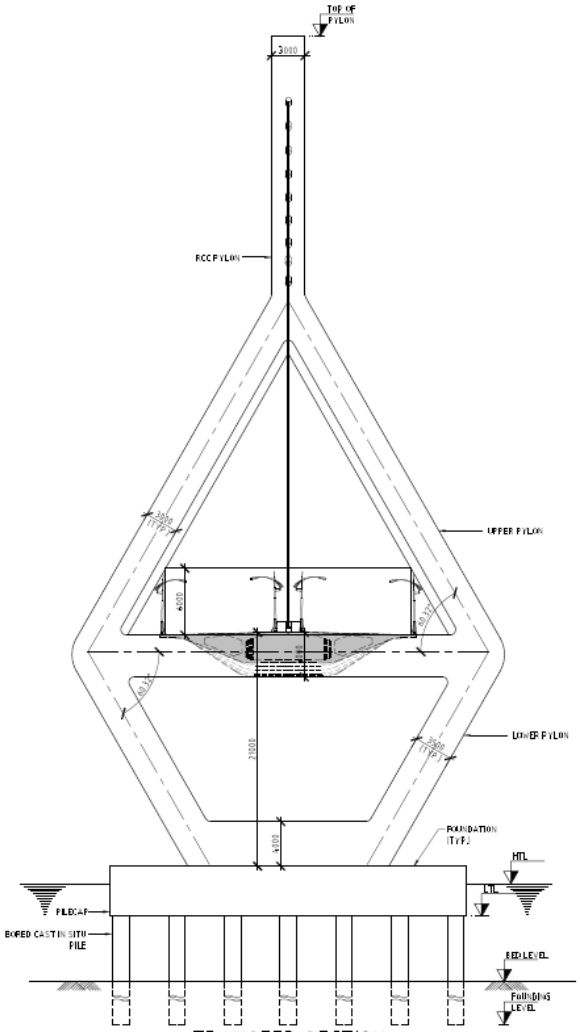
The pylon is proposed as rectangular type with haunches (150mmx150mm). The pylons are cast in place reinforced concrete monolithic with the deck. The cross section proposed for lower pylon is 6.0(longitudinal) x 3.5m(transverse) and for upper pylon it is 6.0m(longitudinal) x 3.0m(transverse)

Pylon is designed for axial thrust, and biaxial bending caused due to various loads acting on structure as specified in sec 4.0.

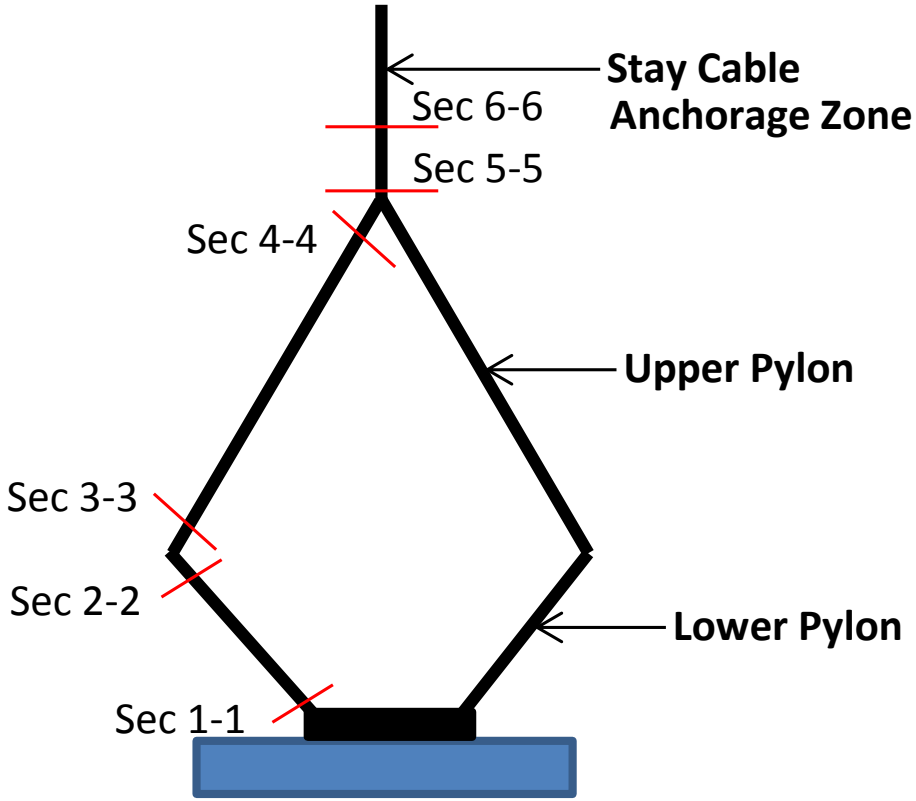
Lower Pylon Grade of concrete considered as M50 and Upper pylon grade of concrete considered as M55.

Pylon section is designed for ULS load combinations as per sec 8.3 of IRC:112-2011 and checked for serviceability load combinations for limits of crack width and material stresses as per Section 12 of IRC:112-2011.

The section forces are extracted from the 2D model analyse in Midas Civil.



Transverse Section



Sections	Location
	Lower Pylon
Sec 1-1	Bottom
Sec 2-2	Top
	Upper Pylon
Sec 3-3	Bottom
Sec 4-4	Top
	Anchorage Zone
Sec 5-5	Bottom
Sec 6-6	Mid

9.2.1 Summary of forces and load combinations for Lower pylon design (Bottom)

Section location	At pilecap bottom (No Scour condition)				
Load Case	P	HL	HT	ML	MT
	kN	kN	kN	kNm	kNm
Dead Load					
SIDL (Fixed)	4730	-287	711	-6408	11510
SIDL (Variable)	3075	-187	462	-4165	7482
Self weight+Stay cable	85540	-1594	13101	-205274	-65054
Secondary Prestress	30	-1331	59	12568	-261
Creep secondary	222	-1316	-790	33394	2028
Shrinkage secondary	174	-1209	-215	16024	2606
Live Loading					
P max	4947	-508	759	-10223	12294
ML max	3887	-1265	448	-23505	7088
MT max	4255	72	871	357	13232
Longitudinal loading (Braking force)					
P max	9	-441	-14	-4930	-239
ML max	9	-441	-14	-4930	-239
MT max	9	-441	-14	-4930	-239
Wind Force					
P max (Without L.L)	3563	781	-781	10149	24003
ML max (Without L.L)	3563	781	-781	10149	24003
MT max (Without L.L)	3563	781	-781	10149	24003
P max	3036	666	-666	8648	20452
ML max	3036	666	-666	8648	20452
MT max	3036	666	-666	8648	20452
Temperature Forces					
Uniform Temp	-725	22273	-94	-303568	211
Pylon Temp Grad	0	0	0	0	0
Deck Temp Grad	-110	1931	48	-23642	-199
Water current force					
0 Deg	0	0	292	0	426
20 Deg	0	100	274	146	400
EQ					
EQV = 0.3ELx+0.3ELy+1.0ELz	2891	1446	-1847	17987	16799
EQT = 0.3ELx+1.0ELy+0.3ELz	1565	3558	-1622	39374	13123
EQL = 1.0ELx+0.3ELy+0.3ELz	1915	1252	-4691	13744	31807

Buoyancy				0	0	0	0	0
Barge impact				0	0	8954	0	49245
Live Loading (SPV)								
P max				5687	-937	932	-20051	12991
ML max				4756	-1321	578	-26876	8250
MT max				5030	-418	1098	-9465	16632

Notations used in load combinations are:

G - Permanent loads which include Self weight + Stay cable, SIDL (fixed), Jack Push, Creep and Shrinkage
S - SIDL (Variable)
P - Secondary prestress
Qi - Live load
QSi - SPV Live load
QCi - Live load (Congestion Factor)
Ql - Braking / Longitudinal force
QSl - SPV Braking / Longitudinal force
WC - Water current force
Wi - Wind load
EQ - Seismic force
AE - Barge collision

9.2.1.1 Load Combinations for Lower pylon design (Bottom):

			Section location		At pilecap bottom (No Scour condition)				
		Load Case	Description		P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	Unfactored Permanent Loads	2.1.0	1.0G + 1.0P +1.0S		93374	-3399	14333	-203279	-46324
	Factored Permanent Loads	2.2.0	1.35G+1.0P+1.75S		127275	-4197	19514	-280491	-59453
	G - I: Normal loading / Wind combination	2.2.1	1.35G+1.0P+1.75S+1.5Q1+1.5QI+0.9W1 +1.0WC	G - I (a): Live load leading with Wind accompanying	137440	-4921	20306	-295292	-22563
		2.2.2	1.35G+1.0P+1.75S+1.5Q2+1.5QI+0.9W2+1.0WC		135851	-6056	19841	-315215	-30372
		2.2.3	1.35G+1.0P+1.75S+1.5Q3+1.5QI+0.9W3+1.0WC		136403	-4052	20475	-279422	-21156
		2.2.4	1.35G+1.0P+1.75S+1.5Q4+1.5QI+0.9W4+1.0WC		127275	-4097	19788	-280346	-59053
		2.2.5	1.35G+1.0P+1.75S+1.5Q5+1.5QI+0.9W5+1.0WC		127275	-4097	19788	-280346	-59053
		2.2.6	1.35G+1.0P+1.75S+1.5Q6+1.5QI+0.9W6+1.0WC		127275	-4097	19788	-280346	-59053
		2.2.7	1.35G+1.0P+1.75S+1.5Q7+1.5QI+0.9W7+1.0WC		127275	-4097	19788	-280346	-59053
		2.2.8	1.35G+1.0P+1.75S+1.5Q8+1.5QI+0.9W8+1.0WC		127275	-4097	19788	-280346	-59053
		2.2.9	1.35G+1.0P+1.75S+1.5Q9+1.5QI+0.9W9+1.0WC		127275	-4097	19788	-280346	-59053
		2.2.10	1.35G+1.0P+1.75S+1.5Q10+1.5QI+0.9W10+1.0WC		127275	-4097	19788	-280346	-59053
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - I: Normal loading / Wind combination	2.3.1	1.35G+1.0P+1.75S+1.15Q1+1.15QI+1.5W1+1.0WC	G - I (b): Wind Leading	137527	-4189	19646	-284800	-14511
		2.3.2	1.35G+1.0P+1.75S+1.15Q2+1.15QI+1.5W2+1.0WC		136309	-5060	19289	-300074	-20498
		2.3.3	1.35G+1.0P+1.75S+1.15Q3+1.15QI+1.5W3+1.0WC		136732	-3523	19776	-272633	-13432
		2.3.4	1.35G+1.0P+1.75S+1.15Q4+1.15QI+1.5W4+1.0WC		127275	-4097	19788	-280346	-59053
		2.3.5	1.35G+1.0P+1.75S+1.15Q5+1.15QI+1.5W5+1.0WC		127275	-4097	19788	-280346	-59053
		2.3.6	1.35G+1.0P+1.75S+1.15Q6+1.15QI+1.5W6+1.0WC		127275	-4097	19788	-280346	-59053
		2.3.7	1.35G+1.0P+1.75S+1.15Q7+1.15QI+1.5W7+1.0WC		127275	-4097	19788	-280346	-59053
		2.3.8	1.35G+1.0P+1.75S+1.15Q8+1.15QI+1.5W8+1.0WC		127275	-4097	19788	-280346	-59053
		2.3.9	1.35G+1.0P+1.75S+1.15Q9+1.15QI+1.5W9+1.0WC		127275	-4097	19788	-280346	-59053
		2.3.10	1.35G+1.0P+1.75S+1.15Q10+1.15QI+1.5W10+1.0WC		127275	-4097	19788	-280346	-59053
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	2.4.1	1.35G + 1.0P +1.75S +0.2Q1+0.2QI +1.0WC+1.5EQV	G - II (a): EQV = 0.3ELx+0.3ELy+1.0ELz	132602	-2118	17166	-256395	-31443
		2.4.2	1.35G + 1.0P +1.75S +0.2Q2+0.2QI +1.0WC+1.5EQV		132390	-2270	17104	-259052	-32484
		2.4.3	1.35G + 1.0P +1.75S +0.2Q3+0.2QI +1.0WC+1.5EQV		132463	-2002	17189	-254279	-31255
		2.4.4	1.35G + 1.0P +1.75S +0.2Q4+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854
		2.4.5	1.35G + 1.0P +1.75S +0.2Q5+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854
		2.4.6	1.35G + 1.0P +1.75S +0.2Q6+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854
		2.4.7	1.35G + 1.0P +1.75S +0.2Q7+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854
		2.4.8	1.35G + 1.0P +1.75S +0.2Q8+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854
		2.4.9	1.35G + 1.0P +1.75S +0.2Q9+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854
		2.4.10	1.35G + 1.0P +1.75S +0.2Q10+0.2QI +1.0WC+1.5EQV		131611	-1929	17017	-253365	-33854

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (b): EQT = 0.3ELx+1.0ELy+0.3ELz	2.5.1	1.35G +1.75S +0.2Q1+0.2Ql+1.0WC+1.5EQT	130613	1050	17505	-224315	-36957
			2.5.2	1.35G +1.75S +0.2Q2+0.2Ql+1.0WC+1.5EQT	130401	898	17443	-226971	-37998
			2.5.3	1.35G +1.75S +0.2Q3+0.2Ql+1.0WC+1.5EQT	130474	1166	17527	-222199	-36769
			2.5.4	1.35G +1.75S +0.2Q4+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
			2.5.5	1.35G +1.75S +0.2Q5+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
			2.5.6	1.35G +1.75S +0.2Q6+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
			2.5.7	1.35G +1.75S +0.2Q7+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
			2.5.8	1.35G +1.75S +0.2Q8+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
			2.5.9	1.35G +1.75S +0.2Q9+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
			2.5.10	1.35G +1.75S +0.2Q10+0.2Ql+1.0WC+1.5EQT	129622	1240	17356	-221284	-39368
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (c): EQL = 1.0ELx+0.3ELy+0.3ELz	2.6.1	1.35G +1.75S +0.2Q1+0.2Ql+1.0WC+1.5EQL	131138	-2409	12901	-262761	-8932
			2.6.2	1.35G +1.75S +0.2Q2+0.2Ql+1.0WC+1.5EQL	130926	-2560	12839	-265417	-9973
			2.6.3	1.35G +1.75S +0.2Q3+0.2Ql+1.0WC+1.5EQL	131000	-2293	12923	-260645	-8744
			2.6.4	1.35G +1.75S +0.2Q4+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
			2.6.5	1.35G +1.75S +0.2Q5+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
			2.6.6	1.35G +1.75S +0.2Q6+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
			2.6.7	1.35G +1.75S +0.2Q7+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
			2.6.8	1.35G +1.75S +0.2Q8+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
			2.6.9	1.35G +1.75S +0.2Q9+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
			2.6.10	1.35G +1.75S +0.2Q10+0.2Ql+1.0WC+1.5EQL	130147	-2219	12752	-259730	-11343
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (a): Live load leading	2.7.1	1.0G + 1.0P +1.0S +0.75Q1+0.75Ql+1.0WC+1.0AE	97091	-4010	24119	-214498	12362
			2.7.2	1.0G + 1.0P +1.0S +0.75Q2+0.75Ql+1.0WC+1.0AE	96296	-4578	23887	-224459	8458
			2.7.3	1.0G + 1.0P +1.0S +0.75Q3+0.75Ql+1.0WC+1.0AE	96572	-3576	24204	-206563	13066
			2.7.4	1.0G + 1.0P +1.0S +0.75Q4+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.7.5	1.0G + 1.0P +1.0S +0.75Q5+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.7.6	1.0G + 1.0P +1.0S +0.75Q6+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.7.7	1.0G + 1.0P +1.0S +0.75Q7+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.7.8	1.0G + 1.0P +1.0S +0.75Q8+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.7.9	1.0G + 1.0P +1.0S +0.75Q9+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.7.10	1.0G + 1.0P +1.0S +0.75Q10+0.75Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (b): Live load accompanying	2.8.1	1.0G + 1.0P +1.0S +0.2Q1+0.2Ql+1.0WC+1.0AE	94365	-3489	23710	-206164	5732
			2.8.2	1.0G + 1.0P +1.0S +0.2Q2+0.2Ql+1.0WC+1.0AE	94154	-3640	23648	-208820	4691
			2.8.3	1.0G + 1.0P +1.0S +0.2Q3+0.2Ql+1.0WC+1.0AE	94227	-3373	23732	-204048	5920
			2.8.4	1.0G + 1.0P +1.0S +0.2Q4+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.8.5	1.0G + 1.0P +1.0S +0.2Q5+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.8.6	1.0G + 1.0P +1.0S +0.2Q6+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.8.7	1.0G + 1.0P +1.0S +0.2Q7+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.8.8	1.0G + 1.0P +1.0S +0.2Q8+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.8.9	1.0G + 1.0P +1.0S +0.2Q9+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
			2.8.10	1.0G + 1.0P +1.0S +0.2Q10+0.2Ql+1.0WC+1.0AE	93374	-3299	23561	-203133	3321
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (a) Thermal load Leading	2.9.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5T+1.0WC	131721	31118	20575	-788586	-45171
			2.9.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5T+1.0WC	130503	30247	20218	-803861	-51158
			2.9.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5T+1.0WC	130926	31784	20705	-776419	-44093
			2.9.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
			2.9.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
			2.9.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
			2.9.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
			2.9.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
			2.9.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
			2.9.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1.5T+1.0WC	126023	32208	19719	-771161	-59034
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (b) Live load leading with Thermal load accompanying	2.10.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+0.9T+1.0WC	133956	16264	20863	-597564	-40960
			2.10.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+0.9T+1.0WC	132367	15128	20398	-617487	-48769
			2.10.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+0.9T+1.0WC	132919	17133	21033	-581694	-39553
			2.10.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042
			2.10.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042
			2.10.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042
			2.10.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042
			2.10.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042
			2.10.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042
			2.10.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+0.9T+1.0WC	126524	17686	19746	-574835	-59042

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - V : SPV loading	G - V : SPV Leading	2.11.1	1.35G+1.0P+1.75S+1.15QS1+1.5QSI+1.0WC	133815	-5174	20860	-303404	-44113
			2.11.2	1.35G+1.0P+1.75S+1.15QS2+1.5QSI+1.0WC	132744	-5616	20453	-311254	-49565
			2.11.3	1.35G+1.0P+1.75S+1.15QS3+1.5QSI+1.0WC	133059	-4578	21051	-291230	-39926
			2.11.4	1.35G+1.0P+1.75S+1.15QS4+1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
			2.11.5	1.35G+1.0P+1.75S+1.15QS5+1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
			2.11.6	1.35G+1.0P+1.75S+1.15QS6+1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
			2.11.7	1.35G+1.0P+1.75S+1.15QS7+1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
			2.11.8	1.35G+1.0P+1.75S+1.15QS8+1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
			2.11.9	1.35G+1.0P+1.75S+1.15QS9+1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
			2.11.10	1.35G+1.0P+1.75S+1.15QS10 +1.5QSI+1.0WC	127275	-4097	19788	-280346	-59053
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	2.12.1	1.35G+1.0P+1.75S+1.5QC1+0.9W1+1.0WC	130007	-3498	19189	-272563	-40645
			2.12.2	1.35G+1.0P+1.75S+1.5QC2+0.9W2+1.0WC	130007	-3498	19189	-272563	-40645
			2.12.3	1.35G+1.0P+1.75S+1.5QC3+0.9W4+1.0WC	127275	-4097	19788	-280346	-59053
			2.12.4	1.35G+1.0P+1.75S+1.5QC4+0.9W6+1.0WC	127275	-4097	19788	-280346	-59053
			2.12.5	1.35G+1.0P+1.75S+1.5QC5+0.9W8+1.0WC	127275	-4097	19788	-280346	-59053
			2.12.6	1.35G+1.0P+1.75S+1.5QC6+0.9W9+1.0WC	127275	-4097	19788	-280346	-59053
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	2.13.1	1.35G+1.0P+1.75S+1.15QC1+1.5W1+1.0WC	131829	-3099	18790	-267374	-28374
			2.13.2	1.35G+1.0P+1.75S+1.15QC2+1.5W2+1.0WC	131829	-3099	18790	-267374	-28374
			2.13.3	1.35G+1.0P+1.75S+1.15QC3+1.5W4+1.0WC	127275	-4097	19788	-280346	-59053
			2.13.4	1.35G+1.0P+1.75S+1.15QC4+1.5W6+1.0WC	127275	-4097	19788	-280346	-59053
			2.13.5	1.35G+1.0P+1.75S+1.15QC5+1.5W8+1.0WC	127275	-4097	19788	-280346	-59053
			2.13.6	1.35G+1.0P+1.75S+1.15QC6+1.5W9+1.0WC	127275	-4097	19788	-280346	-59053

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Permanent Loads		3.1.1	1.0G+1.0P+1.2S	94385	-5961	13420	-154694	-40193
	Rare Combination	G - I Live load leading and wind accompanying	3.1.2	1.0G+1.0P+1.0S+1.0Q1+1.0QI +0.6W1 +1.0WC	101162	-6410	14040	-164513	-15467
			3.1.3	1.0G+1.0P+1.0S+1.0Q2+1.0QI +0.6W2+1.0WC	100103	-7167	13730	-177795	-20673
			3.1.4	1.0G+1.0P+1.0S+1.0Q3+1.0QI +0.6W3+1.0WC	100470	-5831	14153	-153933	-14529
			3.1.5	1.0G+1.0P+1.0S+1.0Q4+1.0QI +0.6W4+1.0WC	94385	-5861	13695	-154548	-39793
			3.1.6	1.0G+1.0P+1.0S+1.0Q5+1.0QI +0.6W5+1.0WC	94385	-5861	13695	-154548	-39793
			3.1.7	1.0G+1.0P+1.0S+1.0Q6+1.0QI +0.6W6+1.0WC	94385	-5861	13695	-154548	-39793
			3.1.8	1.0G+1.0P+1.0S+1.0Q7+1.0QI +0.6W7+1.0WC	94385	-5861	13695	-154548	-39793
			3.1.9	1.0G+1.0P+1.0S+1.0Q8+1.0QI +0.6W8+1.0WC	94385	-5861	13695	-154548	-39793
			3.1.10	1.0G+1.0P+1.0S+1.0Q9+1.0QI +0.6W9+1.0WC	94385	-5861	13695	-154548	-39793
			3.1.11	1.0G+1.0P+1.0S+1.0Q10+1.0QI +0.6W10+1.0WC	94385	-5861	13695	-154548	-39793
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - II Live load leading and thermal load accompanying	3.2.1	1.0G+1.0P+1.0S+Q1+1.0QI+0.6T +1.0WC	98840	7713	14412	-366027	-27731
			3.2.2	1.0G+1.0P+1.0S+Q2+1.0QI+0.6T +1.0WC	97780	6955	14101	-379309	-32937
			3.2.3	1.0G+1.0P+1.0S+Q3+1.0QI+0.6T +1.0WC	98148	8292	14524	-355447	-26793
			3.2.4	1.0G+1.0P+1.0S+Q4+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
			3.2.5	1.0G+1.0P+1.0S+Q5+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
			3.2.6	1.0G+1.0P+1.0S+Q6+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
			3.2.7	1.0G+1.0P+1.0S+Q7+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
			3.2.8	1.0G+1.0P+1.0S+Q8+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
			3.2.9	1.0G+1.0P+1.0S+Q9+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
			3.2.10	1.0G+1.0P+1.0S+Q10+1.0QI+0.6T +1.0WC	93884	8661	13667	-350874	-39785
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - III Wind Leading	3.3.1	1.0G+1.0P+1.0S+0.75Q1+0.75QI+1.0W 1+1.0WC	101137	-5907	13588	-157265	-10299
			3.3.2	1.0G+1.0P+1.0S+0.75Q2+0.75QI+1.0W 2+1.0WC	100343	-6475	13355	-167227	-14204
			3.3.3	1.0G+1.0P+1.0S+0.75Q3+0.75QI+1.0W 3+1.0WC	100619	-5472	13672	-149330	-9596
			3.3.4	1.0G+1.0P+1.0S+0.75Q4+0.75QI+1.0W 4+1.0WC	94385	-5861	13695	-154548	-39793
			3.3.5	1.0G+1.0P+1.0S+0.75Q5+0.75QI+1.0W 5+1.0WC	94385	-5861	13695	-154548	-39793
			3.3.6	1.0G+1.0P+1.0S+0.75Q6+0.75QI+1.0W 6+1.0WC	94385	-5861	13695	-154548	-39793
			3.3.7	1.0G+1.0P+1.0S+0.75Q7+0.75QI+1.0W 7+1.0WC	94385	-5861	13695	-154548	-39793
			3.3.8	1.0G+1.0P+1.0S+0.75Q8+0.75QI+1.0W 8+1.0WC	94385	-5861	13695	-154548	-39793
			3.3.9	1.0G+1.0P+1.0S+0.75Q9+0.75QI+1.0W 9+1.0WC	94385	-5861	13695	-154548	-39793
			3.3.10	1.0G+1.0P+1.0S+0.75Q10+0.75QI+1.0 W10+1.0WC	94385	-5861	13695	-154548	-39793

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - IV Thermal load Leading	3.4.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0T+1.0WC	97267	17631	14207	-493123	-30740
			3.4.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0T+1.0WC	96472	17063	13974	-503084	-34644
			3.4.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0T+1.0WC	96748	18066	14292	-485188	-30036
			3.4.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0T+1.0WC	93550	18342	13648	-481758	-39781
			3.4.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0T+1.0WC	93550	18342	13648	-481758	-39781
			3.4.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0T+1.0WC	93550	18342	13648	-481758	-39781
			3.4.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0T+1.0WC	93550	18342	13648	-481758	-39781
			3.4.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0T+1.0WC	93550	18342	13648	-481758	-39781
			3.4.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0T+1.0WC	93550	18342	13648	-481758	-39781
			3.4.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql0+1.0T+1.0WC	93550	18342	13648	-481758	-39781
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - V : SPV Leading	3.5.1	1.0G+1.0P+1.2S+1.0QS1+1.0QSl+1.0WC	100072	-6798	14627	-174599	-26802
			3.5.2	1.0G+1.0P+1.2S+1.0QS2+1.0QSl+1.0WC	99141	-7182	14272	-181425	-31543
			3.5.3	1.0G+1.0P+1.2S+1.0QS3+1.0QSl+1.0WC	99415	-6279	14793	-164013	-23161
			3.5.4	1.0G+1.0P+1.2S+1.0QS4+1.0QSl+1.0WC	94385	-5861	13695	-154548	-39793
			3.5.5	1.0G+1.0P+1.2S+1.0QS5+1.0QSl+1.0WC	94385	-5861	13695	-154548	-39793
			3.5.6	1.0G+1.0P+1.2S+1.0QS6+1.0QSl++1.0WC	94385	-5861	13695	-154548	-39793
			3.5.7	1.0G+1.0P+1.2S+1.0QS7+1.0QSl+0.6T+1.0WC	94385	-5861	13695	-154548	-39793
			3.5.8	1.0G+1.0P+1.2S+1.0QS8+1.0QSl+1.0WC	94385	-5861	13695	-154548	-39793
			3.5.9	1.0G+1.0P+1.2S+1.0QS9+1.0QSl+1.0WC	94385	-5861	13695	-154548	-39793
			3.5.10	1.0G+1.0P+1.2S+1.0QS10+1.0QSl+1.0WC	94385	-5861	13695	-154548	-39793
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.6.1	1.0G+1.0P+1.2S+1.0QC1+0.6W1+1.0WC	96207	-5462	13295	-149360	-27521
			3.6.2	1.0G+1.0P+1.2S+1.0QC2+0.6W2+1.0WC	96207	-5462	13295	-149360	-27521
			3.6.3	1.0G+1.0P+1.2S+1.0QC3+0.6W4+1.0WC	94385	-5861	13695	-154548	-39793
			3.6.4	1.0G+1.0P+1.2S+1.0QC4+0.6W6+1.0WC	94385	-5861	13695	-154548	-39793
			3.6.5	1.0G+1.0P+1.2S+1.0QC5+0.6W8+1.0WC	94385	-5861	13695	-154548	-39793
			3.6.6	1.0G+1.0P+1.2S+1.0QC6+0.6W9+1.0WC	94385	-5861	13695	-154548	-39793
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	3.7.1	1.0G+1.0P+1.2S+0.75QC1+1.0W1+1.0WC	97421	-5196	13029	-145901	-19340
			3.7.2	1.0G+1.0P+1.2S+0.75QC2+1.0W2+1.0WC	97421	-5196	13029	-145901	-19340
			3.7.3	1.0G+1.0P+1.2S+0.75QC3+1.0W4+1.0WC	94385	-5861	13695	-154548	-39793
			3.7.4	1.0G+1.0P+1.2S+0.75QC4+1.0W6+1.0WC	94385	-5861	13695	-154548	-39793
			3.7.5	1.0G+1.0P+1.2S+0.75QC5+1.0W8+1.0WC	94385	-5861	13695	-154548	-39793
			3.7.6	1.0G+1.0P+1.2S+0.75QC6+1.0W9+1.0WC	94385	-5861	13695	-154548	-39793
	Quasi-permanent		4.1.1	1.0G+1.0P+1.0S+0.5T	93968	6141	13397	-318299	-40187

9.2.1.2 Structural design of Lower pylon (Bottom)

Pier dim. along traffic	=	6000	mm
Pier dim. across traffic	=	3500	mm
Grade of Steel f_{yk}	=	500	mpa
Grade of Concrete f_{ck}	=	50	mpa
f_{ctm} =0.259×50^(2/3)	=	3.52	mpa
f_{cd} =50×0.67/1.5	=	22.33	mpa
Clear cover	=	75	mm

Along traffic			**Across traffic**		
Layer-1			Layer-1		
Dia of bar	=	40 mm	Dia of bar	=	40 mm
No. of bars	=	60 nos	No. of bars	=	33 nos
Layer-2			Layer-2		
Dia of bar	=	40 mm	Dia of bar	=	40 mm
No. of bars	=	60 nos	No. of bars	=	33 nos
Layer-3			Layer-3		
Dia of bar	=	40 mm	Dia of bar	=	40 mm
No. of bars	=	60 nos	No. of bars	=	33 nos
Layer-4			Layer-4		
Dia of bar	=	40 mm	Dia of bar	=	40 mm
No. of bars	=	0 nos	No. of bars	=	0 nos
Total no. of bars	=	558 nos			

% Reinf. Assumed	=	3.34	%
Area of Steel	=	701203	mm^2

Minimum % of Reinforcement:

$A_{s,min}$ =	$0.10*N_{ED}/f_{yd}$	= 31631	mm^2	(CL. 16.2.2 of IRC:112-2011)
	(or) $0.002A_c$	= 42000	mm^2	
	$A_{s,min}$	= 42000	mm^2	< Ast Provided
$A_{s,max}$ =	$0.04 * A_c$	= 840000	mm^2	> Ast Provided

9.2.1.3 Flexural design

The section capacity is found out in two orthogonal directions (i.e. M_{UL} & M_{UT}) for the provided reinforcement

(Refer to P-M curves). The capacity interaction ratio $(M_L / M_{UL})^{\alpha n} + (M_T / M_{UT})^{\alpha n}$ is given in table below.

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	M_{UL}	M_{UT}	Capacity ratio
2.2.0	1.35G+1.0P+1.75S	127275	-4197	19514	-280491	-59453	Live load leading with Wind accompanying	850636	481937	0.37
2.2.1	1.35G+1.0P+1.75S	137440	-4921	20306	-295292	-22563		871125	477671	0.35
2.2.2	1.35G+1.0P+1.75S	135851	-6056	19841	-315215	-30372		867807	468113	0.37
2.2.3	1.35G+1.0P+1.75S	136403	-4052	20475	-279422	-21156		871124	484835	0.33
2.2.4	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.2.5	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.2.6	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.2.7	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.2.8	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.2.9	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.2.10	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.1	1.35G+1.0P+1.75S	137527	-4189	19646	-284800	-14511	Wind Leading	873848	482570	0.33
2.3.2	1.35G+1.0P+1.75S	136309	-5060	19289	-300074	-20498		871300	475227	0.35
2.3.3	1.35G+1.0P+1.75S	136732	-3523	19776	-272633	-13432		873845	488058	0.32
2.3.4	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.5	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.6	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.7	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.8	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.9	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.3.10	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.4.1	1.35G + 1.0P +1.75	132602	-2118	17166	-256395	-31443	Seismic combination - EQV	865988	494485	0.31
2.4.2	1.35G + 1.0P +1.75	132390	-2270	17104	-259052	-32484		865548	493199	0.31
2.4.3	1.35G + 1.0P +1.75	132463	-2002	17189	-254279	-31255		865988	495418	0.31
2.4.4	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31
2.4.5	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31
2.4.6	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31
2.4.7	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31
2.4.8	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31
2.4.9	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31
2.4.10	1.35G + 1.0P +1.75	131611	-1929	17017	-253365	-33854		864744	495586	0.31

2.5.1	1.35G +1.75S +0.2	130613	1050	17505	-224315	-36957	Seismic combination - EQT	863261	508618	0.28
2.5.2	1.35G +1.75S +0.2	130401	898	17443	-226971	-37998		862821	507332	0.28
2.5.3	1.35G +1.75S +0.2	130474	1166	17527	-222199	-36769		863259	509544	0.28
2.5.4	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.5.5	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.5.6	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.5.7	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.5.8	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.5.9	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.5.10	1.35G +1.75S +0.2	129622	1240	17356	-221284	-39368		862017	509688	0.28
2.6.1	1.35G +1.75S +0.2	131138	-2409	12901	-262761	-8932	Seismic combination - EQL	872768	491132	0.30
2.6.2	1.35G +1.75S +0.2	130926	-2560	12839	-265417	-9973		872317	489851	0.31
2.6.3	1.35G +1.75S +0.2	131000	-2293	12923	-260645	-8744		872760	492063	0.30
2.6.4	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.6.5	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.6.6	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.6.7	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.6.8	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.6.9	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.6.10	1.35G +1.75S +0.2	130147	-2219	12752	-259730	-11343		871472	492236	0.30
2.7.1	1.0G + 1.0P +1.0S	97091	-4010	24119	-214498	12362	Accidental load combination - Live load leading	850676	-498992	0.26
2.7.2	1.0G + 1.0P +1.0S	96296	-4578	23887	-224459	8458		851276	-494358	0.27
2.7.3	1.0G + 1.0P +1.0S	96572	-3576	24204	-206563	13066		850074	-502091	0.25
2.7.4	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.7.5	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.7.6	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.7.7	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.7.8	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.7.9	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.7.10	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.1	1.0G + 1.0P +1.0S	94365	-3489	23710	-206164	5732	Accidental load combination - Live load accompanying	850650	-501105	0.24
2.8.2	1.0G + 1.0P +1.0S	94154	-3640	23648	-208820	4691		850805	-499873	0.25
2.8.3	1.0G + 1.0P +1.0S	94227	-3373	23732	-204048	5920		850487	-501926	0.24
2.8.4	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.5	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.6	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.7	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.8	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.9	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24
2.8.10	1.0G + 1.0P +1.0S	93374	-3299	23561	-203133	3321		850627	-501862	0.24

2.9.1	1.35G+1.0P+1.75S	131721	31118	20575	-788586	-45171	Thermal load Leading	860672	146143	0.92
2.9.2	1.35G+1.0P+1.75S	130503	30247	20218	-803861	-51158		856785	127650	0.94
2.9.3	1.35G+1.0P+1.75S	130926	31784	20705	-776419	-44093		860920	156987	0.91
2.9.4	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.9.5	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.9.6	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.9.7	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.9.8	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.9.9	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.9.10	1.35G+1.0P+1.75S	126023	32208	19719	-771161	-59034		850227	160149	0.91
2.10.1	1.35G+1.0P+1.75S	133956	16264	20863	-597564	-40960	Live load leading with Thermal load accompanying	863437	300769	0.70
2.10.2	1.35G+1.0P+1.75S	132367	15128	20398	-617487	-48769		858949	286911	0.73
2.10.3	1.35G+1.0P+1.75S	132919	17133	21033	-581694	-39553		863441	311415	0.68
2.10.4	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.10.5	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.10.6	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.10.7	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.10.8	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.10.9	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.10.10	1.35G+1.0P+1.75S	126524	17686	19746	-574835	-59042		850479	314880	0.69
2.11.1	1.35G+1.0P+1.75S	133815	-5174	20860	-303404	-44113	SPV Leading	862196	473145	0.37
2.11.2	1.35G+1.0P+1.75S	132744	-5616	20453	-311254	-49565		858672	469258	0.39
2.11.3	1.35G+1.0P+1.75S	133059	-4578	21051	-291230	-39926		863380	478564	0.36
2.11.4	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.11.5	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.11.6	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.11.7	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.11.8	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.11.9	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.11.10	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.12.1	1.35G+1.0P+1.75S	130007	-3498	19189	-272563	-40645	Congestion loading : Live loading Leading / Wind accompanying	861771	486314	0.34
2.12.2	1.35G+1.0P+1.75S	130007	-3498	19189	-272563	-40645		861771	486314	0.34
2.12.3	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.12.4	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.12.5	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.12.6	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.13.1	1.35G+1.0P+1.75S	131829	-3099	18790	-267374	-28374	Congestion loading : Wind loading Leading / Live Load accompanying	866658	489209	0.32
2.13.2	1.35G+1.0P+1.75S	131829	-3099	18790	-267374	-28374		866658	489209	0.32
2.13.3	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.13.4	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.13.5	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36
2.13.6	1.35G+1.0P+1.75S	127275	-4097	19788	-280346	-59053		850858	482003	0.36

9.2.1.4 Check for Shear (Cl 10.3.2, IRC 112)

Check for Shear along Traffic Direction

Thickness of the web (across traffic)		=	3500	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	75	mm
Effective depth in the longitudinal direction		=	5895	mm
Effective depth in the transverse direction		=	3395	mm
Area of tension steel in bott. Flange	A_{st}	=	82938	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	15	nos.
Spacing of stirrups	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1178	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	32208	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.18	
Percentage of Main reinforcement	ρ_1	=	0.0040	
	σ_{cp}	=	4.45	
	V_{min}	=	0.28	=0.031×(1.18^1.5)×50^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	21093 kN	Shear reinf. required

Therefore provide 15 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0022	=1178/(3500×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0010	Safe

Check for Shear across Traffic Direction

Thickness of the web (across traffic)		=	3500	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	75	mm
Effective depth in the longitudinal direction		=	5895	mm
Effective depth in the transverse direction		=	3395	mm
Area of tension steel in bott. Flange	A_{st}	=	150797	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	26	nos.
Spacing of shear legs	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	2042	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	24204	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.24	
Percentage of Main reinforcement	ρ_1	=	0.0074	

	σ_{cp}	=	4.45	
	V_{min}	=	0.30	=0.031×(1.24^1.5)×50^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	22878 kN	Shear reinf. required

Therefore provide 26 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0023	=2042/(6000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0010	Safe

9.2.1.5 Serviceability condition

		Steel	Concrete
Allowable stresses Rare combination in MPa	=	**400**	**24**
Allowable stresses Quasi combination in MPa	=	**400**	**18**

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	Crack Width (mm)	Stress in Concrete (Mpa)	Stress in Steel (Mpa)
3.1.1	1.0G+1.0P+1.2S	94385	-5961	13420	-154694	-40193	Live load leading and wind accompanying		9.92	36.84
3.1.2	1.0G+1.0P+1.0S+1	101162	-6410	14040	-164513	-15467			9.26	23.95
3.1.3	1.0G+1.0P+1.0S+1	100103	-7167	13730	-177795	-20673			9.88	31.88
3.1.4	1.0G+1.0P+1.0S+1	100470	-5831	14153	-153933	-14529			8.87	20.03
3.1.5	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.1.6	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.1.7	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.1.8	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.1.9	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.1.10	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.1.11	1.0G+1.0P+1.0S+1	94385	-5861	13695	-154548	-39793			9.90	36.57
3.2.1	1.0G+1.0P+1.0S+0	98840	7713	14412	-366027	-27731	Live load leading and thermal load accompanying		18.08	180.00
3.2.2	1.0G+1.0P+1.0S+0	97780	6955	14101	-379309	-32937			18.91	195.57
3.2.3	1.0G+1.0P+1.0S+0	98148	8292	14524	-355447	-26793			17.59	172.03
3.2.4	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91
3.2.5	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91
3.2.6	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91
3.2.7	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91
3.2.8	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91
3.2.9	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91
3.2.10	1.0G+1.0P+1.0S+0	93884	8661	13667	-350874	-39785			18.16	183.91

3.3.1	1.0G+1.0P+1.0S+0	101137	-5907	13588	-157265	-10299	Wind Leading	8.79	18.61
3.3.2	1.0G+1.0P+1.0S+0	100343	-6475	13355	-167227	-14204		9.25	24.55
3.3.3	1.0G+1.0P+1.0S+0	100619	-5472	13672	-149330	-9596		8.50	15.66
3.3.4	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.3.5	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.3.6	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.3.7	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.3.8	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.3.9	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.3.10	1.0G+1.0P+1.0S+0	94385	-5861	13695	-154548	-39793		9.90	36.57
3.4.1	1.0G+1.0P+1.0S+0	97267	17631	14207	-493123	-30740	Thermal load Leading	23.20	283.40
3.4.2	1.0G+1.0P+1.0S+0	96472	17063	13974	-503084	-34644		23.83	295.41
3.4.3	1.0G+1.0P+1.0S+0	96748	18066	14292	-485188	-30036		22.83	277.28
3.4.4	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.4.5	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.4.6	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.4.7	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.4.8	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.4.9	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.4.10	1.0G+1.0P+1.0S+0	93550	18342	13648	-481758	-39781		23.29	286.61
3.5.1	1.0G+1.0P+1.2S+1	100072	-6798	14627	-174599	-26802	SPV Leading	10.07	34.12
3.5.2	1.0G+1.0P+1.2S+1	99141	-7182	14272	-181425	-31543		10.98	51.22
3.5.3	1.0G+1.0P+1.2S+1	99415	-6279	14793	-164013	-23161		9.56	28.71
3.5.4	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.5.5	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.5.6	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.5.7	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.5.8	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.5.9	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.5.10	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.6.1	1.0G+1.0P+1.2S+1	96207	-5462	13295	-149360	-27521	Congestion loading : Live loading Leading / Wind accompanying	9.21	27.30
3.6.2	1.0G+1.0P+1.2S+1	96207	-5462	13295	-149360	-27521		9.21	27.30
3.6.3	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.6.4	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.6.5	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57
3.6.6	1.0G+1.0P+1.2S+1	94385	-5861	13695	-154548	-39793		9.90	36.57

Crack width check is not required as per annexure B of IRC:6-2017

3.7.1	1.0G+1.0P+1.2S+0	97421	-5196	13029	-145901	-19340	Congestion loading : Wind loading Leading / Live Load accompanying		8.75	21.12
3.7.2	1.0G+1.0P+1.2S+0	97421	-5196	13029	-145901	-19340			8.75	21.12
3.7.3	1.0G+1.0P+1.2S+0	94385	-5861	13695	-154548	-39793			9.90	36.57
3.7.4	1.0G+1.0P+1.2S+0	94385	-5861	13695	-154548	-39793			9.90	36.57
3.7.5	1.0G+1.0P+1.2S+0	94385	-5861	13695	-154548	-39793			9.90	36.57
3.7.6	1.0G+1.0P+1.2S+0	94385	-5861	13695	-154548	-39793			9.90	36.57
4.1.1	1.0G+1.0P+1.0S+0	93968	6141	13397	-318299	-40187	Quasi-permanent Combination		16.90	159.20

9.2.2 Summary of forces and load combinations for pylon design (Top)

Section location	At pilecap bottom (No Scour condition)				
Load Case	P	HL	HT	ML	MT
	kN	kN	kN	kNm	kNm
Dead Load					
SIDL (Fixed)	3872	-511	768	-12718	9085
SIDL (Variable)	2517	-332	499	-8267	5905
Self weight+Stay cable	84832	1201	16112	218961	214603
Secondary Prestress	113	3350	199	8029	2486
Creep secondary	164	2150	-499	-6734	-11067
Shrinkage secondary	405	3544	-623	2840	-1993
Live Loading					
P max	4040	-721	852	-15121	10093
ML max	2893	-2530	344	-46510	3930
MT max	3513	351	965	4278	11152
Longitudinal loading (Braking force)					
P max	9	-441	-14	-4930	-239
ML max	9	-441	-14	-4930	-239
MT max	9	-441	-14	-4930	-239
Wind Force					
P max (Without L.L)	3888	871	-871	5949	18945
ML max (Without L.L)	3888	871	-871	5949	18945
MT max (Without L.L)	3888	871	-871	5949	18945
P max	3313	742	-742	5069	16143
ML max	3313	742	-742	5069	16143
MT max	3313	742	-742	5069	16143
Temperature Forces					
Uniform Temp	-648	19222	-23	29337	-387
Pylon Temp Grad	0	0	0	0	0
Deck Temp Grad	-108	1686	47	5203	566
Water current force					
0 Deg	0	0	292	0	426
20 Deg	0	100	274	146	400
EQ					
EQV = 0.3ELx+0.3ELy+1.0ELz	2891	1446	-1847	17987	16799
EQT = 0.3ELx+1.0ELy+0.3ELz	1565	3558	-1622	39374	13123
EQL = 1.0ELx+0.3ELy+0.3ELz	1915	1252	-4691	13744	31807

Buoyancy				0	0	0	0	0
Barge impact				0	0	8954	0	49245
Live Loading (SPV)								
P max				4624	-1736	794	-43952	8519
ML max				3640	-2570	402	-59903	4468
MT max				3986	-129	1207	-2809	14000

Notations used in load combinations are:

G - Permanent loads which include Self weight + Stay cable, SIDL (fixed), Jack Push, Creep and Shrinkage
S - SIDL (Variable)
P - Secondary prestress
Qi - Live load
QSi - SPV Live load
QCi - Live load (Congestion Factor)
Ql - Braking / Longitudinal force
QSl - SPV Braking / Longitudinal force
WC - Water current force
Wi - Wind load
EQ - Seismic force
AE - Barge collision

9.2.2.1 Load Combinations for pylon design (Top):

			Section location		At pilecap bottom (No Scour condition)				
		Load Case	Description	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	Unfactored Permanent Loads	2.1.0	1.0G + 1.0P +1.0S	91334	3709	17577	206005	232079
	Factored Permanent Loads	2.2.0	1.35G+1.0P+1.75S	124268	3702	23860	271990	314799
	G - I: Normal loading / Wind combination / G - I (a): Live load leading with Wind accompanying	2.2.1	1.35G+1.0P+1.75S+1.5Q1+1.5QI+0.9W1 +1.0WC	133323	2727	24723	246620	344509
		2.2.2	1.35G+1.0P+1.75S+1.5Q2+1.5QI+0.9W2+1.0WC	131602	14	23961	199537	335264
		2.2.3	1.35G+1.0P+1.75S+1.5Q3+1.5QI+0.9W3+1.0WC	132533	4335	24893	275719	346097
		2.2.4	1.35G+1.0P+1.75S+1.5Q4+1.5QI+0.9W4+1.0WC	124268	3801	24134	272135	315199
		2.2.5	1.35G+1.0P+1.75S+1.5Q5+1.5QI+0.9W5+1.0WC	124268	3801	24134	272135	315199
		2.2.6	1.35G+1.0P+1.75S+1.5Q6+1.5QI+0.9W6+1.0WC	124268	3801	24134	272135	315199
		2.2.7	1.35G+1.0P+1.75S+1.5Q7+1.5QI+0.9W7+1.0WC	124268	3801	24134	272135	315199
		2.2.8	1.35G+1.0P+1.75S+1.5Q8+1.5QI+0.9W8+1.0WC	124268	3801	24134	272135	315199
		2.2.9	1.35G+1.0P+1.75S+1.5Q9+1.5QI+0.9W9+1.0WC	124268	3801	24134	272135	315199
		2.2.10	1.35G+1.0P+1.75S+1.5Q10+1.5QI+0.9W10+1.0WC	124268	3801	24134	272135	315199
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - I: Normal loading / Wind combination / G - I (b): Wind Leading	2.3.1	1.35G+1.0P+1.75S+1.15Q1+1.15QI+1.5W1+1.0WC	133894	3579	23984	256679	350745
		2.3.2	1.35G+1.0P+1.75S+1.15Q2+1.15QI+1.5W2+1.0WC	132574	1499	23400	220582	343658
		2.3.3	1.35G+1.0P+1.75S+1.15Q3+1.15QI+1.5W3+1.0WC	133288	4812	24114	278989	351963
		2.3.4	1.35G+1.0P+1.75S+1.15Q4+1.15QI+1.5W4+1.0WC	124268	3801	24134	272135	315199
		2.3.5	1.35G+1.0P+1.75S+1.15Q5+1.15QI+1.5W5+1.0WC	124268	3801	24134	272135	315199
		2.3.6	1.35G+1.0P+1.75S+1.15Q6+1.15QI+1.5W6+1.0WC	124268	3801	24134	272135	315199
		2.3.7	1.35G+1.0P+1.75S+1.15Q7+1.15QI+1.5W7+1.0WC	124268	3801	24134	272135	315199
		2.3.8	1.35G+1.0P+1.75S+1.15Q8+1.15QI+1.5W8+1.0WC	124268	3801	24134	272135	315199
		2.3.9	1.35G+1.0P+1.75S+1.15Q9+1.15QI+1.5W9+1.0WC	124268	3801	24134	272135	315199
		2.3.10	1.35G+1.0P+1.75S+1.15Q10+1.15QI+1.5W10+1.0WC	124268	3801	24134	272135	315199
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination / G - II (a): EQV = 0.3ELx+0.3ELy+1.0ELz	2.4.1	1.35G + 1.0P +1.75S +0.2Q1+0.2QI +1.0WC+1.5EQV	129414	5738	21531	295106	342368
		2.4.2	1.35G + 1.0P +1.75S +0.2Q2+0.2QI +1.0WC+1.5EQV	129184	5376	21429	288828	341136
		2.4.3	1.35G + 1.0P +1.75S +0.2Q3+0.2QI +1.0WC+1.5EQV	129308	5952	21553	298986	342580
		2.4.4	1.35G + 1.0P +1.75S +0.2Q4+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397
		2.4.5	1.35G + 1.0P +1.75S +0.2Q5+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397
		2.4.6	1.35G + 1.0P +1.75S +0.2Q6+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397
		2.4.7	1.35G + 1.0P +1.75S +0.2Q7+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397
		2.4.8	1.35G + 1.0P +1.75S +0.2Q8+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397
		2.4.9	1.35G + 1.0P +1.75S +0.2Q9+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397
		2.4.10	1.35G + 1.0P +1.75S +0.2Q10+0.2QI +1.0WC+1.5EQV	128604	5970	21363	299116	340397

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (b): EQT = 0.3ELx+1.0ELy+0.3ELz	2.5.1	1.35G +1.75S +0.2Q1+0.2Ql+1.0WC+1.5EQT	127425	8906	21869	327187	336855
			2.5.2	1.35G +1.75S +0.2Q2+0.2Ql+1.0WC+1.5EQT	127195	8544	21768	320909	335622
			2.5.3	1.35G +1.75S +0.2Q3+0.2Ql+1.0WC+1.5EQT	127319	9120	21892	331066	337066
			2.5.4	1.35G +1.75S +0.2Q4+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
			2.5.5	1.35G +1.75S +0.2Q5+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
			2.5.6	1.35G +1.75S +0.2Q6+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
			2.5.7	1.35G +1.75S +0.2Q7+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
			2.5.8	1.35G +1.75S +0.2Q8+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
			2.5.9	1.35G +1.75S +0.2Q9+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
			2.5.10	1.35G +1.75S +0.2Q10+0.2Ql+1.0WC+1.5EQT	126615	9138	21702	331197	334884
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (c): EQL = 1.0ELx+0.3ELy+0.3ELz	2.6.1	1.35G +1.75S +0.2Q1+0.2Ql+1.0WC+1.5EQL	127950	5447	17265	288740	364879
			2.6.2	1.35G +1.75S +0.2Q2+0.2Ql+1.0WC+1.5EQL	127721	5086	17164	282462	363647
			2.6.3	1.35G +1.75S +0.2Q3+0.2Ql+1.0WC+1.5EQL	127845	5662	17288	292620	365091
			2.6.4	1.35G +1.75S +0.2Q4+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
			2.6.5	1.35G +1.75S +0.2Q5+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
			2.6.6	1.35G +1.75S +0.2Q6+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
			2.6.7	1.35G +1.75S +0.2Q7+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
			2.6.8	1.35G +1.75S +0.2Q8+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
			2.6.9	1.35G +1.75S +0.2Q9+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
			2.6.10	1.35G +1.75S +0.2Q10+0.2Ql+1.0WC+1.5EQL	127141	5680	17098	292750	362909
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (a): Live load leading	2.7.1	1.0G + 1.0P +1.0S +0.75Q1+0.75Ql+1.0WC+1.0AE	94371	2937	27434	191112	289114
			2.7.2	1.0G + 1.0P +1.0S +0.75Q2+0.75Ql+1.0WC+1.0AE	93510	1581	27053	167571	284492
			2.7.3	1.0G + 1.0P +1.0S +0.75Q3+0.75Ql+1.0WC+1.0AE	93976	3741	27519	205662	289908
			2.7.4	1.0G + 1.0P +1.0S +0.75Q4+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.7.5	1.0G + 1.0P +1.0S +0.75Q5+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.7.6	1.0G + 1.0P +1.0S +0.75Q6+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.7.7	1.0G + 1.0P +1.0S +0.75Q7+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.7.8	1.0G + 1.0P +1.0S +0.75Q8+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.7.9	1.0G + 1.0P +1.0S +0.75Q9+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.7.10	1.0G + 1.0P +1.0S +0.75Q10+0.75Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (b): Live load accompanying	2.8.1	1.0G + 1.0P +1.0S +0.2Q1+0.2Ql+1.0WC+1.0AE	92144	3576	26973	202140	283695
			2.8.2	1.0G + 1.0P +1.0S +0.2Q2+0.2Ql+1.0WC+1.0AE	91914	3215	26871	195863	282462
			2.8.3	1.0G + 1.0P +1.0S +0.2Q3+0.2Ql+1.0WC+1.0AE	92038	3791	26996	206020	283906
			2.8.4	1.0G + 1.0P +1.0S +0.2Q4+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.8.5	1.0G + 1.0P +1.0S +0.2Q5+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.8.6	1.0G + 1.0P +1.0S +0.2Q6+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.8.7	1.0G + 1.0P +1.0S +0.2Q7+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.8.8	1.0G + 1.0P +1.0S +0.2Q8+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.8.9	1.0G + 1.0P +1.0S +0.2Q9+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
			2.8.10	1.0G + 1.0P +1.0S +0.2Q10+0.2Ql+1.0WC+1.0AE	91334	3809	26805	206150	281724
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (a) Thermal load Leading	2.9.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5T+1.0WC	127791	33828	25134	300885	326800
			2.9.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5T+1.0WC	126471	31748	24550	264789	319712
			2.9.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5T+1.0WC	127185	35061	25264	323195	328017
			2.9.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
			2.9.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
			2.9.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
			2.9.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
			2.9.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
			2.9.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
			2.9.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1.5T+1.0WC	123134	35164	24170	323944	315467
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (b) Live load leading with Thermal load accompanying	2.10.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+0.9T+1.0WC	129661	20876	25413	273143	330141
			2.10.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+0.9T+1.0WC	127940	18163	24651	226061	320897
			2.10.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+0.9T+1.0WC	128871	22484	25582	302243	331729
			2.10.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360
			2.10.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360
			2.10.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360
			2.10.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360
			2.10.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360
			2.10.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360
			2.10.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+0.9T+1.0WC	123588	22619	24156	303220	315360

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - V : SPV loading	G - V : SPV Leading	2.11.1	1.35G+1.0P+1.75S+1.15QS1+1.5QSl+1.0WC	129585	1806	25047	221590	324995
			2.11.2	1.35G+1.0P+1.75S+1.15QS2+1.5QSl+1.0WC	128454	846	24597	203246	320337
			2.11.3	1.35G+1.0P+1.75S+1.15QS3+1.5QSl+1.0WC	128852	3653	25522	268905	331299
			2.11.4	1.35G+1.0P+1.75S+1.15QS4+1.5QSl+1.0WC	124268	3801	24134	272135	315199
			2.11.5	1.35G+1.0P+1.75S+1.15QS5+1.5QSl+1.0WC	124268	3801	24134	272135	315199
			2.11.6	1.35G+1.0P+1.75S+1.15QS6+1.5QSl+1.0WC	124268	3801	24134	272135	315199
			2.11.7	1.35G+1.0P+1.75S+1.15QS7+1.5QSl+1.0WC	124268	3801	24134	272135	315199
			2.11.8	1.35G+1.0P+1.75S+1.15QS8+1.5QSl+1.0WC	124268	3801	24134	272135	315199
			2.11.9	1.35G+1.0P+1.75S+1.15QS9+1.5QSl+1.0WC	124268	3801	24134	272135	315199
			2.11.10	1.35G+1.0P+1.75S+1.15QS10 +1.5QSl+1.0WC	124268	3801	24134	272135	315199
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	2.12.1	1.35G+1.0P+1.75S+1.5QC1+0.9W1+1.0WC	127250	4470	23466	276697	329727
			2.12.2	1.35G+1.0P+1.75S+1.5QC2+0.9W2+1.0WC	127250	4470	23466	276697	329727
			2.12.3	1.35G+1.0P+1.75S+1.5QC3+0.9W4+1.0WC	124268	3801	24134	272135	315199
			2.12.4	1.35G+1.0P+1.75S+1.5QC4+0.9W6+1.0WC	124268	3801	24134	272135	315199
			2.12.5	1.35G+1.0P+1.75S+1.5QC5+0.9W8+1.0WC	124268	3801	24134	272135	315199
			2.12.6	1.35G+1.0P+1.75S+1.5QC6+0.9W9+1.0WC	124268	3801	24134	272135	315199
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	2.13.1	1.35G+1.0P+1.75S+1.15QC1+1.5W1+1.0WC	129237	4915	23020	279738	339413
			2.13.2	1.35G+1.0P+1.75S+1.15QC2+1.5W2+1.0WC	129237	4915	23020	279738	339413
			2.13.3	1.35G+1.0P+1.75S+1.15QC3+1.5W4+1.0WC	124268	3801	24134	272135	315199
			2.13.4	1.35G+1.0P+1.75S+1.15QC4+1.5W6+1.0WC	124268	3801	24134	272135	315199
			2.13.5	1.35G+1.0P+1.75S+1.15QC5+1.5W8+1.0WC	124268	3801	24134	272135	315199
			2.13.6	1.35G+1.0P+1.75S+1.15QC6+1.5W9+1.0WC	124268	3801	24134	272135	315199

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Permanent Loads		3.1.1	1.0G+1.0P+1.2S	92407	9337	16555	200458	220200
	Rare Combination	G - I Live load leading and wind accompanying	3.1.2	1.0G+1.0P+1.0S+1.0Q1+1.0Ql +0.6W1 +1.0WC	98443	8721	17221	183593	240140
			3.1.3	1.0G+1.0P+1.0S+1.0Q2+1.0Ql +0.6W2+1.0WC	97296	6912	16714	152205	233977
			3.1.4	1.0G+1.0P+1.0S+1.0Q3+1.0Ql +0.6W3+1.0WC	97917	9793	17335	202993	241198
			3.1.5	1.0G+1.0P+1.0S+1.0Q4+1.0Ql +0.6W4+1.0WC	92407	9437	16829	200603	220600
			3.1.6	1.0G+1.0P+1.0S+1.0Q5+1.0Ql +0.6W5+1.0WC	92407	9437	16829	200603	220600
			3.1.7	1.0G+1.0P+1.0S+1.0Q6+1.0Ql +0.6W6+1.0WC	92407	9437	16829	200603	220600
			3.1.8	1.0G+1.0P+1.0S+1.0Q7+1.0Ql +0.6W7+1.0WC	92407	9437	16829	200603	220600
			3.1.9	1.0G+1.0P+1.0S+1.0Q8+1.0Ql +0.6W8+1.0WC	92407	9437	16829	200603	220600
			3.1.10	1.0G+1.0P+1.0S+1.0Q9+1.0Ql +0.6W9+1.0WC	92407	9437	16829	200603	220600
			3.1.11	1.0G+1.0P+1.0S+1.0Q10+1.0Ql +0.6W10+1.0WC	92407	9437	16829	200603	220600
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - II Live load leading and thermal load accompanying	3.2.1	1.0G+1.0P+1.0S+Q1+1.0Ql+0.6T +1.0WC	96002	20820	17681	201276	230561
			3.2.2	1.0G+1.0P+1.0S+Q2+1.0Ql+0.6T +1.0WC	94855	19012	17173	169887	224398
			3.2.3	1.0G+1.0P+1.0S+Q3+1.0Ql+0.6T +1.0WC	95476	21892	17794	220675	231620
			3.2.4	1.0G+1.0P+1.0S+Q4+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
			3.2.5	1.0G+1.0P+1.0S+Q5+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
			3.2.6	1.0G+1.0P+1.0S+Q6+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
			3.2.7	1.0G+1.0P+1.0S+Q7+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
			3.2.8	1.0G+1.0P+1.0S+Q8+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
			3.2.9	1.0G+1.0P+1.0S+Q9+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
			3.2.10	1.0G+1.0P+1.0S+Q10+1.0Ql+0.6T +1.0WC	91953	21982	16843	221327	220707
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - III Wind Leading	3.3.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0W 1+1.0WC	98756	9308	16715	190633	244133
			3.3.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0W 2+1.0WC	97896	7952	16334	167092	239511
			3.3.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0W 3+1.0WC	98361	10112	16800	205183	244927
			3.3.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0W 4+1.0WC	92407	9437	16829	200603	220600
			3.3.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0W 5+1.0WC	92407	9437	16829	200603	220600
			3.3.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0W 6+1.0WC	92407	9437	16829	200603	220600
			3.3.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0W 7+1.0WC	92407	9437	16829	200603	220600
			3.3.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0W 8+1.0WC	92407	9437	16829	200603	220600
			3.3.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0W 9+1.0WC	92407	9437	16829	200603	220600
			3.3.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql+1.0 W10+1.0WC	92407	9437	16829	200603	220600

			Section location		At pilecap bottom (No Scour condition)				
			Load Case	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - IV Thermal load Leading	3.4.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0T+1.0WC	94688	29474	17481	220104	228169
			3.4.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0T+1.0WC	93827	28117	17101	196563	223547
			3.4.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0T+1.0WC	94293	30278	17566	234654	228964
			3.4.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0T+1.0WC	91651	30345	16853	235143	220779
			3.4.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0T+1.0WC	91651	30345	16853	235143	220779
			3.4.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0T+1.0WC	91651	30345	16853	235143	220779
			3.4.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0T+1.0WC	91651	30345	16853	235143	220779
			3.4.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0T+1.0WC	91651	30345	16853	235143	220779
			3.4.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0T+1.0WC	91651	30345	16853	235143	220779
			3.4.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql0+1.0T+1.0WC	91651	30345	16853	235143	220779
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - V : SPV Leading	3.5.1	1.0G+1.0P+1.2S+1.0QS1+1.0QSl +1.0WC	97030	7701	17623	156651	229119
			3.5.2	1.0G+1.0P+1.2S+1.0QS2+1.0QSl +1.0WC	96046	6867	17231	140700	225068
			3.5.3	1.0G+1.0P+1.2S+1.0QS3+1.0QSl +1.0WC	96392	9308	18036	197794	234600
			3.5.4	1.0G+1.0P+1.2S+1.0QS4+1.0QSl +1.0WC	92407	9437	16829	200603	220600
			3.5.5	1.0G+1.0P+1.2S+1.0QS5+1.0QSl +1.0WC	92407	9437	16829	200603	220600
			3.5.6	1.0G+1.0P+1.2S+1.0QS6+1.0QSl ++1.0WC	92407	9437	16829	200603	220600
			3.5.7	1.0G+1.0P+1.2S+1.0QS7+1.0QSl +0.6T+1.0WC	92407	9437	16829	200603	220600
			3.5.8	1.0G+1.0P+1.2S+1.0QS8+1.0QSl +1.0WC	92407	9437	16829	200603	220600
			3.5.9	1.0G+1.0P+1.2S+1.0QS9+1.0QSl +1.0WC	92407	9437	16829	200603	220600
			3.5.10	1.0G+1.0P+1.2S+1.0QS10+1.0QSl +1.0WC	92407	9437	16829	200603	220600
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.6.1	1.0G+1.0P+1.2S+1.0QC1+0.6W1 +1.0WC	94394	9882	16383	203644	230285
			3.6.2	1.0G+1.0P+1.2S+1.0QC2+0.6W2 +1.0WC	94394	9882	16383	203644	230285
			3.6.3	1.0G+1.0P+1.2S+1.0QC3+0.6W4 +1.0WC	92407	9437	16829	200603	220600
			3.6.4	1.0G+1.0P+1.2S+1.0QC4+0.6W6 +1.0WC	92407	9437	16829	200603	220600
			3.6.5	1.0G+1.0P+1.2S+1.0QC5+0.6W8 +1.0WC	92407	9437	16829	200603	220600
			3.6.6	1.0G+1.0P+1.2S+1.0QC6+0.6W9 +1.0WC	92407	9437	16829	200603	220600
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	3.7.1	1.0G+1.0P+1.2S+0.75QC1+1.0W1 +1.0WC	95720	10179	16086	205672	236743
			3.7.2	1.0G+1.0P+1.2S+0.75QC2+1.0W2 +1.0WC	95720	10179	16086	205672	236743
			3.7.3	1.0G+1.0P+1.2S+0.75QC3+1.0W4 +1.0WC	92407	9437	16829	200603	220600
			3.7.4	1.0G+1.0P+1.2S+0.75QC4+1.0W6 +1.0WC	92407	9437	16829	200603	220600
			3.7.5	1.0G+1.0P+1.2S+0.75QC5+1.0W8 +1.0WC	92407	9437	16829	200603	220600
			3.7.6	1.0G+1.0P+1.2S+0.75QC6+1.0W9 +1.0WC	92407	9437	16829	200603	220600
	Quasi-permanent		4.1.1	1.0G+1.0P+1.0S+0.5T	92029	19791	16567	217727	220289

9.2.2.2 Structural design for Lower Pylon (Top)

Pier dim. along traffic	=	6000	mm
Pier dim. across traffic	=	3500	mm
Grade of Steel f_{yk}	=	500	mpa
Grade of Concrete f_{ck}	=	50	mpa
f_{ctm} =0.259×50^(2/3)	=	3.52	mpa
f_{cd} =50×0.67/1.5	=	22.33	mpa
Clear cover	=	75	mm

Along traffic				**Across traffic**			
Layer-1				Layer-1			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	50	nos	No. of bars	=	31	nos
Layer-2				Layer-2			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	50	nos	No. of bars	=	31	nos
Layer-3				Layer-2			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	50	nos	No. of bars	=	31	nos
Layer-4				Layer-2			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	50	nos	No. of bars	=	31	nos
Total no. of bars	=	648	nos				

% Reinf. Assumed	=	3.88	%
Area of Steel	=	814301	mm^2

Minimum % of Reinforcement:

$A_{s,min}$	=	$0.10*N_{ED}/f_{yd}$	= 30796 mm^2	(CL. 16.2.2 of IRC:112-2011)	
		(or) $0.002A_c$	= 42000 mm^2		
		$A_{s,min}$	= 42000 mm^2	< Ast Provided	
$A_{s,max}$	=	$0.04 * A_c$	= 840000 mm^2	> Ast Provided	

9.2.2.3 Flexural design

The section capacity is found out in two orthogonal directions (i.e. M_{UL} & M_{UT}) for the provided reinforcement

(Refer to P-M curves). The capacity interaction ratio $(M_L / M_{UL})^{\alpha n} + (M_T / M_{UT})^{\alpha n}$ is given in table below.

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	M_{UL}	M_{UT}	Capacity ratio
2.2.0	1.35G+1.0P+1.75S	124268	3702	23860	271990	314799	Live load leading with Wind accompanying	672229	536169	0.67
2.2.1	1.35G+1.0P+1.75S	133323	2727	24723	246620	344509		629106	550243	0.69
2.2.2	1.35G+1.0P+1.75S	131602	14	23961	199537	335264		642792	570921	0.64
2.2.3	1.35G+1.0P+1.75S	132533	4335	24893	275719	346097		626538	536556	0.71
2.2.4	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.2.5	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.2.6	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.2.7	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.2.8	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.2.9	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.2.10	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.1	1.35G+1.0P+1.75S	133894	3579	23984	256679	350745	Wind Leading	619759	545691	0.71
2.3.2	1.35G+1.0P+1.75S	132574	1499	23400	220582	343658		630248	562165	0.67
2.3.3	1.35G+1.0P+1.75S	133288	4812	24114	278989	351963		617789	535190	0.72
2.3.4	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.5	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.6	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.7	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.8	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.9	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.3.10	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.4.1	1.35G + 1.0P +1.75	129414	5738	21531	295106	342368	Seismic combination - EQV	631573	526869	0.72
2.4.2	1.35G + 1.0P +1.75	129184	5376	21429	288828	341136		633397	529711	0.72
2.4.3	1.35G + 1.0P +1.75	129308	5952	21553	298986	342580		631230	525050	0.73
2.4.4	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72
2.4.5	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72
2.4.6	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72
2.4.7	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72
2.4.8	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72
2.4.9	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72

2.4.10	1.35G + 1.0P +1.75	128604	5970	21363	299116	340397		634403	524815	0.72
2.5.1	1.35G +1.75S +0.2	127425	8906	21869	327187	336855	Seismic combination - EQT	639546	511591	0.74
2.5.2	1.35G +1.75S +0.2	127195	8544	21768	320909	335622		641372	514430	0.73
2.5.3	1.35G +1.75S +0.2	127319	9120	21892	331066	337066		639204	509780	0.74
2.5.4	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.5.5	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.5.6	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.5.7	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.5.8	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.5.9	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.5.10	1.35G +1.75S +0.2	126615	9138	21702	331197	334884		642366	509562	0.74
2.6.1	1.35G +1.75S +0.2	127950	5447	17265	288740	364879	Seismic combination - EQL	597101	529436	0.75
2.6.2	1.35G +1.75S +0.2	127721	5086	17164	282462	363647		598925	532271	0.75
2.6.3	1.35G +1.75S +0.2	127845	5662	17288	292620	365091		596758	527620	0.76
2.6.4	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.6.5	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.6.6	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.6.7	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.6.8	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.6.9	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.6.10	1.35G +1.75S +0.2	127141	5680	17098	292750	362909		599927	527382	0.75
2.7.1	1.0G + 1.0P +1.0S	94371	2937	27434	191112	289114	Accidental load combination - Live load leading	699544	557182	0.58
2.7.2	1.0G + 1.0P +1.0S	93510	1581	27053	167571	284492		705248	561508	0.56
2.7.3	1.0G + 1.0P +1.0S	93976	3741	27519	205662	289908		698303	554035	0.59
2.7.4	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.7.5	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.7.6	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.7.7	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.7.8	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.7.9	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.7.10	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.1	1.0G + 1.0P +1.0S	92144	3576	26973	202140	283695	Accidental load combination - Live load accompanying	705640	553821	0.58
2.8.2	1.0G + 1.0P +1.0S	91914	3215	26871	195863	282462		707158	554968	0.57
2.8.3	1.0G + 1.0P +1.0S	92038	3791	26996	206020	283906		705309	552983	0.58
2.8.4	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.5	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.6	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.7	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.8	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.9	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58
2.8.10	1.0G + 1.0P +1.0S	91334	3809	26805	206150	281724		707851	552572	0.58

2.9.1	1.35G+1.0P+1.75S	127791	33828	25134	300885	326800	Thermal load Leading	654885	523797	0.70
2.9.2	1.35G+1.0P+1.75S	126471	31748	24550	264789	319712		665363	540073	0.67
2.9.3	1.35G+1.0P+1.75S	127185	35061	25264	323195	328017		652918	513375	0.72
2.9.4	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.9.5	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.9.6	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.9.7	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.9.8	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.9.9	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.9.10	1.35G+1.0P+1.75S	123134	35164	24170	323944	315467		670912	512099	0.71
2.10.1	1.35G+1.0P+1.75S	129661	20876	25413	273143	330141	Live load leading with Thermal load accompanying	650183	537085	0.69
2.10.2	1.35G+1.0P+1.75S	127940	18163	24651	226061	320897		663877	558330	0.64
2.10.3	1.35G+1.0P+1.75S	128871	22484	25582	302243	331729		647615	523437	0.71
2.10.4	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.10.5	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.10.6	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.10.7	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.10.8	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.10.9	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.10.10	1.35G+1.0P+1.75S	123588	22619	24156	303220	315360		671196	521690	0.69
2.11.1	1.35G+1.0P+1.75S	129585	1806	25047	221590	324995	SPV Leading	657979	560894	0.64
2.11.2	1.35G+1.0P+1.75S	128454	846	24597	203246	320337		664828	569012	0.63
2.11.3	1.35G+1.0P+1.75S	128852	3653	25522	268905	331299		648264	538825	0.69
2.11.4	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.11.5	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.11.6	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.11.7	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.11.8	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.11.9	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.11.10	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.12.1	1.35G+1.0P+1.75S	127250	4470	23466	276697	329727	Congestion loading : Live loading Leading / Wind accompanying	650334	534803	0.69
2.12.2	1.35G+1.0P+1.75S	127250	4470	23466	276697	329727		650334	534803	0.69
2.12.3	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.12.4	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.12.5	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.12.6	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.13.1	1.35G+1.0P+1.75S	129237	4915	23020	279738	339413	Congestion loading : Wind loading Leading / Live Load accompanying	636023	533924	0.71
2.13.2	1.35G+1.0P+1.75S	129237	4915	23020	279738	339413		636023	533924	0.71
2.13.3	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.13.4	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.13.5	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67
2.13.6	1.35G+1.0P+1.75S	124268	3801	24134	272135	315199		671622	536103	0.67

9.2.2.4 Check for Shear (Cl 10.3.2, IRC 112)

Check for Shear along Traffic Direction

Thickness of the web (across traffic)		=	3500	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	75	mm
Effective depth in the longitudinal direction		=	5895	mm
Effective depth in the transverse direction		=	3395	mm
Area of tension steel in bott. Flange	A_{st}	=	77912	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	15	nos.
Spacing of stirrups	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1178	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	35164	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.18	
Percentage of Main reinforcement	ρ_1	=	0.0038	
	σ_{cp}	=	4.35	
	V_{min}	=	0.28	=0.031×(1.18^1.5)×50^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	20643 kN	Shear reinf. required

Therefore provide 15 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0022	=1178/(3500×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0010	Safe

Check for Shear across Traffic Direction

Thickness of the web (across traffic)		=	3500	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	75	mm
Effective depth in the longitudinal direction		=	5895	mm
Effective depth in the transverse direction		=	3395	mm
Area of tension steel in bott. Flange	A_{st}	=	125664	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	26	nos.
Spacing of shear legs	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	2042	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	27519	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.24	
Percentage of Main reinforcement	ρ_1	=	0.0062	

	σ_{cp}	=	4.35	
	V_{min}	=	0.30	=0.031×(1.24^1.5)×50^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	22039 kN	Shear reinf. required

Therefore provide 26 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0023	=2042/(6000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0010	Safe

9.2.2.5 Serviceability condition

		Steel	Concrete
Allowable stresses Rare combination in MPa	=	**400**	**24**
Allowable stresses Quasi combination in MPa	=	**400**	**18**

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	Crack Width (mm)	Stress in Concrete (Mpa)	Stress in Steel (Mpa)
3.1.1	1.0G+1.0P+1.2S	92407	9337	16555	200458	220200	Live load leading and wind accompanying		22.15	231.60
3.1.2	1.0G+1.0P+1.0S+1	98443	8721	17221	183593	240140			22.79	236.67
3.1.3	1.0G+1.0P+1.0S+1	97296	6912	16714	152205	233977			21.22	215.37
3.1.4	1.0G+1.0P+1.0S+1	97917	9793	17335	202993	241198			23.58	248.55
3.1.5	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.1.6	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.1.7	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.1.8	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.1.9	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.1.10	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.1.11	1.0G+1.0P+1.0S+1	92407	9437	16829	200603	220600			22.18	232.09
3.2.1	1.0G+1.0P+1.0S+0	96002	20820	17681	201276	230561	Live load leading and thermal load accompanying		22.85	238.74
3.2.2	1.0G+1.0P+1.0S+0	94855	19012	17173	169887	224398			21.28	217.13
3.2.3	1.0G+1.0P+1.0S+0	95476	21892	17794	220675	231620			23.64	250.83
3.2.4	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92
3.2.5	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92
3.2.6	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92
3.2.7	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92
3.2.8	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92
3.2.9	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92
3.2.10	1.0G+1.0P+1.0S+0	91953	21982	16843	221327	220707			22.96	243.92

3.3.1	1.0G+1.0P+1.0S+0	98756	9308	16715	190633	244133	Wind Leading	23.30	244.16
3.3.2	1.0G+1.0P+1.0S+0	97896	7952	16334	167092	239511		22.12	228.09
3.3.3	1.0G+1.0P+1.0S+0	98361	10112	16800	205183	244927		23.89	253.09
3.3.4	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.3.5	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.3.6	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.3.7	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.3.8	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.3.9	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.3.10	1.0G+1.0P+1.0S+0	92407	9437	16829	200603	220600		22.18	232.09
3.4.1	1.0G+1.0P+1.0S+0	94688	29474	17481	220104	228169	Thermal load Leading	23.40	247.85
3.4.2	1.0G+1.0P+1.0S+0	93827	28117	17101	196563	223547		22.22	231.39
3.4.3	1.0G+1.0P+1.0S+0	94293	30278	17566	234654	228964		23.99	257.06
3.4.4	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.4.5	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.4.6	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.4.7	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.4.8	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.4.9	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.4.10	1.0G+1.0P+1.0S+0	91651	30345	16853	235143	220779		23.48	251.94
3.5.1	1.0G+1.0P+1.2S+1	97030	7701	17623	156651	229119	SPV Leading	21.10	212.86
3.5.2	1.0G+1.0P+1.2S+1	96046	6867	17231	140700	225068		20.24	201.62
3.5.3	1.0G+1.0P+1.2S+1	96392	9308	18036	197794	234600		22.97	240.65
3.5.4	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.5.5	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.5.6	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.5.7	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.5.8	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.5.9	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.5.10	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.6.1	1.0G+1.0P+1.2S+1	94394	9882	16383	203644	230285	Congestion loading : Live loading Leading / Wind accompanying	22.90	241.51
3.6.2	1.0G+1.0P+1.2S+1	94394	9882	16383	203644	230285		22.90	241.51
3.6.3	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.6.4	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.6.5	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09
3.6.6	1.0G+1.0P+1.2S+1	92407	9437	16829	200603	220600		22.18	232.09

Crack width check is not required as per annexure B of IRC:6-2017

3.7.1	1.0G+1.0P+1.2S+0	95720	10179	16086	205672	236743	Congestion loading : Wind loading Leading / Live Load accompanying		23.38	247.81
3.7.2	1.0G+1.0P+1.2S+0	95720	10179	16086	205672	236743			23.38	247.81
3.7.3	1.0G+1.0P+1.2S+0	92407	9437	16829	200603	220600			22.18	232.09
3.7.4	1.0G+1.0P+1.2S+0	92407	9437	16829	200603	220600			22.18	232.09
3.7.5	1.0G+1.0P+1.2S+0	92407	9437	16829	200603	220600			22.18	232.09
3.7.6	1.0G+1.0P+1.2S+0	92407	9437	16829	200603	220600			22.18	232.09
4.1.1	1.0G+1.0P+1.0S+0	92029	19791	16567	217727	220289	Quasi-permanent Combination		22.80	241.44

9.2.3 Summary of forces and load combinations at Upper Pylon (Bottom)

9.2.3.1 Summary of forces

Section location			At upper pylon bottom				
Load Case			P	HL	HT	ML	MT
			kN	kN	kN	kNm	kNm
Dead Load							
SIDL (Fixed)			2170	-386	103	-2541	-1850
SIDL (Variable)			1410	-251	67	-1651	-1202
SW+STAY			51913	-18565	-4612	251393	83413
Secondary Prestress			728	6	94	8396	-2528
Creep secondary			11	426	1014	-12406	-27461
Shrinkage secondary			226	-59	1	6459	-965
Live Loading							
P max			2409	-281	44	-8791	-369
Ml max			2130	7	48	-17746	-675
Mt max			709	-136	118	1247	-2684
Longitudinal loading							
P max			8	8	4	394	22
Wind Force							
P max (Without L.L)			3106	636	-636	-908	-755
Ml max (Without L.L)			3106	636	-636	-908	-755
Mt max (Without L.L)			3106	636	-636	-908	-755
P max			2647	542	-542	-774	-644
Ml max			2647	542	-542	-774	-644
Mt max			2647	542	-542	-774	-644
Temperature Forces							
Uniform Temp			-547	-737	392	40412	-9383
Pylon Temp Grad			0	0	0	0	0
Deck Temp Grad			15	-83	37	4760	-890
EQ							
EQV = 0.3ELx+0.3ELy+1.0ELz			1896	513	-119	-9757	4107
EQT = 0.3ELx+1.0ELy+0.3ELz			1467	381	-157	-17602	4271
EQL = 1.0ELx+0.3ELy+0.3ELz			3372	403	-114	-7388	7531
Live Loading (SPV)							
P max			3173	-254	57	-15948	-550
ML max			795	-816	42	25298	-484
MT max			639	-96	155	18	-3614

Note:
3) Uniform temperature difference forces have been reduced by 50% to account long te

9.2.3.2 Load Combinations for Upper Pylon (Bottom):

			Section location	At upper pylon bottom				
		SL No.	Description	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	Unfactored Permanent Loads	1.1.1	1.0G+1.0P+1.0S	56222	-19195	-4348	255597	77833
	Factored Permanent Loads	1.1.2	1.35G+1.0P+1.75S	76209	-26016	-5876	341456	105479
	G - I (a): Live load leading with Wind accompanying	1.2.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+0.9W1 +1.0WC	82215	-25938	-6293	328164	104379
		1.2.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+0.9W2 +1.0WC	81786	-25517	-6292	314141	103887
		1.2.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+0.9W3 +1.0WC	79655	-25732	-6187	342631	100873
		1.2.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+0.9W4 +1.0WC	76209	-26016	-5876	341456	105479
		1.2.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+0.9W5 +1.0WC	76209	-26016	-5876	341456	105479
		1.2.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+0.9W6 +1.0WC	76209	-26016	-5876	341456	105479
		1.2.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+0.9W7 +1.0WC	76209	-26016	-5876	341456	105479
		1.2.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+0.9W8 +1.0WC	76209	-26016	-5876	341456	105479
		1.2.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+0.9W9 +1.0WC	76209	-26016	-5876	341456	105479
		1.2.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+0.9W10 +1.0WC	76209	-26016	-5876	341456	105479
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - I (b): Wind Leading	1.3.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5W1 +1.0WC	82958	-25517	-6635	330639	104114
		1.3.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5W2 +1.0WC	82629	-25195	-6634	319888	103737
		1.3.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5W3 +1.0WC	80995	-25359	-6553	341730	101426
		1.3.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5W4 +1.0WC	76209	-26016	-5876	341456	105479
		1.3.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5W5 +1.0WC	76209	-26016	-5876	341456	105479
		1.3.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5W6 +1.0WC	76209	-26016	-5876	341456	105479
		1.3.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5W7 +1.0WC	76209	-26016	-5876	341456	105479
		1.3.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5W8 +1.0WC	76209	-26016	-5876	341456	105479
		1.3.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5W9 +1.0WC	76209	-26016	-5876	341456	105479
		1.3.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1.5W10 +1.0WC	76209	-26016	-5876	341456	105479
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination / G - II (a): EQV = 0.3ELx+0.3ELy+1.0ELz	1.4.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQV	79536	-25301	-6046	325141	111570
		1.4.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQV	79479	-25245	-6046	323271	111505
		1.4.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQV	79195	-25274	-6032	327070	111103
		1.4.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640
		1.4.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640
		1.4.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640
		1.4.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640
		1.4.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640
		1.4.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640
		1.4.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQV	79053	-25247	-6055	326820	111640

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (b): EQT = 0.3ELx+1.0ELy+0.3ELz	1.5.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQT	78893	-25500	-6102	313373	111815
			1.5.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQT	78835	-25444	-6101	311504	111750
			1.5.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQT	78551	-25472	-6087	315302	111348
			1.5.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
			1.5.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
			1.5.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
			1.5.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
			1.5.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
			1.5.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
			1.5.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQT	78409	-25445	-6111	315053	111885
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (c): EQL = 1.0ELx+0.3ELy+0.3ELz	1.6.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQL	81751	-25466	-6038	328695	116706
			1.6.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQL	81693	-25410	-6037	326825	116640
			1.6.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQL	81409	-25439	-6023	330623	116238
			1.6.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
			1.6.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
			1.6.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
			1.6.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
			1.6.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
			1.6.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
			1.6.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQL	81267	-25412	-6047	330374	116775
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (a): Live load leading	1.7.1	1.0G +1.0S +0.75Q1+0.75Fl +1.0WC+1.0AE	58034	-19400	-4312	249299	77573
			1.7.2	1.0G +1.0S +0.75Q2+0.75Fl +1.0WC+1.0AE	57820	-19190	-4312	242287	77327
			1.7.3	1.0G +1.0S +0.75Q3+0.75Fl +1.0WC+1.0AE	56754	-19297	-4259	256532	75820
			1.7.4	1.0G +1.0S +0.75Q4+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.7.5	1.0G +1.0S +0.75Q5+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.7.6	1.0G +1.0S +0.75Q6+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.7.7	1.0G +1.0S +0.75Q7+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.7.8	1.0G +1.0S +0.75Q8+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.7.9	1.0G +1.0S +0.75Q9+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.7.10	1.0G +1.0S +0.75Q10+0.75Fl +1.0WC+1.0AE	56222	-19195	-4348	255597	77833

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (b): Live load accompanying	1.8.1	1.0G +1.0S +0.2Q1+0.2FI +1.0WC+1.0AE	56705	-19250	-4339	253917	77764
			1.8.2	1.0G +1.0S +0.2Q2+0.2FI +1.0WC+1.0AE	56648	-19194	-4339	252047	77698
			1.8.3	1.0G +1.0S +0.2Q3+0.2FI +1.0WC+1.0AE	56364	-19223	-4324	255846	77296
			1.8.4	1.0G +1.0S +0.2Q4+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.8.5	1.0G +1.0S +0.2Q5+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.8.6	1.0G +1.0S +0.2Q6+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.8.7	1.0G +1.0S +0.2Q7+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.8.8	1.0G +1.0S +0.2Q8+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.8.9	1.0G +1.0S +0.2Q9+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
			1.8.10	1.0G +1.0S +0.2Q10+0.2FI +1.0WC+1.0AE	56222	-19195	-4348	255597	77833
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (a) Thermal load Leading	1.9.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5 T+1.0WC	78190	-27561	-5177	399558	89671
			1.9.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5 T+1.0WC	77861	-27238	-5177	388807	89293
			1.9.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5 T+1.0WC	76227	-27402	-5096	410649	86982
			1.9.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5 T+1.0WC	75411	-27246	-5232	409215	90070
			1.9.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5 T+1.0WC	75411	-27246	-5232	409215	90070
			1.9.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5 T+1.0WC	75411	-27246	-5232	409215	90070
			1.9.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5 T+1.0WC	75411	-27246	-5232	409215	90070
			1.9.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5 T+1.0WC	75411	-27246	-5232	409215	90070
			1.9.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5 T+1.0WC	75411	-27246	-5232	409215	90070
			1.9.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1. 5T+1.0WC	75411	-27246	-5232	409215	90070
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (b) Live Load Leading & Thermal load accompanying	1.10.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+ 0.9T+1.0WC	79355	-27164	-5418	369516	95713
			1.10.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+ 0.9T+1.0WC	78926	-26744	-5417	355492	95221
			1.10.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+ 0.9T+1.0WC	76794	-26958	-5312	383982	92207
			1.10.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233
			1.10.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233
			1.10.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233
			1.10.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233
			1.10.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233
			1.10.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233
			1.10.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+ 0.9T+1.0WC	75730	-26754	-5490	382112	96233

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - V : Live load (SPV)		1.11.1	1.35G+1.0P+1.75S+1.15QS1+1.5QSl+1.0WC	79379	-27046	-5424	363771	95601
			1.11.2	1.35G+1.0P+1.75S+1.15QS2+1.5QSl+1.0WC	76644	-27692	-5441	411205	95676
			1.11.3	1.35G+1.0P+1.75S+1.15QS3+1.5QSl+1.0WC	76465	-26864	-5311	382133	92077
			1.11.4	1.35G+1.0P+1.75S+1.15QS4+1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
			1.11.5	1.35G+1.0P+1.75S+1.15QS5+1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
			1.11.6	1.35G+1.0P+1.75S+1.15QS6+1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
			1.11.7	1.35G+1.0P+1.75S+1.15QS7+1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
			1.11.8	1.35G+1.0P+1.75S+1.15QS8+1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
			1.11.9	1.35G+1.0P+1.75S+1.15QS9+1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
			1.11.10	1.35G+1.0P+1.75S+1.15QS10 +1.5QSl+1.0WC	75730	-26754	-5490	382112	96233
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	1.12.1	1.35G+1.0P+1.75S+1.5QC1+0.9W1+1.0WC	78591	-25528	-6364	340760	104899
			1.12.2	1.35G+1.0P+1.75S+1.5QC2+0.9W2+1.0WC	78591	-25528	-6364	340760	104899
			1.12.3	1.35G+1.0P+1.75S+1.5QC3+0.9W4+1.0WC	76209	-26016	-5876	341456	105479
			1.12.4	1.35G+1.0P+1.75S+1.5QC4+0.9W6+1.0WC	76209	-26016	-5876	341456	105479
			1.12.5	1.35G+1.0P+1.75S+1.5QC5+0.9W8+1.0WC	76209	-26016	-5876	341456	105479
			1.12.6	1.35G+1.0P+1.75S+1.5QC6+0.9W9+1.0WC	76209	-26016	-5876	341456	105479
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	1.13.1	1.35G+1.0P+1.75S+1.15QC1+1.5W1+1.0WC	80179	-25203	-6690	340296	104513
			1.13.2	1.35G+1.0P+1.75S+1.15QC2+1.5W2+1.0WC	80179	-25203	-6690	340296	104513
			1.13.3	1.35G+1.0P+1.75S+1.15QC3+1.5W4+1.0WC	76209	-26016	-5876	341456	105479
			1.13.4	1.35G+1.0P+1.75S+1.15QC4+1.5W6+1.0WC	76209	-26016	-5876	341456	105479
			1.13.5	1.35G+1.0P+1.75S+1.15QC5+1.5W8+1.0WC	76209	-26016	-5876	341456	105479
			1.13.6	1.35G+1.0P+1.75S+1.15QC6+1.5W9+1.0WC	76209	-26016	-5876	341456	105479

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	UnfactoredPermanentloads		3.1.1	1.0G+1.0P+1.0S	56459	-18829	-3333	249649	49407
	Rare Combination	G - I Live load leading and wind accompanying	3.1.2	1.0G+1.0P+1.0S+1.0Q1+1.0QI+0.6W1 +1.0WC	60463	-18777	-3610	240788	48674
			3.1.3	1.0G+1.0P+1.0S+1.0Q2+1.0QI+0.6W2 +1.0WC	60177	-18497	-3610	231439	48346
			3.1.4	1.0G+1.0P+1.0S+1.0Q3+1.0QI+0.6W3 +1.0WC	58756	-18639	-3540	250432	46337
			3.1.5	1.0G+1.0P+1.0S+1.0Q4+1.0QI+0.6W4 +1.0WC	56459	-18829	-3333	249649	49407
			3.1.6	1.0G+1.0P+1.0S+1.0Q5+1.0QI+0.6W5 +1.0WC	56459	-18829	-3333	249649	49407
			3.1.7	1.0G+1.0P+1.0S+1.0Q6+1.0QI+0.6W6 +1.0WC	56459	-18829	-3333	249649	49407
			3.1.8	1.0G+1.0P+1.0S+1.0Q7+1.0QI+0.6W7 +1.0WC	56459	-18829	-3333	249649	49407
			3.1.9	1.0G+1.0P+1.0S+1.0Q8+1.0QI+0.6W8 +1.0WC	56459	-18829	-3333	249649	49407
			3.1.10	1.0G+1.0P+1.0S+1.0Q9+1.0QI+0.6W9 +1.0WC	56459	-18829	-3333	249649	49407
			3.1.11	1.0G+1.0P+1.0S+1.0Q10+1.0QI+0.6W10 +1.0WC	56459	-18829	-3333	249649	49407
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - II Live load leading and thermal load accompanying	3.2.1	1.0G+1.0P+1.0SQ1+1.0QI+0.6T +1.0WC	58556	-19594	-3027	268355	42897
			3.2.2	1.0G+1.0P+1.0SQ2+1.0QI+0.6T +1.0WC	58270	-19314	-3027	259007	42569
			3.2.3	1.0G+1.0P+1.0SQ3+1.0QI+0.6T +1.0WC	56849	-19457	-2957	278000	40559
			3.2.4	1.0G+1.0P+1.0SQ4+1.0QI+0.6T +1.0WC	56140	-19321	-3075	276753	43244
			3.2.5	1.0G+1.0P+1.0SQ5+1.0QI+0.6T +1.0WC	56140	-19321	-3075	276753	43244
			3.2.6	1.0G+1.0P+1.0SQ6+1.0QI+0.6T +1.0WC	56140	-19321	-3075	276753	43244
			3.2.7	1.0G+1.0P+1.0SQ7+1.0QI+0.6T +1.0WC	56140	-19321	-3075	276753	43244
			3.2.8	1.0G+1.0P+1.0SQ8+1.0QI+0.6T +1.0WC	56140	-19321	-3075	276753	43244
			3.2.9	1.0G+1.0P+1.0SQ9+1.0QI+0.6T +1.0WC	56140	-19321	-3075	276753	43244
			3.2.10	1.0G+1.0P+1.0SQ10+1.0QI0+0.6T +1.0WC	56140	-19321	-3075	276753	43244
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - III Wind Leading	3.3.1	1.0G+1.0P+1.0S+0.75Q1+0.75QI+1.0W1 +0.75WC	60918	-18492	-3839	242578	48504
			3.3.2	1.0G+1.0P+1.0S+0.75Q2+0.75QI+1.0W2 +0.75WC	60703	-18281	-3839	235566	48257
			3.3.3	1.0G+1.0P+1.0S+0.75Q3+0.75QI+1.0W3 +0.75WC	59637	-18389	-3786	249811	46750
			3.3.4	1.0G+1.0P+1.0S+0.75Q4+0.75QI+1.0W4 +0.75WC	56459	-18829	-3333	249649	49407
			3.3.5	1.0G+1.0P+1.0S+0.75Q5+0.75QI+1.0W5 +0.75WC	56459	-18829	-3333	249649	49407
			3.3.6	1.0G+1.0P+1.0S+0.75Q6+0.75QI+1.0W6 +0.75WC	56459	-18829	-3333	249649	49407
			3.3.7	1.0G+1.0P+1.0S+0.75Q7+0.75QI+1.0W7 +0.75WC	56459	-18829	-3333	249649	49407
			3.3.8	1.0G+1.0P+1.0S+0.75Q8+0.75QI+1.0W8 +0.75WC	56459	-18829	-3333	249649	49407
			3.3.9	1.0G+1.0P+1.0S+0.75Q9+0.75QI+1.0W9 +0.75WC	56459	-18829	-3333	249649	49407
			3.3.10	1.0G+1.0P+1.0S+0.75Q10+0.75QI+1.0W10 +0.75WC	56459	-18829	-3333	249649	49407

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - IV Thermal load Leading	3.4.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0T +1.0WC	57739	-19854	-2868	288524	38874
			3.4.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0T +1.0WC	57525	-19644	-2867	281512	38628
			3.4.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0T +1.0WC	56459	-19751	-2815	295757	37121
			3.4.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0T +1.0WC	55927	-19649	-2903	294822	39135
			3.4.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0T +1.0WC	55927	-19649	-2903	294822	39135
			3.4.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0T +1.0WC	55927	-19649	-2903	294822	39135
			3.4.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0T +1.0WC	55927	-19649	-2903	294822	39135
			3.4.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0T +1.0WC	55927	-19649	-2903	294822	39135
			3.4.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0T +1.0WC	55927	-19649	-2903	294822	39135
			3.4.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql0+1.0 T +1.0WC	55927	-19649	-2903	294822	39135
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - V : SPV Leading	3.5.1	1.0G+1.0P+1.2S+1.0QS1+1.0QSl +1.0WC	59312	-19575	-3018	260805	42694
			3.5.2	1.0G+1.0P+1.2S+1.0QS2+1.0QSl +1.0WC	56934	-20137	-3033	302051	42759
			3.5.3	1.0G+1.0P+1.2S+1.0QS3+1.0QSl +1.0WC	56779	-19417	-2920	276771	39629
			3.5.4	1.0G+1.0P+1.2S+1.0QS4+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
			3.5.5	1.0G+1.0P+1.2S+1.0QS5+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
			3.5.6	1.0G+1.0P+1.2S+1.0QS6+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
			3.5.7	1.0G+1.0P+1.2S+1.0QS7+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
			3.5.8	1.0G+1.0P+1.2S+1.0QS8+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
			3.5.9	1.0G+1.0P+1.2S+1.0QS9+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
			3.5.10	1.0G+1.0P+1.2S+1.0QS10+1.0QSl +1.0WC	56140	-19321	-3075	276753	43244
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.6.1	1.0G+1.0P+1.2S+1.0QC1+0.6W1 +1.0WC	58047	-18504	-3658	249185	49021
			3.6.2	1.0G+1.0P+1.2S+1.0QC2+0.6W2 +1.0WC	58047	-18504	-3658	249185	49021
			3.6.3	1.0G+1.0P+1.2S+1.0QC3+0.6W4 +1.0WC	56459	-18829	-3333	249649	49407
			3.6.4	1.0G+1.0P+1.2S+1.0QC4+0.6W6 +1.0WC	56459	-18829	-3333	249649	49407
			3.6.5	1.0G+1.0P+1.2S+1.0QC5+0.6W8 +1.0WC	56459	-18829	-3333	249649	49407
			3.6.6	1.0G+1.0P+1.2S+1.0QC6+0.6W9 +1.0WC	56459	-18829	-3333	249649	49407
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.7.1	1.0G+1.0P+1.2S+0.75QC1+1.0W1 +1.0WC	59106	-18287	-3875	248876	48764
			3.7.2	1.0G+1.0P+1.2S+0.75QC2+1.0W2 +1.0WC	59106	-18287	-3875	248876	48764
			3.7.3	1.0G+1.0P+1.2S+0.75QC3+1.0W4 +1.0WC	56459	-18829	-3333	249649	49407
			3.7.4	1.0G+1.0P+1.2S+0.75QC4+1.0W6 +1.0WC	56459	-18829	-3333	249649	49407
			3.7.5	1.0G+1.0P+1.2S+0.75QC5+1.0W8 +1.0WC	56459	-18829	-3333	249649	49407
			3.7.6	1.0G+1.0P+1.2S+0.75QC6+1.0W9 +1.0WC	56459	-18829	-3333	249649	49407
	Quasi-perm.		4.1.1	1.0G+1.0P+1.0S+0.5T	56193	-19239	-3118	272236	44271

9.2.3.3 Structural design of Upper pylon at Bottom location

9.2.3.3 At Upper Pylon Bottom

Pier dim. along traffic	=	6000	mm
Pier dim. across traffic	=	3000	mm
Grade of Steel f_{yk}	=	500	mpa
Grade of Concrete f_{ck}	=	55	mpa
f_{ctm}	=	3.75	mpa
f_{cd}	=	24.57	mpa
Clear cover	=	50	mm

Along traffic				**Across traffic**			
Layer-1				Layer-1			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	52	nos	No. of bars	=	22	nos
Layer-2				Layer-2			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	52	nos	No. of bars	=	22	nos
Total no. of bars	=	296	nos				

% Reinf. Assumed	=	2.07	%
Area of Steel	=	371965	mm^2

Minimum % of Reinforcement:

$A_{s,min}$	=	$0.10*N_{ED}/f_{yd}$	= 19080	mm^2	(CL. 16.2.2 of IRC:112-2011)
		(or) $0.002A_c$	= 36000	mm^2	
		$A_{s,min}$	= 36000	mm^2	< Ast Provided
$A_{s,max}$	=	$0.04 * A_c$	= 720000	mm^2	> Ast Provided

9.2.3.4 Flexural design

The section capacity is found out in two orthogonal directions (i.e. M_{UL} & M_{UT}) for the provided reinforcement

(Refer to P-M curves). The capacity interaction ratio $(M_L / M_{UL})^{\alpha n} + (M_T / M_{UT})^{\alpha n}$ is given in table below.

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	M_{UL}	M_{UT}	Capacity ratio
1.2.1	G - I (a) (Case 1)	82215	-25938	-6293	328164	104379	Live load leading with Wind accompanying	464773	198420	0.77
1.2.2	G - I (a) (Case 2)	81786	-25517	-6292	314141	103887		464858	205704	0.75
1.2.3	G - I (a) (Case 3)	79655	-25732	-6187	342631	100873		465722	189194	0.79
1.2.4	G - I (a) (Case 4)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.2.5	G - I (a) (Case 5)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.2.6	G - I (a) (Case 6)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.2.7	G - I (a) (Case 7)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.2.8	G - I (a) (Case 8)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.2.9	G - I (a) (Case 9)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.2.10	G - I (a) (Case 10)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.1	G - I (b) (Case 1)	82958	-25517	-6635	330639	104114	Wind Leading	465738	197488	0.77
1.3.2	G - I (b) (Case 2)	82629	-25195	-6634	319888	103737		465803	203084	0.76
1.3.3	G - I (b) (Case 3)	80995	-25359	-6553	341730	101426		466534	190447	0.79
1.3.4	G - I (b) (Case 4)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.5	G - I (b) (Case 5)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.6	G - I (b) (Case 6)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.7	G - I (b) (Case 7)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.8	G - I (b) (Case 8)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.9	G - I (b) (Case 9)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.3.10	G - I (b) (Case 10)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.4.1	G - II (a) (Case 1)	79536	-25301	-6046	325141	111570	Seismic combination - EQV	453604	198511	0.78
1.4.2	G - II (a) (Case 2)	79479	-25245	-6046	323271	111505		453628	199482	0.78
1.4.3	G - II (a) (Case 3)	79195	-25274	-6032	327070	111103		453844	197280	0.79
1.4.4	G - II (a) (Case 4)	79053	-25247	-6055	326820	111640		453027	197333	0.79
1.4.5	G - II (a) (Case 5)	79053	-25247	-6055	326820	111640		453027	197333	0.79
1.4.6	G - II (a) (Case 6)	79053	-25247	-6055	326820	111640		453027	197333	0.79
1.4.7	G - II (a) (Case 7)	79053	-25247	-6055	326820	111640		453027	197333	0.79
1.4.8	G - II (a) (Case 8)	79053	-25247	-6055	326820	111640		453027	197333	0.79
1.4.9	G - II (a) (Case 9)	79053	-25247	-6055	326820	111640		453027	197333	0.79
1.4.10	G - II (a) (Case 10)	79053	-25247	-6055	326820	111640		453027	197333	0.79

1.5.1	G - II (b) (Case 1)	78893	-25500	-6102	313373	111815	Seismic combination - EQT	452645	204457	0.77
1.5.2	G - II (b) (Case 2)	78835	-25444	-6101	311504	111750		452667	205427	0.76
1.5.3	G - II (b) (Case 3)	78551	-25472	-6087	315302	111348		452881	203226	0.77
1.5.4	G - II (b) (Case 4)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.5.5	G - II (b) (Case 5)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.5.6	G - II (b) (Case 6)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.5.7	G - II (b) (Case 7)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.5.8	G - II (b) (Case 8)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.5.9	G - II (b) (Case 9)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.5.10	G - II (b) (Case 10)	78409	-25445	-6111	315053	111885		452064	203276	0.77
1.6.1	G - II (c) (Case 1)	81751	-25466	-6038	328695	116706	Seismic combination - EQL	449340	197875	0.80
1.6.2	G - II (c) (Case 2)	81693	-25410	-6037	326825	116640		449368	198845	0.80
1.6.3	G - II (c) (Case 3)	81409	-25439	-6023	330623	116238		449609	196645	0.80
1.6.4	G - II (c) (Case 4)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.6.5	G - II (c) (Case 5)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.6.6	G - II (c) (Case 6)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.6.7	G - II (c) (Case 7)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.6.8	G - II (c) (Case 8)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.6.9	G - II (c) (Case 9)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.6.10	G - II (c) (Case 10)	81267	-25412	-6047	330374	116775		448799	196697	0.80
1.7.1	G - III (a) (Case 1)	58034	-19400	-4312	249299	77573	Accidental load combination - Live load leading	464234	223775	0.61
1.7.2	G - III (a) (Case 2)	57820	-19190	-4312	242287	77327		464205	225945	0.60
1.7.3	G - III (a) (Case 3)	56754	-19297	-4259	256532	75820		464326	219963	0.62
1.7.4	G - III (a) (Case 4)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.7.5	G - III (a) (Case 5)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.7.6	G - III (a) (Case 6)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.7.7	G - III (a) (Case 7)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.7.8	G - III (a) (Case 8)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.7.9	G - III (a) (Case 9)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.7.10	G - III (a) (Case 10	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.1	G - III (b) (Case 1)	56705	-19250	-4339	253917	77764	Accidental load combination - Live load accompanying	462409	221297	0.62
1.8.2	G - III (b) (Case 2)	56648	-19194	-4339	252047	77698		462402	221965	0.61
1.8.3	G - III (b) (Case 3)	56364	-19223	-4324	255846	77296		462433	220035	0.62
1.8.4	G - III (b) (Case 4)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.5	G - III (b) (Case 5)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.6	G - III (b) (Case 6)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.7	G - III (b) (Case 7)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.8	G - III (b) (Case 8)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.9	G - III (b) (Case 9)	56222	-19195	-4348	255597	77833		461744	220060	0.62
1.8.10	G - III (b) (Case 10	56222	-19195	-4348	255597	77833		461744	220060	0.62

1.9.1	G - IV (a) (Case 1)	78190	-27561	-5177	399558	89671	Thermal load Leading	475349	151783	0.87
1.9.2	G - IV (a) (Case 2)	77861	-27238	-5177	388807	89293		475389	158619	0.85
1.9.3	G - IV (a) (Case 3)	76227	-27402	-5096	410649	86982		475946	143190	0.88
1.9.4	G - IV (a) (Case 4)	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.9.5	G - IV (a) (Case 5)	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.9.6	G - IV (a) (Case 6)	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.9.7	G - IV (a) (Case 7)	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.9.8	G - IV (a) (Case 8)	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.9.9	G - IV (a) (Case 9)	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.9.10	G - IV (a) (Case 10	75411	-27246	-5232	409215	90070		472034	143585	0.89
1.10.1	G - IV (b) (Case 1)	79355	-27164	-5418	369516	95713	Live Load Leading & Thermal load accompanying	470538	172259	0.83
1.10.2	G - IV (b) (Case 2)	78926	-26744	-5417	355492	95221		470590	181179	0.80
1.10.3	G - IV (b) (Case 3)	76794	-26958	-5312	383982	92207		471378	161078	0.85
1.10.4	G - IV (b) (Case 4)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.10.5	G - IV (b) (Case 5)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.10.6	G - IV (b) (Case 6)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.10.7	G - IV (b) (Case 7)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.10.8	G - IV (b) (Case 8)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.10.9	G - IV (b) (Case 9)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.10.10	G - IV (b) (Case 10	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.1	G - V (b) (Case 1)	79379	-27046	-5424	363771	95601	Live load (SPV)	470673	176043	0.82
1.11.2	G - V (b) (Case 2)	76644	-27692	-5441	411205	95676		467789	143104	0.90
1.11.3	G - V (b) (Case 3)	76465	-26864	-5311	382133	92077		471161	162074	0.84
1.11.4	G - V (b) (Case 4)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.5	G - V (b) (Case 5)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.6	G - V (b) (Case 6)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.7	G - V (b) (Case 7)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.8	G - V (b) (Case 8)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.9	G - V (b) (Case 9)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.11.10	G - V (b) (Case 10)	75730	-26754	-5490	382112	96233		466288	161601	0.85
1.12.1	G - VI (a) (Case 1)	78591	-25528	-6364	340760	104899	Congestion loading: Live loading Leading / Wind accompanying	460646	189586	0.80
1.12.2	G - VI (a) (Case 2)	78591	-25528	-6364	340760	104899		460646	189586	0.80
1.12.3	G - VI (a) (Case 3)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.12.4	G - VI (a) (Case 4)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.12.5	G - VI (a) (Case 5)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.12.6	G - VI (a) (Case 6)	76209	-26016	-5876	341456	105479		457649	187833	0.80

1.13.1	G - VI (b) (Case 1)	80179	-25203	-6690	340296	104513	Congestion loading: Wind loading Leading / Live Load accompanying	462641	190748	0.79
1.13.2	G - VI (b) (Case 2)	80179	-25203	-6690	340296	104513		462641	190748	0.79
1.13.3	G - VI (b) (Case 3)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.13.4	G - VI (b) (Case 4)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.13.5	G - VI (b) (Case 5)	76209	-26016	-5876	341456	105479		457649	187833	0.80
1.13.6	G - VI (b) (Case 6)	76209	-26016	-5876	341456	105479		457649	187833	0.80

Note: Refer annexure 1 for Capacity ratio considering P - Δ effect

9.2.3.5 Check for Shear (Cl 10.3.2, IRC 112)

Check for Shear along Traffic Direction

Thickness of the web (across traffic)		=	3000	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	50	mm
Effective depth in the longitudinal direction		=	5920	mm
Effective depth in the transverse direction		=	2920	mm
Area of tension steel in bott. Flange	A_{st}	=	55292	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	9	nos.
Spacing of stirrups	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	707	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	27692	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.18	
Percentage of Main reinforcement	ρ_1	=	0.0031	
	σ_{cp}	=	3.12	
	V_{min}	=	0.30	=0.031×(1.18^1.5)×55^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	14305 kN	Shear reinf. required

Therefore provide 9 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0016	=707/(3000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0011	Safe

Check for Shear across Traffic Direction

Thickness of the web (across traffic)		=	3000	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	50	mm
Effective depth in the longitudinal direction		=	5920	mm
Effective depth in the transverse direction		=	2920	mm
Area of tension steel in bott. Flange	A_{st}	=	130691	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	21	nos.
Spacing of shear legs	s	=	150	mm

C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1649	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	6690	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.26	
Percentage of Main reinforcement	ρ_1	=	0.0075	
	σ_{cp}	=	3.12	
	V_{min}	=	0.33	=0.031×(1.26^1.5)×55^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	16603 kN	Provide min. Shear reinf.

Therefore provide 21 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0018	=1649/(6000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0011	Safe

9.2.3.6 Serviceability condition

		Steel	Concrete
Allowable stresses Rare combination in MPa	=	**400**	**26.4**
Allowable stresses Quasi combination in MPa	=	**400**	**19.8**

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	Crack Width (mm)	Stress in Concrete (Mpa)	Stress in Steel (Mpa)
3.1.2	G - I (Case 1)	60463	-18777	-3610	240788	48674	Live load leading and wind accompanying		21.71	270.24
3.1.3	G - I (Case 2)	60177	-18497	-3610	231439	48346			21.05	256.87
3.1.4	G - I (Case 3)	58756	-18639	-3540	250432	46337			22.07	285.20
3.1.5	G - I (Case 4)	56459	-18829	-3333	249649	49407			22.39	294.95
3.1.6	G - I (Case 5)	56459	-18829	-3333	249649	49407			22.39	294.95
3.1.7	G - I (Case 6)	56459	-18829	-3333	249649	49407			22.39	294.95
3.1.8	G - I (Case 7)	56459	-18829	-3333	249649	49407			22.39	294.95
3.1.9	G - I (Case 8)	56459	-18829	-3333	249649	49407			22.39	294.95
3.1.10	G - I (Case 9)	56459	-18829	-3333	249649	49407			22.39	294.95
3.1.11	G - I (Case 10)	56459	-18829	-3333	249649	49407			22.39	294.95

3.2.1	G - II (Case 1)	58556	-19594	-3027	268355	42897	Live load leading and thermal load accompanying	Crack width check is not required as per annexure B of IRC:6-2017	22.83	306.90
3.2.2	G - II (Case 2)	58270	-19314	-3027	259007	42569			22.18	293.33
3.2.3	G - II (Case 3)	56849	-19457	-2957	278000	40559			23.16	322.25
3.2.4	G - II (Case 4)	56140	-19321	-3075	276753	43244			23.40	326.40
3.2.5	G - II (Case 5)	56140	-19321	-3075	276753	43244			23.40	326.40
3.2.6	G - II (Case 6)	56140	-19321	-3075	276753	43244			23.40	326.40
3.2.7	G - II (Case 7)	56140	-19321	-3075	276753	43244			23.40	326.40
3.2.8	G - II (Case 8)	56140	-19321	-3075	276753	43244			23.40	326.40
3.2.9	G - II (Case 9)	56140	-19321	-3075	276753	43244			23.40	326.40
3.2.10	G - II (Case 10)	56140	-19321	-3075	276753	43244			23.40	326.40
3.3.1	G - III (Case 1)	60918	-18492	-3839	242578	48504	Wind Leading		21.81	271.41
3.3.2	G - III (Case 2)	60703	-18281	-3839	235566	48257			21.32	261.37
3.3.3	G - III (Case 3)	59637	-18389	-3786	249811	46750			22.08	282.61
3.3.4	G - III (Case 4)	56459	-18829	-3333	249649	49407			22.39	294.95
3.3.5	G - III (Case 5)	56459	-18829	-3333	249649	49407			22.39	294.95
3.3.6	G - III (Case 6)	56459	-18829	-3333	249649	49407			22.39	294.95
3.3.7	G - III (Case 7)	56459	-18829	-3333	249649	49407			22.39	294.95
3.3.8	G - III (Case 8)	56459	-18829	-3333	249649	49407			22.39	294.95
3.3.9	G - III (Case 9)	56459	-18829	-3333	249649	49407			22.39	294.95
3.3.10	G - III (Case 10)	56459	-18829	-3333	249649	49407			22.39	294.95
3.4.1	G - IV (Case 1)	57739	-19854	-2868	288524	38874	Thermal load Leading		23.63	332.98
3.4.2	G - IV (Case 2)	57525	-19644	-2867	281512	38628			23.15	322.73
3.4.3	G - IV (Case 3)	56459	-19751	-2815	295757	37121			23.87	344.61
3.4.4	G - IV (Case 4)	55927	-19649	-2903	294822	39135			24.06	347.69
3.4.5	G - IV (Case 5)	55927	-19649	-2903	294822	39135			24.06	347.69
3.4.6	G - IV (Case 6)	55927	-19649	-2903	294822	39135			24.06	347.69
3.4.7	G - IV (Case 7)	55927	-19649	-2903	294822	39135			24.06	347.69
3.4.8	G - IV (Case 8)	55927	-19649	-2903	294822	39135			24.06	347.69
3.4.9	G - IV (Case 9)	55927	-19649	-2903	294822	39135			24.06	347.69
3.4.10	G - IV (Case 10)	55927	-19649	-2903	294822	39135			24.06	347.69

3.5.1	G - V (Case 1)	59312	-19575	-3018	260805	42694	SPV Leading		22.31	293.41
3.5.2	G - V (Case 2)	56934	-20137	-3033	302051	42759			24.97	361.26
3.5.3	G - V (Case 3)	56779	-19417	-2920	276771	39629			22.97	319.19
3.5.4	G - V (Case 4)	56140	-19321	-3075	276753	43244			23.40	326.40
3.5.5	G - V (Case 5)	56140	-19321	-3075	276753	43244			23.40	326.40
3.5.6	G - V (Case 6)	56140	-19321	-3075	276753	43244			23.40	326.40
3.5.7	G - V (Case 7)	56140	-19321	-3075	276753	43244			23.40	326.40
3.5.8	G - V (Case 8)	56140	-19321	-3075	276753	43244			23.40	326.40
3.5.9	G - V (Case 9)	56140	-19321	-3075	276753	43244			23.40	326.40
3.5.10	G - V (Case 10)	56140	-19321	-3075	276753	43244			23.40	326.40
3.6.1	G - VI (a)(Case 1)	58047	-18504	-3658	249185	49021	Congestion loading: Live loading Leading / Wind accompanying		22.31	289.43
3.6.2	G - VI (a)(Case 2)	58047	-18504	-3658	249185	49021			22.31	289.43
3.6.3	G - VI (a)(Case 3)	56459	-18829	-3333	249649	49407			22.39	294.95
3.6.4	G - VI (a)(Case 4)	56459	-18829	-3333	249649	49407			22.39	294.95
3.6.5	G - VI (a)(Case 5)	56459	-18829	-3333	249649	49407			22.39	294.95
3.6.6	G - VI (a)(Case 6)	56459	-18829	-3333	249649	49407			22.39	294.95
3.7.1	G - VI (b)(Case 1)	59106	-18287	-3875	248876	48764	Congestion loading: Wind loading Leading / Live Load accompanying		22.26	285.77
3.7.2	G - VI (b)(Case 2)	59106	-18287	-3875	248876	48764			22.26	285.77
3.7.3	G - VI (b)(Case 3)	56459	-18829	-3333	249649	49407			22.39	294.95
3.7.4	G - VI (b)(Case 4)	56459	-18829	-3333	249649	49407			22.39	294.95
3.7.5	G - VI (b)(Case 5)	56459	-18829	-3333	249649	49407			22.39	294.95
3.7.6	G - VI (b)(Case 6)	56459	-18829	-3333	249649	49407			22.39	294.95
4.1.1	G - V	56193	-19239	-3118	272236	44271	Quasi-permanent Combination		23.24	321.12

9.2.4 Summary of forces and load combinations at Upper pylon (Top)

9.2.4.1 Summary of forces

Section location	At upper pylon bottom				
Load Case	P	HL	HT	ML	MT
	kN	kN	kN	kNm	kNm
Dead Load					
SIDL (Fixed)	2204	99	-7	-10121	26
SIDL (Variable)	1433	65	-5	-6579	17
SW+STAY	42836	-1735	-1569	-141596	-18775
Secondary Prestress	706	-159	125	6510	1450
Creep secondary	30	377	1033	2265	8490
Shrinkage secondary	207	-108	8	3780	-594
Live Loading					
P max	2441	111	-68	-11866	-587
Ml max	2269	301	-63	-12709	-606
Mt max	124	-44	88	921	933
Longitudinal loading					
P max	10	-42	-6	887	-10
Wind Force					
P max (Without L.L)	2974	-230	230	9783	3257
Ml max (Without L.L)	2974	-230	230	9783	3257
Mt max (Without L.L)	2974	-230	230	9783	3257
P max	2534	-196	196	8336	2775
Ml max	2534	-196	196	8336	2775
Mt max	2534	-196	196	8336	2775
Temperature Forces					
Uniform Temp	-714	-614	332	15797	4950
Pylon Temp Grad	0	0	0	0	0
Deck Temp Grad	-5	-85	33	1786	468
EQ					
EQV = 0.3ELx+0.3ELy+1.0ELz	1720	281	-352	-10269	2338
EQT = 0.3ELx+1.0ELy+0.3ELz	1238	520	-338	-14180	2234
EQL = 1.0ELx+0.3ELy+0.3ELz	2892	507	-865	-7904	5775
Live Loading (SPV)					
P max	3150	451	-88	-15991	-775
ML max	3008	504	-101	-16838	-954
MT max	248	0	131	-75	1333

Note:
3) Uniform temperature difference forces have been reduced by 50% to account long term modulus of elasticity.

9.2.4.2 Load Combinations for Upper pylon (Top):

			Section location	At upper pylon bottom				
		SL No.	Description	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	Unfactored Permanent Loads	1.1.1	1.0G+1.0P+1.0S	47178	-1730	-1456	-151786	-17282
	Factored Permanent Loads	1.1.2	1.35G+1.0P+1.75S	64017	-2254	-2011	-209821	-23832
	G - I (a): Live load leading with Wind accompanying	1.2.1	1.35G+1.0P+1.75S+1.5Q1+1.5QI+0.9W 1 +1.0WC	69974	-2328	-1947	-218786	-22231
		1.2.2	1.35G+1.0P+1.75S+1.5Q2+1.5QI+0.9W 2 +1.0WC	69700	-1979	-1929	-221383	-22243
		1.2.3	1.35G+1.0P+1.75S+1.5Q3+1.5QI+0.9W 3 +1.0WC	66483	-2496	-1702	-200936	-19934
		1.2.4	1.35G+1.0P+1.75S+1.5Q4+1.5QI+0.9W 4 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.2.5	1.35G+1.0P+1.75S+1.5Q5+1.5QI+0.9W 5 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.2.6	1.35G+1.0P+1.75S+1.5Q6+1.5QI+0.9W 6 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.2.7	1.35G+1.0P+1.75S+1.5Q7+1.5QI+0.9W 7 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.2.8	1.35G+1.0P+1.75S+1.5Q8+1.5QI+0.9W 8 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.2.9	1.35G+1.0P+1.75S+1.5Q9+1.5QI+0.9W 9 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.2.10	1.35G+1.0P+1.75S+1.5Q10+1.5QI+0.9 W10 +1.0WC	64017	-2254	-2011	-209821	-23832
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - I (b): Wind Leading	1.3.1	1.35G+1.0P+1.75S+1.15Q1+1.15QI+1.5 W1 +1.0WC	70637	-2469	-1803	-209942	-20356
		1.3.2	1.35G+1.0P+1.75S+1.15Q2+1.15QI+1.5 W2 +1.0WC	70427	-2202	-1789	-211933	-20366
		1.3.3	1.35G+1.0P+1.75S+1.15Q3+1.15QI+1.5 W3 +1.0WC	67960	-2599	-1615	-196257	-18596
		1.3.4	1.35G+1.0P+1.75S+1.15Q4+1.15QI+1.5 W4 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.3.5	1.35G+1.0P+1.75S+1.15Q5+1.15QI+1.5 W5 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.3.6	1.35G+1.0P+1.75S+1.15Q6+1.15QI+1.5 W6 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.3.7	1.35G+1.0P+1.75S+1.15Q7+1.15QI+1.5 W7 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.3.8	1.35G+1.0P+1.75S+1.15Q8+1.15QI+1.5 W8 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.3.9	1.35G+1.0P+1.75S+1.15Q9+1.15QI+1.5 W9 +1.0WC	64017	-2254	-2011	-209821	-23832
		1.3.10	1.35G+1.0P+1.75S+1.15Q10+1.15QI+1. 5W10 +1.0WC	64017	-2254	-2011	-209821	-23832
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination / G - II (a): EQV = 0.3ELx+0.3ELy+1.0ELz	1.4.1	1.35G +1.75S +0.2Q1+0.2FI +1.0WC+1.5EQV	67087	-1819	-2553	-227420	-20445
		1.4.2	1.35G +1.75S +0.2Q2+0.2FI +1.0WC+1.5EQV	67050	-1773	-2551	-227766	-20446
		1.4.3	1.35G +1.75S +0.2Q3+0.2FI +1.0WC+1.5EQV	66621	-1842	-2521	-225040	-20139
		1.4.4	1.35G +1.75S +0.2Q4+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325
		1.4.5	1.35G +1.75S +0.2Q5+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325
		1.4.6	1.35G +1.75S +0.2Q6+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325
		1.4.7	1.35G +1.75S +0.2Q7+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325
		1.4.8	1.35G +1.75S +0.2Q8+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325
		1.4.9	1.35G +1.75S +0.2Q9+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325
		1.4.10	1.35G +1.75S +0.2Q10+0.2FI +1.0WC+1.5EQV	66596	-1833	-2538	-225224	-20325

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (b): EQT = 0.3ELx+1.0ELy+0.3ELz	1.5.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQT	66363	-1461	-2533	-233287	-20600
			1.5.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQT	66327	-1414	-2530	-233633	-20602
			1.5.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQT	65898	-1483	-2500	-230907	-20294
			1.5.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
			1.5.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
			1.5.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
			1.5.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
			1.5.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
			1.5.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
			1.5.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQT	65873	-1475	-2518	-231091	-20481
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (c): EQL = 1.0ELx+0.3ELy+0.3ELz	1.6.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQL	68845	-1480	-3324	-223872	-15289
			1.6.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQL	68809	-1433	-3322	-224219	-15290
			1.6.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQL	68380	-1502	-3292	-221492	-14983
			1.6.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
			1.6.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
			1.6.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
			1.6.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
			1.6.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
			1.6.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
			1.6.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQL	68355	-1493	-3309	-221677	-15169
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (a): Live load leading	1.7.1	1.0G +1.0S +0.75Q1+0.75Fl +1.0WC+1.0AE	49016	-1679	-1512	-160020	-17731
			1.7.2	1.0G +1.0S +0.75Q2+0.75Fl +1.0WC+1.0AE	48880	-1505	-1503	-161318	-17737
			1.7.3	1.0G +1.0S +0.75Q3+0.75Fl +1.0WC+1.0AE	47271	-1763	-1390	-151095	-16582
			1.7.4	1.0G +1.0S +0.75Q4+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.7.5	1.0G +1.0S +0.75Q5+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.7.6	1.0G +1.0S +0.75Q6+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.7.7	1.0G +1.0S +0.75Q7+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.7.8	1.0G +1.0S +0.75Q8+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.7.9	1.0G +1.0S +0.75Q9+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.7.10	1.0G +1.0S +0.75Q10+0.75Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (b): Live load accompanying	1.8.1	1.0G +1.0S +0.2Q1+0.2Fl +1.0WC+1.0AE	47668	-1716	-1471	-153981	-17402
			1.8.2	1.0G +1.0S +0.2Q2+0.2Fl +1.0WC+1.0AE	47632	-1670	-1469	-154328	-17404
			1.8.3	1.0G +1.0S +0.2Q3+0.2Fl +1.0WC+1.0AE	47203	-1739	-1438	-151601	-17096
			1.8.4	1.0G +1.0S +0.2Q4+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.8.5	1.0G +1.0S +0.2Q5+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.8.6	1.0G +1.0S +0.2Q6+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.8.7	1.0G +1.0S +0.2Q7+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.8.8	1.0G +1.0S +0.2Q8+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.8.9	1.0G +1.0S +0.2Q9+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
			1.8.10	1.0G +1.0S +0.2Q10+0.2Fl +1.0WC+1.0AE	47178	-1730	-1456	-151786	-17282
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (a) Thermal load Leading	1.9.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5 T+1.0WC	65756	-3224	-1550	-196073	-16393
			1.9.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5 T+1.0WC	65546	-2957	-1536	-198063	-16403
			1.9.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5 T+1.0WC	63080	-3353	-1362	-182388	-14633
			1.9.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5 T+1.0WC	62937	-3303	-1464	-183448	-15706
			1.9.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5 T+1.0WC	62937	-3303	-1464	-183448	-15706
			1.9.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5 T+1.0WC	62937	-3303	-1464	-183448	-15706
			1.9.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5 T+1.0WC	62937	-3303	-1464	-183448	-15706
			1.9.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5 T+1.0WC	62937	-3303	-1464	-183448	-15706
			1.9.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5 T+1.0WC	62937	-3303	-1464	-183448	-15706
			1.9.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1. 5T+1.0WC	62937	-3303	-1464	-183448	-15706
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (b) Live Load Leading & Thermal load accompanying	1.10.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+ 0.9T+1.0WC	67046	-2780	-1795	-210465	-19853
			1.10.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+ 0.9T+1.0WC	66772	-2432	-1777	-213061	-19865
			1.10.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+ 0.9T+1.0WC	63555	-2949	-1550	-192615	-17556
			1.10.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956
			1.10.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956
			1.10.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956
			1.10.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956
			1.10.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956
			1.10.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956
			1.10.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+ 0.9T+1.0WC	63369	-2883	-1683	-193997	-18956

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - V : Live load (SPV)		1.11.1	1.35G+1.0P+1.75S+1.15QS1+1.5QSl+1.0WC	66991	-2364	-1784	-212387	-19848
			1.11.2	1.35G+1.0P+1.75S+1.15QS2+1.5QSl+1.0WC	66828	-2304	-1799	-213361	-20054
			1.11.3	1.35G+1.0P+1.75S+1.15QS3+1.5QSl+1.0WC	63654	-2883	-1532	-194083	-17423
			1.11.4	1.35G+1.0P+1.75S+1.15QS4+1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
			1.11.5	1.35G+1.0P+1.75S+1.15QS5+1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
			1.11.6	1.35G+1.0P+1.75S+1.15QS6+1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
			1.11.7	1.35G+1.0P+1.75S+1.15QS7+1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
			1.11.8	1.35G+1.0P+1.75S+1.15QS8+1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
			1.11.9	1.35G+1.0P+1.75S+1.15QS9+1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
			1.11.10	1.35G+1.0P+1.75S+1.15QS10 +1.5QSl+1.0WC	63369	-2883	-1683	-193997	-18956
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	1.12.1	1.35G+1.0P+1.75S+1.5QC1+0.9W1+1.0WC	66298	-2431	-1835	-202319	-21334
			1.12.2	1.35G+1.0P+1.75S+1.5QC2+0.9W2+1.0WC	66298	-2431	-1835	-202319	-21334
			1.12.3	1.35G+1.0P+1.75S+1.5QC3+0.9W4+1.0WC	64017	-2254	-2011	-209821	-23832
			1.12.4	1.35G+1.0P+1.75S+1.5QC4+0.9W6+1.0WC	64017	-2254	-2011	-209821	-23832
			1.12.5	1.35G+1.0P+1.75S+1.5QC5+0.9W8+1.0WC	64017	-2254	-2011	-209821	-23832
			1.12.6	1.35G+1.0P+1.75S+1.5QC6+0.9W9+1.0WC	64017	-2254	-2011	-209821	-23832
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	1.13.1	1.35G+1.0P+1.75S+1.15QC1+1.5W1+1.0WC	67818	-2549	-1717	-197317	-19669
			1.13.2	1.35G+1.0P+1.75S+1.15QC2+1.5W2+1.0WC	67818	-2549	-1717	-197317	-19669
			1.13.3	1.35G+1.0P+1.75S+1.15QC3+1.5W4+1.0WC	64017	-2254	-2011	-209821	-23832
			1.13.4	1.35G+1.0P+1.75S+1.15QC4+1.5W6+1.0WC	64017	-2254	-2011	-209821	-23832
			1.13.5	1.35G+1.0P+1.75S+1.15QC5+1.5W8+1.0WC	64017	-2254	-2011	-209821	-23832
			1.13.6	1.35G+1.0P+1.75S+1.15QC6+1.5W9+1.0WC	64017	-2254	-2011	-209821	-23832

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	UnfactoredPermanentloads		3.1.1	1.0G+1.0P+1.0S	47415	-1461	-415	-145741	-9386
	Rare Combination	G - I Live load leading and wind accompanying	3.1.2	1.0G+1.0P+1.0S+1.0Q1+1.0Ql+0.6W1 +1.0WC	51386	-1510	-372	-151718	-8319
			3.1.3	1.0G+1.0P+1.0S+1.0Q2+1.0Ql+0.6W2 +1.0WC	51204	-1278	-360	-153449	-8327
			3.1.4	1.0G+1.0P+1.0S+1.0Q3+1.0Ql+0.6W3 +1.0WC	49059	-1622	-209	-139818	-6788
			3.1.5	1.0G+1.0P+1.0S+1.0Q4+1.0Ql+0.6W4 +1.0WC	47415	-1461	-415	-145741	-9386
			3.1.6	1.0G+1.0P+1.0S+1.0Q5+1.0Ql+0.6W5 +1.0WC	47415	-1461	-415	-145741	-9386
			3.1.7	1.0G+1.0P+1.0S+1.0Q6+1.0Ql+0.6W6 +1.0WC	47415	-1461	-415	-145741	-9386
			3.1.8	1.0G+1.0P+1.0S+1.0Q7+1.0Ql+0.6W7 +1.0WC	47415	-1461	-415	-145741	-9386
			3.1.9	1.0G+1.0P+1.0S+1.0Q8+1.0Ql+0.6W8 +1.0WC	47415	-1461	-415	-145741	-9386
			3.1.10	1.0G+1.0P+1.0S+1.0Q9+1.0Ql+0.6W9 +1.0WC	47415	-1461	-415	-145741	-9386
			3.1.11	1.0G+1.0P+1.0S+1.0Q10+1.0Ql+0.6W10 +1.0WC	47415	-1461	-415	-145741	-9386
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - II Live load leading and thermal load accompanying	3.2.1	1.0G+1.0P+1.0SQ1+1.0Ql+0.6T +1.0WC	49434	-1812	-271	-146171	-6733
			3.2.2	1.0G+1.0P+1.0SQ2+1.0Ql+0.6T +1.0WC	49252	-1579	-259	-147902	-6742
			3.2.3	1.0G+1.0P+1.0SQ3+1.0Ql+0.6T +1.0WC	47107	-1924	-108	-134271	-5203
			3.2.4	1.0G+1.0P+1.0SQ4+1.0Ql+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
			3.2.5	1.0G+1.0P+1.0SQ5+1.0Ql+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
			3.2.6	1.0G+1.0P+1.0SQ6+1.0Ql+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
			3.2.7	1.0G+1.0P+1.0SQ7+1.0Ql+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
			3.2.8	1.0G+1.0P+1.0SQ8+1.0Ql+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
			3.2.9	1.0G+1.0P+1.0SQ9+1.0Ql+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
			3.2.10	1.0G+1.0P+1.0SQ10+1.0Ql0+0.6T +1.0WC	46983	-1880	-196	-135192	-6136
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - III Wind Leading	3.3.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0W1 +0.75WC	51787	-1605	-275	-145639	-7059
			3.3.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0W2 +0.75WC	51651	-1431	-266	-146938	-7066
			3.3.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0W3 +0.75WC	50042	-1690	-153	-136715	-5911
			3.3.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0W4 +0.75WC	47415	-1461	-415	-145741	-9386
			3.3.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0W5 +0.75WC	47415	-1461	-415	-145741	-9386
			3.3.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0W6 +0.75WC	47415	-1461	-415	-145741	-9386
			3.3.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0W7 +0.75WC	47415	-1461	-415	-145741	-9386
			3.3.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0W8 +0.75WC	47415	-1461	-415	-145741	-9386
			3.3.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0W9 +0.75WC	47415	-1461	-415	-145741	-9386
			3.3.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql+1.0W10 +0.75WC	47415	-1461	-415	-145741	-9386

			Section location		At upper pylon bottom				
			SL No.	Description	P	H_L	H_T	M_L	M_T
					kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - IV Thermal load Leading	3.4.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0T +1.0WC	48534	-2108	-107	-136393	-4417
			3.4.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0T +1.0WC	48397	-1934	-97	-137691	-4423
			3.4.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0T +1.0WC	46788	-2193	16	-127468	-3269
			3.4.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0T +1.0WC	46695	-2160	-50	-128159	-3969
			3.4.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0T +1.0WC	46695	-2160	-50	-128159	-3969
			3.4.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0T +1.0WC	46695	-2160	-50	-128159	-3969
			3.4.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0T +1.0WC	46695	-2160	-50	-128159	-3969
			3.4.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0T +1.0WC	46695	-2160	-50	-128159	-3969
			3.4.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0T +1.0WC	46695	-2160	-50	-128159	-3969
			3.4.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql0+1.0 T +1.0WC	46695	-2160	-50	-128159	-3969
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - V : SPV Leading	3.5.1	1.0G+1.0P+1.2S+1.0QS1+1.0QSl +1.0WC	50133	-1429	-285	-151183	-6911
			3.5.2	1.0G+1.0P+1.2S+1.0QS2+1.0QSl +1.0WC	49991	-1376	-297	-152030	-7090
			3.5.3	1.0G+1.0P+1.2S+1.0QS3+1.0QSl +1.0WC	47231	-1880	-65	-135267	-4803
			3.5.4	1.0G+1.0P+1.2S+1.0QS4+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
			3.5.5	1.0G+1.0P+1.2S+1.0QS5+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
			3.5.6	1.0G+1.0P+1.2S+1.0QS6+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
			3.5.7	1.0G+1.0P+1.2S+1.0QS7+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
			3.5.8	1.0G+1.0P+1.2S+1.0QS8+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
			3.5.9	1.0G+1.0P+1.2S+1.0QS9+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
			3.5.10	1.0G+1.0P+1.2S+1.0QS10+1.0QSl +1.0WC	46983	-1880	-196	-135192	-6136
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.6.1	1.0G+1.0P+1.2S+1.0QC1+0.6W1 +1.0WC	48935	-1579	-298	-140740	-7721
			3.6.2	1.0G+1.0P+1.2S+1.0QC2+0.6W2 +1.0WC	48935	-1579	-298	-140740	-7721
			3.6.3	1.0G+1.0P+1.2S+1.0QC3+0.6W4 +1.0WC	47415	-1461	-415	-145741	-9386
			3.6.4	1.0G+1.0P+1.2S+1.0QC4+0.6W6 +1.0WC	47415	-1461	-415	-145741	-9386
			3.6.5	1.0G+1.0P+1.2S+1.0QC5+0.6W8 +1.0WC	47415	-1461	-415	-145741	-9386
			3.6.6	1.0G+1.0P+1.2S+1.0QC6+0.6W9 +1.0WC	47415	-1461	-415	-145741	-9386
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.7.1	1.0G+1.0P+1.2S+0.75QC1+1.0W1 +1.0WC	49949	-1657	-219	-137406	-6611
			3.7.2	1.0G+1.0P+1.2S+0.75QC2+1.0W2 +1.0WC	49949	-1657	-219	-137406	-6611
			3.7.3	1.0G+1.0P+1.2S+0.75QC3+1.0W4 +1.0WC	47415	-1461	-415	-145741	-9386
			3.7.4	1.0G+1.0P+1.2S+0.75QC4+1.0W6 +1.0WC	47415	-1461	-415	-145741	-9386
			3.7.5	1.0G+1.0P+1.2S+0.75QC5+1.0W8 +1.0WC	47415	-1461	-415	-145741	-9386
			3.7.6	1.0G+1.0P+1.2S+0.75QC6+1.0W9 +1.0WC	47415	-1461	-415	-145741	-9386
	Quasi-perm.		4.1.1	1.0G+1.0P+1.0S+0.5T	47055	-1810	-233	-136950	-6678

9.2.4.3 Structural design of Upper pylon at Top Location

9.2.4.3 At Upper Pylon Top

Pier dim. along traffic	=	4500	mm
Pier dim. across traffic	=	3000	mm
Grade of Steel f_{yk}	=	500	mpa
Grade of Concrete f_{ck}	=	55	mpa
f_{ctm}	=	3.75	mpa
f_{cd}	=	24.57	mpa
Clear cover	=	50	mm

Along traffic				**Across traffic**			
Layer-1				Layer-1			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	42	nos	No. of bars	=	19	nos
Layer-2				Layer-2			
Dia of bar	=	32	mm	Dia of bar	=	40	mm
No. of bars	=	0	nos	No. of bars	=	19	nos
Total no. of bars	=	160	nos				
% Reinf. Assumed	=	1.49	%				
Area of Steel	=	201062	mm^2				

Minimum % of Reinforcement:

$A_{s,min}$ =	$0.10*N_{ED}/f_{yd}$	= 16246	mm^2	(CL. 16.2.2 of IRC:112-2011)
	(or) $0.002A_c$	= 27000	mm^2	
	$A_{s,min}$	= 27000	mm^2	< Ast Provided
$A_{s,max}$ =	$0.04 * A_c$	= 540000	mm^2	> Ast Provided

9.2.4.4 Flexural design

The section capacity is found out in two orthogonal directions (i.e. M_{UL} & M_{UT}) for the provided reinforcement (Refer to P-M curves). The capacity interaction ratio $(M_L / M_{UL})^{\alpha n} + (M_T / M_{UT})^{\alpha n}$ is given in table below.

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	M_{UL}	M_{UT}	Capacity ratio
1.2.1	G - I (a) (Case 1)	69974	-2328	-1947	-218786	-22231	Live load leading with Wind accompanying	265795	84149	0.83
1.2.2	G - I (a) (Case 2)	69700	-1979	-1929	-221383	-22243		265541	81761	0.84
1.2.3	G - I (a) (Case 3)	66483	-2496	-1702	-200936	-19934		263616	96875	0.77
1.2.4	G - I (a) (Case 4)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.2.5	G - I (a) (Case 5)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.2.6	G - I (a) (Case 6)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.2.7	G - I (a) (Case 7)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.2.8	G - I (a) (Case 8)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.2.9	G - I (a) (Case 9)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.2.10	G - I (a) (Case 10)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.1	G - I (b) (Case 1)	70637	-2469	-1803	-209942	-20356	Wind Leading	267282	92090	0.79
1.3.2	G - I (b) (Case 2)	70427	-2202	-1789	-211933	-20366		267086	90263	0.80
1.3.3	G - I (b) (Case 3)	67960	-2599	-1615	-196257	-18596		265656	101920	0.75
1.3.4	G - I (b) (Case 4)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.5	G - I (b) (Case 5)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.6	G - I (b) (Case 6)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.7	G - I (b) (Case 7)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.8	G - I (b) (Case 8)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.9	G - I (b) (Case 9)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.3.10	G - I (b) (Case 10)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.4.1	G - II (a) (Case 1)	67087	-1819	-2553	-227420	-20445	Seismic combination - EQV	263950	73465	0.87
1.4.2	G - II (a) (Case 2)	67050	-1773	-2551	-227766	-20446		263914	73046	0.87
1.4.3	G - II (a) (Case 3)	66621	-1842	-2521	-225040	-20139		263651	75661	0.86
1.4.4	G - II (a) (Case 4)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86
1.4.5	G - II (a) (Case 5)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86
1.4.6	G - II (a) (Case 6)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86
1.4.7	G - II (a) (Case 7)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86
1.4.8	G - II (a) (Case 8)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86
1.4.9	G - II (a) (Case 9)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86
1.4.10	G - II (a) (Case 10)	66596	-1833	-2538	-225224	-20325		263539	75433	0.86

1.5.1	G - II (b) (Case 1)	66363	-1461	-2533	-233287	-20600	Seismic combination - EQT	263188	66253	0.89
1.5.2	G - II (b) (Case 2)	66327	-1414	-2530	-233633	-20602		263152	65833	0.89
1.5.3	G - II (b) (Case 3)	65898	-1483	-2500	-230907	-20294		262889	68443	0.88
1.5.4	G - II (b) (Case 4)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.5.5	G - II (b) (Case 5)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.5.6	G - II (b) (Case 6)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.5.7	G - II (b) (Case 7)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.5.8	G - II (b) (Case 8)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.5.9	G - II (b) (Case 9)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.5.10	G - II (b) (Case 10)	65873	-1475	-2518	-231091	-20481		262777	68213	0.88
1.6.1	G - II (c) (Case 1)	68845	-1480	-3324	-223872	-15289	Seismic combination - EQL	267589	79042	0.84
1.6.2	G - II (c) (Case 2)	68809	-1433	-3322	-224219	-15290		267556	78626	0.84
1.6.3	G - II (c) (Case 3)	68380	-1502	-3292	-221492	-14983		267231	80749	0.83
1.6.4	G - II (c) (Case 4)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.6.5	G - II (c) (Case 5)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.6.6	G - II (c) (Case 6)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.6.7	G - II (c) (Case 7)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.6.8	G - II (c) (Case 8)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.6.9	G - II (c) (Case 9)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.6.10	G - II (c) (Case 10)	68355	-1493	-3309	-221677	-15169		267167	80573	0.83
1.7.1	G - III (a) (Case 1)	49016	-1679	-1512	-160020	-17731	Accidental load combination - Live load leading	246213	114059	0.66
1.7.2	G - III (a) (Case 2)	48880	-1505	-1503	-161318	-17737		246054	113059	0.67
1.7.3	G - III (a) (Case 3)	47271	-1763	-1390	-151095	-16582		244525	118787	0.63
1.7.4	G - III (a) (Case 4)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.7.5	G - III (a) (Case 5)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.7.6	G - III (a) (Case 6)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.7.7	G - III (a) (Case 7)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.7.8	G - III (a) (Case 8)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.7.9	G - III (a) (Case 9)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.7.10	G - III (a) (Case 10	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.1	G - III (b) (Case 1)	47668	-1716	-1471	-153981	-17402	Accidental load combination - Live load accompanying	244807	117170	0.64
1.8.2	G - III (b) (Case 2)	47632	-1670	-1469	-154328	-17404		244763	116903	0.64
1.8.3	G - III (b) (Case 3)	47203	-1739	-1438	-151601	-17096		244338	118447	0.63
1.8.4	G - III (b) (Case 4)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.5	G - III (b) (Case 5)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.6	G - III (b) (Case 6)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.7	G - III (b) (Case 7)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.8	G - III (b) (Case 8)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.9	G - III (b) (Case 9)	47178	-1730	-1456	-151786	-17282		244270	118301	0.63
1.8.10	G - III (b) (Case 10	47178	-1730	-1456	-151786	-17282		244270	118301	0.63

1.9.1	G - IV (a) (Case 1)	65756	-3224	-1550	-196073	-16393	Thermal load Leading	264413	100503	0.75
1.9.2	G - IV (a) (Case 2)	65546	-2957	-1536	-198063	-16403		264209	98654	0.76
1.9.3	G - IV (a) (Case 3)	63080	-3353	-1362	-182388	-14633		262166	108652	0.70
1.9.4	G - IV (a) (Case 4)	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.9.5	G - IV (a) (Case 5)	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.9.6	G - IV (a) (Case 6)	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.9.7	G - IV (a) (Case 7)	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.9.8	G - IV (a) (Case 8)	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.9.9	G - IV (a) (Case 9)	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.9.10	G - IV (a) (Case 10	62937	-3303	-1464	-183448	-15706		261792	107834	0.71
1.10.1	G - IV (b) (Case 1)	67046	-2780	-1795	-210465	-19853	Live Load Leading & Thermal load accompanying	264190	89159	0.80
1.10.2	G - IV (b) (Case 2)	66772	-2432	-1777	-213061	-19865		263924	86746	0.81
1.10.3	G - IV (b) (Case 3)	63555	-2949	-1550	-192615	-17556		261901	101886	0.74
1.10.4	G - IV (b) (Case 4)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.10.5	G - IV (b) (Case 5)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.10.6	G - IV (b) (Case 6)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.10.7	G - IV (b) (Case 7)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.10.8	G - IV (b) (Case 8)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.10.9	G - IV (b) (Case 9)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.10.10	G - IV (b) (Case 10	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.1	G - V (b) (Case 1)	66991	-2364	-1784	-212387	-19848	Live load (SPV)	264140	87481	0.81
1.11.2	G - V (b) (Case 2)	66828	-2304	-1799	-213361	-20054		263888	86531	0.82
1.11.3	G - V (b) (Case 3)	63654	-2883	-1532	-194083	-17423		262064	100700	0.75
1.11.4	G - V (b) (Case 4)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.5	G - V (b) (Case 5)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.6	G - V (b) (Case 6)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.7	G - V (b) (Case 7)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.8	G - V (b) (Case 8)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.9	G - V (b) (Case 9)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.11.10	G - V (b) (Case 10)	63369	-2883	-1683	-193997	-18956		261056	100569	0.75
1.12.1	G - VI (a) (Case 1)	66298	-2431	-1835	-202319	-21334	Congestion loading: Live loading Leading / Wind accompanying	262780	95562	0.78
1.12.2	G - VI (a) (Case 2)	66298	-2431	-1835	-202319	-21334		262780	95562	0.78
1.12.3	G - VI (a) (Case 3)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.12.4	G - VI (a) (Case 4)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.12.5	G - VI (a) (Case 5)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.12.6	G - VI (a) (Case 6)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82

1.13.1	G - VI (b) (Case 1)	67818	-2549	-1717	-197317	-19669	Congestion loading: Wind loading Leading / Live Load accompanying	265013	100917	0.75
1.13.2	G - VI (b) (Case 2)	67818	-2549	-1717	-197317	-19669		265013	100917	0.75
1.13.3	G - VI (b) (Case 3)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.13.4	G - VI (b) (Case 4)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.13.5	G - VI (b) (Case 5)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82
1.13.6	G - VI (b) (Case 6)	64017	-2254	-2011	-209821	-23832		259414	87494	0.82

Note: Refer annexure 1 for Capacity ratio considering P - Δ effect

9.2.4.5 Check for Shear (Cl 10.3.2, IRC 112)

Check for Shear along Traffic Direction

Thickness of the web (across traffic)		=	3000	mm
Thickness of the web (along traffic)		=	4500	mm
Clear Cover		=	50	mm
Effective depth in the longitudinal direction		=	4420	mm
Effective depth in the transverse direction		=	2920	mm
Area of tension steel in bott. Flange	A_{st}	=	47752	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	9	nos.
Spacing of stirrups	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	707	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	3353	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.21	
Percentage of Main reinforcement	ρ_1	=	0.0036	
	σ_{cp}	=	3.49	
	V_{min}	=	0.31	=0.031×(1.21^1.5)×55^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	11753 kN	Provide min. Shear reinf.

Therefore provide 9 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0016	=707/(3000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0011	Safe

Check for Shear across Traffic Direction

Thickness of the web (across traffic)		=	3000	mm
Thickness of the web (along traffic)		=	4500	mm
Clear Cover		=	50	mm
Effective depth in the longitudinal direction		=	4420	mm
Effective depth in the transverse direction		=	2920	mm
Area of tension steel in bott. Flange	A_{st}	=	52779	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	21	nos.
Spacing of shear legs	s	=	150	mm

C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1649	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	3324	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.26	
Percentage of Main reinforcement	ρ_1	=	0.0040	
	σ_{cp}	=	3.49	
	V_{min}	=	0.33	=0.031×(1.26^1.5)×55^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	12021 kN	Provide min. Shear reinf.

Therefore provide 21 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0024	=1649/(4500×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0011	Safe

9.2.4.6 Serviceability condition

		Steel	Concrete
Allowable stresses Rare combination in MPa	=	**400**	**26.4**
Allowable stresses Quasi combination in MPa	=	**400**	**19.8**

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	Crack Width (mm)	Stress in Concrete (Mpa)	Stress in Steel (Mpa)
3.1.2	G - I (Case 1)	51386	-1510	-372	-151718	-8319	Live load leading and wind accompanying		20.14	272.87
3.1.3	G - I (Case 2)	51204	-1278	-360	-153449	-8327			20.35	279.00
3.1.4	G - I (Case 3)	49059	-1622	-209	-139818	-6788			18.41	242.43
3.1.5	G - I (Case 4)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.1.6	G - I (Case 5)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.1.7	G - I (Case 6)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.1.8	G - I (Case 7)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.1.9	G - I (Case 8)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.1.10	G - I (Case 9)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.1.11	G - I (Case 10)	47415	-1461	-415	-145741	-9386			19.60	273.55

3.2.1	G - II (Case 1)	49434	-1812	-271	-146171	-6733	Live load leading and thermal load accompanying	Crack width check is not required as per annexure B of IRC:6-2017	19.16	260.28
3.2.2	G - II (Case 2)	49252	-1579	-259	-147902	-6742			19.37	266.40
3.2.3	G - II (Case 3)	47107	-1924	-108	-134271	-5203			17.43	229.88
3.2.4	G - II (Case 4)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.2.5	G - II (Case 5)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.2.6	G - II (Case 6)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.2.7	G - II (Case 7)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.2.8	G - II (Case 8)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.2.9	G - II (Case 9)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.2.10	G - II (Case 10)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.3.1	G - III (Case 1)	51787	-1605	-275	-145639	-7059	Wind Leading		19.18	249.69
3.3.2	G - III (Case 2)	51651	-1431	-266	-146938	-7066			19.34	254.24
3.3.3	G - III (Case 3)	50042	-1690	-153	-136715	-5911			17.88	227.02
3.3.4	G - III (Case 4)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.3.5	G - III (Case 5)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.3.6	G - III (Case 6)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.3.7	G - III (Case 7)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.3.8	G - III (Case 8)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.3.9	G - III (Case 9)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.3.10	G - III (Case 10)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.4.1	G - IV (Case 1)	48534	-2108	-107	-136393	-4417	Thermal load Leading		17.55	228.81
3.4.2	G - IV (Case 2)	48397	-1934	-97	-137691	-4423			17.70	233.34
3.4.3	G - IV (Case 3)	46788	-2193	16	-127468	-3269			16.25	206.21
3.4.4	G - IV (Case 4)	46695	-2160	-50	-128159	-3969			16.46	210.21
3.4.5	G - IV (Case 5)	46695	-2160	-50	-128159	-3969			16.46	210.21
3.4.6	G - IV (Case 6)	46695	-2160	-50	-128159	-3969			16.46	210.21
3.4.7	G - IV (Case 7)	46695	-2160	-50	-128159	-3969			16.46	210.21
3.4.8	G - IV (Case 8)	46695	-2160	-50	-128159	-3969			16.46	210.21
3.4.9	G - IV (Case 9)	46695	-2160	-50	-128159	-3969			16.46	210.21
3.4.10	G - IV (Case 10)	46695	-2160	-50	-128159	-3969			16.46	210.21

3.5.1	G - V (Case 1)	50133	-1429	-285	-151183	-6911	SPV Leading		19.80	273.24
3.5.2	G - V (Case 2)	49991	-1376	-297	-152030	-7090			19.93	276.87
3.5.3	G - V (Case 3)	47231	-1880	-65	-135267	-4803			17.47	231.53
3.5.4	G - V (Case 4)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.5.5	G - V (Case 5)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.5.6	G - V (Case 6)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.5.7	G - V (Case 7)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.5.8	G - V (Case 8)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.5.9	G - V (Case 9)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.5.10	G - V (Case 10)	46983	-1880	-196	-135192	-6136			17.72	235.30
3.6.1	G - VI (a)(Case 1)	48935	-1579	-298	-140740	-7721	Congestion loading: Live loading Leading / Wind accompanying		18.70	247.88
3.6.2	G - VI (a)(Case 2)	48935	-1579	-298	-140740	-7721			18.70	247.88
3.6.3	G - VI (a)(Case 3)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.6.4	G - VI (a)(Case 4)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.6.5	G - VI (a)(Case 5)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.6.6	G - VI (a)(Case 6)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.7.1	G - VI (b)(Case 1)	49949	-1657	-219	-137406	-6611	Congestion loading: Wind loading Leading / Live Load accompanying		18.10	231.05
3.7.2	G - VI (b)(Case 2)	49949	-1657	-219	-137406	-6611			18.10	231.05
3.7.3	G - VI (b)(Case 3)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.7.4	G - VI (b)(Case 4)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.7.5	G - VI (b)(Case 5)	47415	-1461	-415	-145741	-9386			19.60	273.55
3.7.6	G - VI (b)(Case 6)	47415	-1461	-415	-145741	-9386			19.60	273.55
4.1.1	G - V	47055	-1810	-233	-136950	-6678	Quasi-permanent Combination		18.03	241.63

9.2.5 Summary of forces and load combinations at stay cable anchorage zone of upper pylon

Bottom & Mid location

9.2.5.1 Summary of forces

Section location	At stay cable anchorage zone of upper pylon bottom					At stay cable anchorage zone of upper pylon Mid				
Load Case	P	HL	HT	ML	MT	P	HL	HT	ML	MT
	kN	kN	kN	kNm	kNm	kN	kN	kN	kNm	kNm
Dead Load										
SIDL (Fixed)	3880	295	0	-17885	0	3854	355	0	-13612	0
SIDL (Variable)	2522	191	0	-11625	0	2505	230	0	-8848	0
SW+STAY	75558	-1034	0	-245154	0	24742	66810	0	-105892	0
Secondary Prestress	1349	-356	0	11470	0	201	-474	0	5421	0
Creep secondary	1057	685	0	5093	0	1239	-1034	0	6141	0
Shrinkage secondary	364	-225	0	6241	0	57	-299	0	2887	0
Live Loading										
P max	4354	332	0	-21219	0	2384	192	-286	-8498	-1324
Ml max	4032	704	0	-22888	0	2197	123	-228	-11267	-1046
Mt max	0	0	0	0	0	1215	2	-57	-8800	-132
Longitudinal loading										
P max	10	-42	-6	887	-10	10	-42	-6	887	-10
Wind Force										
P max (Without L.L)	2521	-258	258	13911	8997	2624	54	-54	-4538	9016
Ml max (Without L.L)	2521	-258	258	13911	8997	2624	54	-54	-4538	9016
Mt max (Without L.L)	2521	-258	258	13911	8997	2624	54	-54	-4538	9016
P max	2148	-220	220	11853	7666	2236	46	-46	-3867	7682
Ml max	2148	-220	220	11853	7666	2236	46	-46	-3867	7682
Mt max	2148	-220	220	11853	7666	2236	46	-46	-3867	7682
Temperature Forces										
Uniform Temp	-986	-1217	0	25683	0	-81	-857	0	18691	0
Pylon Temp Grad	0	0	0	0	0	0	0	0	0	0
Deck Temp Grad	17	-172	0	3054	0	112	-114	0	1695	0
EQ										
EQV = 0.3ELx+0.3ELy+1.0ELz	1657	398	-369	-17784	4922	1657	398	-369	-17784	4922
EQT = 0.3ELx+1.0ELy+0.3ELz	844	895	-369	-26225	4922	844	895	-369	-26225	4922
EQL = 1.0ELx+0.3ELy+0.3ELz	577	298	-1230	-10156	16406	577	298	-1230	-10156	16406
Live Loading (SPV)										
P max	5602	1043	0	-29038	0	3170	324	-392	-9346	-1790
ML max	5316	1131	0	-30630	0	1606	-80	-114	-12712	-482
MT max	0	0	0	0	0	1070	8	6	-10902	227

Note:
3) Uniform temperature difference forces have been reduced by 50% to account long term modulus of elasticity.

9.2.5.2 Load Combinations:

		Section location		At stay cable anchorage zone of upper pylon bottom					At stay cable anchorage zone of upper pylon Mid				
		SL No.	Description	P	H_L	H_T	M_L	M_T	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm	kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	Unfactored Permanent Loads	1.1.1	1.0G+1.0P+1.0S	83309	-904	0	-263194	0	31303	66920	0	-122931	0
	Factored Permanent Loads	1.1.2	1.35G+1.0P+1.75S	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
	G - I (a): Live load leading with Wind accompanying	1.2.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+0.9W1 +1.0WC	121482	-782	188	-383807	6884	48793	90866	-481	-186289	4912
		1.2.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+0.9W2 +1.0WC	120984	-161	198	-387642	6900	48498	90826	-383	-191773	5345
		1.2.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+0.9W3 +1.0WC	114936	-1217	198	-353309	6900	47025	90645	-128	-188074	6716
		1.2.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+0.9W4 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.2.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+0.9W5 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.2.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+0.9W6 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.2.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+0.9W7 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.2.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+0.9W8 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.2.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+0.9W9 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.2.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+0.9W10 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - I (b): Wind Leading	1.3.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5W1 +1.0WC	121244	-1015	322	-369579	11487	49297	90842	-406	-185945	9988
		1.3.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5W2 +1.0WC	120862	-539	330	-372519	11499	49070	90811	-331	-190150	10320
		1.3.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5W3 +1.0WC	116225	-1349	330	-346198	11499	47941	90672	-135	-187313	11371
		1.3.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5W4 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.3.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5W5 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.3.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5W6 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.3.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5W7 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.3.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5W8 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.3.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5W9 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
		1.3.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1.5W10 +1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination G - II (a): EQV = 0.3ELx+0.3ELy+1.0ELz	1.4.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQV	116361	-364	-555	-394720	7381	46155	91228	-612	-199592	7116
		1.4.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQV	116295	-281	-554	-395231	7383	46115	91222	-599	-200323	7174
		1.4.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45919	91198	-565	-199830	7356
		1.4.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383
		1.4.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383
		1.4.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383
		1.4.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383
		1.4.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383
		1.4.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383
		1.4.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQV	115489	-422	-554	-390653	7383	45676	91198	-554	-198070	7383

		Section location		At stay cable anchorage zone of upper pylon bottom					At stay cable anchorage zone of upper pylon Mid				
	SL No.	Description	P	H_L	H_T	M_L	M_T	P	H_L	H_T	M_L	M_T
			kN	kN	kN	kNm	kNm	kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (b): EQT = 0.3ELx+1.0ELy+0.3ELz	1.5.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQT	115141	381	-555	-407380	7381	44935	91972	-612	-212253	7116
			1.5.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQT	115075	463	-554	-407892	7383	44896	91967	-599	-212984	7174
			1.5.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44699	91943	-565	-212491	7356
			1.5.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
			1.5.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
			1.5.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
			1.5.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
			1.5.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
			1.5.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
			1.5.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQT	114269	323	-554	-403314	7383	44456	91942	-554	-210731	7383
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - II: Seismic Combination	G - II (c): EQL = 1.0ELx+0.3ELy+0.3ELz	1.6.1	1.35G +1.75S +0.2Q1+0.2Fl +1.0WC+1.5EQL	114742	-514	-1846	-383277	24607	44535	91078	-1904	-188149	24343
			1.6.2	1.35G +1.75S +0.2Q2+0.2Fl +1.0WC+1.5EQL	114675	-431	-1845	-383788	24609	44496	91073	-1891	-188881	24400
			1.6.3	1.35G +1.75S +0.2Q3+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44299	91048	-1857	-188387	24583
			1.6.4	1.35G +1.75S +0.2Q4+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
			1.6.5	1.35G +1.75S +0.2Q5+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
			1.6.6	1.35G +1.75S +0.2Q6+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
			1.6.7	1.35G +1.75S +0.2Q7+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
			1.6.8	1.35G +1.75S +0.2Q8+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
			1.6.9	1.35G +1.75S +0.2Q9+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
			1.6.10	1.35G +1.75S +0.2Q10+0.2Fl +1.0WC+1.5EQL	113869	-572	-1845	-379211	24609	44056	91048	-1845	-186627	24609
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (a): Live load leading	1.7.1	1.0G +1.0S +0.75Q1+0.75Fl +1.0WC+1.0AE	86582	-687	-5	-278443	-8	33098	67032	-219	-128639	-1001
			1.7.2	1.0G +1.0S +0.75Q2+0.75Fl +1.0WC+1.0AE	86333	-376	0	-280360	0	32951	67012	-171	-131381	-784
			1.7.3	1.0G +1.0S +0.75Q3+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	32214	66921	-43	-129531	-99
			1.7.4	1.0G +1.0S +0.75Q4+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.7.5	1.0G +1.0S +0.75Q5+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.7.6	1.0G +1.0S +0.75Q6+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.7.7	1.0G +1.0S +0.75Q7+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.7.8	1.0G +1.0S +0.75Q8+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.7.9	1.0G +1.0S +0.75Q9+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.7.10	1.0G +1.0S +0.75Q10+0.75Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - III: Accidental load Combination	G - III (b): Live load accompanying	1.8.1	1.0G +1.0S +0.2Q1+0.2Fl +1.0WC+1.0AE	84181	-846	-1	-267261	-2	31782	66950	-59	-124453	-267
			1.8.2	1.0G +1.0S +0.2Q2+0.2Fl +1.0WC+1.0AE	84115	-763	0	-267772	0	31742	66945	-46	-125184	-209
			1.8.3	1.0G +1.0S +0.2Q3+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31546	66921	-11	-124691	-26
			1.8.4	1.0G +1.0S +0.2Q4+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.8.5	1.0G +1.0S +0.2Q5+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.8.6	1.0G +1.0S +0.2Q6+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.8.7	1.0G +1.0S +0.2Q7+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.8.8	1.0G +1.0S +0.2Q8+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.8.9	1.0G +1.0S +0.2Q9+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0
			1.8.10	1.0G +1.0S +0.2Q10+0.2Fl +1.0WC+1.0AE	83309	-904	0	-263194	0	31303	66920	0	-122931	0

			Section location		At stay cable anchorage zone of upper pylon bottom					At stay cable anchorage zone of upper pylon Mid				
		SL No.	Description	P	H_L	H_T	M_L	M_T	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm	kN	kN	kN	kNm	kNm
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (a) Thermal load Leading	1.9.1	1.35G+1.0P+1.75S+1.15Q1+1.15Ql+1.5T+1.0WC	116568	-2770	-7	-344252	-12	45990	89315	-336	-149567	-1535
			1.9.2	1.35G+1.0P+1.75S+1.15Q2+1.15Ql+1.5T+1.0WC	116186	-2294	0	-347192	0	45764	89285	-262	-153772	-1203
			1.9.3	1.35G+1.0P+1.75S+1.15Q3+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	44635	89145	-66	-150936	-152
			1.9.4	1.35G+1.0P+1.75S+1.15Q4+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
			1.9.5	1.35G+1.0P+1.75S+1.15Q5+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
			1.9.6	1.35G+1.0P+1.75S+1.15Q6+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
			1.9.7	1.35G+1.0P+1.75S+1.15Q7+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
			1.9.8	1.35G+1.0P+1.75S+1.15Q8+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
			1.9.9	1.35G+1.0P+1.75S+1.15Q9+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
			1.9.10	1.35G+1.0P+1.75S+1.15Q10+1.15Ql+1.5T+1.0WC	111549	-3103	0	-320870	0	43238	89144	0	-140815	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - IV: Thermal load Combination	G - IV (b) Live Load Leading & Thermal load accompanying	1.10.1	1.35G+1.0P+1.75S+1.5Q1+1.5Ql+0.9T+1.0WC	118677	-1835	-10	-368610	-15	46809	89950	-439	-164462	-2002
			1.10.2	1.35G+1.0P+1.75S+1.5Q2+1.5Ql+0.9T+1.0WC	118179	-1214	0	-372445	0	46514	89910	-341	-169947	-1569
			1.10.3	1.35G+1.0P+1.75S+1.5Q3+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	45042	89729	-86	-166247	-198
			1.10.4	1.35G+1.0P+1.75S+1.5Q4+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.10.5	1.35G+1.0P+1.75S+1.5Q5+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.10.6	1.35G+1.0P+1.75S+1.5Q6+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.10.7	1.35G+1.0P+1.75S+1.5Q7+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.10.8	1.35G+1.0P+1.75S+1.5Q8+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.10.9	1.35G+1.0P+1.75S+1.5Q9+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.10.10	1.35G+1.0P+1.75S+1.5Q10+1.5Ql+0.9T+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - V : Live load (SPV)		1.11.1	1.35G+1.0P+1.75S+1.15QS1+1.5QSl+1.0WC	118573	-1070	0	-371507	0	46865	90099	-451	-163794	-2059
			1.11.2	1.35G+1.0P+1.75S+1.15QS2+1.5QSl+1.0WC	118244	-969	0	-373337	0	45066	89634	-131	-167665	-554
			1.11.3	1.35G+1.0P+1.75S+1.15QS3+1.5QSl+1.0WC	112131	-2270	0	-338113	0	44449	89735	7	-165583	261
			1.11.4	1.35G+1.0P+1.75S+1.15QS4+1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.11.5	1.35G+1.0P+1.75S+1.15QS5+1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.11.6	1.35G+1.0P+1.75S+1.15QS6+1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.11.7	1.35G+1.0P+1.75S+1.15QS7+1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.11.8	1.35G+1.0P+1.75S+1.15QS8+1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.11.9	1.35G+1.0P+1.75S+1.15QS9+1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
			1.11.10	1.35G+1.0P+1.75S+1.15QS10 +1.5QSl+1.0WC	112131	-2270	0	-338113	0	43219	89726	0	-153046	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	1.12.1	1.35G+1.0P+1.75S+1.5QC1+0.9W1+1.0WC	114936	-1217	198	-353309	6900	45203	90642	-42	-174873	6914
			1.12.2	1.35G+1.0P+1.75S+1.5QC2+0.9W2+1.0WC	114936	-1217	198	-353309	6900	45203	90642	-42	-174873	6914
			1.12.3	1.35G+1.0P+1.75S+1.5QC3+0.9W4+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
			1.12.4	1.35G+1.0P+1.75S+1.5QC4+0.9W6+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
			1.12.5	1.35G+1.0P+1.75S+1.5QC5+0.9W8+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
			1.12.6	1.35G+1.0P+1.75S+1.5QC6+0.9W9+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
Load Combinations for Structural design (IRC 6:2017 Table B.2)	G - VI : Congestion loading	G - VI (b) : Wind Leading / Live loading accompanying	1.13.1	1.35G+1.0P+1.75S+1.15QC1+1.5W1+1.0WC	116225	-1349	330	-346198	11499	46544	90670	-70	-177193	11523
			1.13.2	1.35G+1.0P+1.75S+1.15QC2+1.5W2+1.0WC	116225	-1349	330	-346198	11499	46544	90670	-70	-177193	11523
			1.13.3	1.35G+1.0P+1.75S+1.15QC3+1.5W4+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
			1.13.4	1.35G+1.0P+1.75S+1.15QC4+1.5W6+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
			1.13.5	1.35G+1.0P+1.75S+1.15QC5+1.5W8+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0
			1.13.6	1.35G+1.0P+1.75S+1.15QC6+1.5W9+1.0WC	113003	-1019	0	-363977	0	43191	90601	0	-171393	0

			Section location		At stay cable anchorage zone of upper pylon bottom					At stay cable anchorage zone of upper pylon Mid				
		SL No.	Description	P	H_L	H_T	M_L	M_T	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm	kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	UnfactoredPermanentloads	3.1.1	1.0G+1.0P+1.0S	84730	-445	0	-251861	0	32599	65587	0	-113902	0
	Rare Combination / G - I Live load leading and wind accompanying	3.1.2	1.0G+1.0P+1.0S+1.0Q1+1.0Ql+0.6W1 +1.0WC	90383	-286	125	-265081	4589	36334	65764	-320	-123833	3275
		3.1.3	1.0G+1.0P+1.0S+1.0Q2+1.0Ql+0.6W2 +1.0WC	90051	128	132	-267638	4600	36137	65738	-255	-127489	3563
		3.1.4	1.0G+1.0P+1.0S+1.0Q3+1.0Ql+0.6W3 +1.0WC	86019	-576	132	-244749	4600	35155	65617	-85	-125022	4477
		3.1.5	1.0G+1.0P+1.0S+1.0Q4+1.0Ql+0.6W4 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.1.6	1.0G+1.0P+1.0S+1.0Q5+1.0Ql+0.6W5 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.1.7	1.0G+1.0P+1.0S+1.0Q6+1.0Ql+0.6W6 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.1.8	1.0G+1.0P+1.0S+1.0Q7+1.0Ql+0.6W7 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.1.9	1.0G+1.0P+1.0S+1.0Q8+1.0Ql+0.6W8 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.1.10	1.0G+1.0P+1.0S+1.0Q9+1.0Ql+0.6W9 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.1.11	1.0G+1.0P+1.0S+1.0Q10+1.0Ql+0.6W10 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination / G - II Live load leading and thermal load accompanying	3.2.1	1.0G+1.0P+1.0SQ1+1.0Ql+0.6T +1.0WC	88513	-988	-6	-254950	-10	35011	65154	-293	-109281	-1334
		3.2.2	1.0G+1.0P+1.0SQ2+1.0Ql+0.6T +1.0WC	88180	-574	0	-257507	0	34814	65127	-228	-112938	-1046
		3.2.3	1.0G+1.0P+1.0SQ3+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	33833	65006	-57	-110471	-132
		3.2.4	1.0G+1.0P+1.0SQ4+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
		3.2.5	1.0G+1.0P+1.0SQ5+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
		3.2.6	1.0G+1.0P+1.0SQ6+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
		3.2.7	1.0G+1.0P+1.0SQ7+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
		3.2.8	1.0G+1.0P+1.0SQ8+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
		3.2.9	1.0G+1.0P+1.0SQ9+1.0Ql+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
		3.2.10	1.0G+1.0P+1.0SQ10+1.0Ql0+0.6T +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination / G - III Wind Leading	3.3.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0W1 +0.75WC	90151	-447	215	-255257	7658	36630	65746	-266	-123477	6681
		3.3.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0W2 +0.75WC	89902	-136	220	-257175	7666	36482	65726	-217	-126219	6898
		3.3.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0W3 +0.75WC	86878	-664	220	-240008	7666	35746	65635	-89	-124369	7583
		3.3.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0W4 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.3.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0W5 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.3.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0W6 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.3.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0W7 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.3.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0W8 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.3.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0W9 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
		3.3.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql+1.0W10 +0.75WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination / G - IV Thermal load Leading	3.4.1	1.0G+1.0P+1.0S+0.75Q1+0.75Ql+1.0T +1.0WC	87034	-1616	-5	-238372	-8	34425	64728	-219	-99225	-1001
		3.4.2	1.0G+1.0P+1.0S+0.75Q2+0.75Ql+1.0T +1.0WC	86785	-1306	0	-240290	0	34278	64708	-171	-101967	-784
		3.4.3	1.0G+1.0P+1.0S+0.75Q3+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	33542	64617	-43	-100117	-99
		3.4.4	1.0G+1.0P+1.0S+0.75Q4+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0
		3.4.5	1.0G+1.0P+1.0S+0.75Q5+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0
		3.4.6	1.0G+1.0P+1.0S+0.75Q6+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0
		3.4.7	1.0G+1.0P+1.0S+0.75Q7+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0
		3.4.8	1.0G+1.0P+1.0S+0.75Q8+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0
		3.4.9	1.0G+1.0P+1.0S+0.75Q9+0.75Ql+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0
		3.4.10	1.0G+1.0P+1.0S+0.75Q10+0.75Ql0+1.0T +1.0WC	83761	-1834	0	-223123	0	32630	64616	0	-93517	0

			Section location		At stay cable anchorage zone of upper pylon bottom					At stay cable anchorage zone of upper pylon Mid				
		SL No.	Description	P	H_L	H_T	M_L	M_T	P	H_L	H_T	M_L	M_T
				kN	kN	kN	kNm	kNm	kN	kN	kN	kNm	kNm
Load Combinations for Serviceability check (IRC 6:2017 Table B.3)	Rare Combination	G - V : SPV Leading	3.5.1	1.0G+1.0P+1.2S+1.0QS1+1.0QSl +1.0WC	89750	-235	0	-263657	0	35788	65328	-392	-111017	-1790
			3.5.2	1.0G+1.0P+1.2S+1.0QS2+1.0QSl +1.0WC	89465	-147	0	-265248	0	34223	64924	-114	-114383	-482
			3.5.3	1.0G+1.0P+1.2S+1.0QS3+1.0QSl +1.0WC	84149	-1278	0	-234618	0	33688	65012	6	-112573	227
			3.5.4	1.0G+1.0P+1.2S+1.0QS4+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
			3.5.5	1.0G+1.0P+1.2S+1.0QS5+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
			3.5.6	1.0G+1.0P+1.2S+1.0QS6+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
			3.5.7	1.0G+1.0P+1.2S+1.0QS7+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
			3.5.8	1.0G+1.0P+1.2S+1.0QS8+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
			3.5.9	1.0G+1.0P+1.2S+1.0QS9+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
			3.5.10	1.0G+1.0P+1.2S+1.0QS10+1.0QSl +1.0WC	84149	-1278	0	-234618	0	32618	65004	0	-101671	0
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.6.1	1.0G+1.0P+1.2S+1.0QC1+0.6W1 +1.0WC	86019	-576	132	-244749	4600	33940	65615	-28	-116222	4609
			3.6.2	1.0G+1.0P+1.2S+1.0QC2+0.6W2 +1.0WC	86019	-576	132	-244749	4600	33940	65615	-28	-116222	4609
			3.6.3	1.0G+1.0P+1.2S+1.0QC3+0.6W4 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
			3.6.4	1.0G+1.0P+1.2S+1.0QC4+0.6W6 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
			3.6.5	1.0G+1.0P+1.2S+1.0QC5+0.6W8 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
			3.6.6	1.0G+1.0P+1.2S+1.0QC6+0.6W9 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
Load Combinations for Structural design (IRC 6:2017 Table B.3)	G - VI : Congestion loading	G - VI (a) : Live loading Leading / Wind accompanying	3.7.1	1.0G+1.0P+1.2S+0.75QC1+1.0W1 +1.0WC	86878	-664	220	-240008	7666	34835	65634	-46	-117769	7682
			3.7.2	1.0G+1.0P+1.2S+0.75QC2+1.0W2 +1.0WC	86878	-664	220	-240008	7666	34835	65634	-46	-117769	7682
			3.7.3	1.0G+1.0P+1.2S+0.75QC3+1.0W4 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
			3.7.4	1.0G+1.0P+1.2S+0.75QC4+1.0W6 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
			3.7.5	1.0G+1.0P+1.2S+0.75QC5+1.0W8 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
			3.7.6	1.0G+1.0P+1.2S+0.75QC6+1.0W9 +1.0WC	84730	-445	0	-251861	0	32599	65587	0	-113902	0
	Quasi-perm.		4.1.1	1.0G+1.0P+1.0S+0.5T	84246	-1139	0	-237492	0	32615	65102	0	-103710	0

9.2.5.3 Structural design of Upper pylon at stay cable anchorage zone at Bottom location

9.2.5.3 At Upper Pylon Bottom

Pier dim. along traffic	=	6000	mm
Pier dim. across traffic	=	3000	mm
Grade of Steel f_{yk}	=	500	mpa
Grade of Concrete f_{ck}	=	55	mpa
f_{ctm}	=	3.75	mpa
f_{cd}	=	24.57	mpa
Clear cover	=	50	mm

Along traffic				**Across traffic**			
Layer-1				Layer-1			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	52	nos	No. of bars	=	22	nos
Layer-2				Layer-2			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	52	nos	No. of bars	=	22	nos
Total no. of bars	=	296	nos				

% Reinf. Assumed	=	2.07	%
Area of Steel	=	371965	mm^2

Minimum % of Reinforcement:

$A_{s,min}$ =	$0.10*N_{ED}/f_{yd}$	= 27941 mm^2	(CL. 16.2.2 of IRC:112-2011)	
	(or) $0.002A_c$	= 36000 mm^2		
	$A_{s,min}$	= 36000 mm^2	< Ast Provided	
$A_{s,max}$ =	$0.04 * A_c$	= 720000 mm^2	> Ast Provided	

9.2.5.4 Flexural design

The section capacity is found out in two orthogonal directions (i.e. M_{UL} & M_{UT}) for the provided reinforcement (Refer to P-M curves). The capacity interaction ratio $(M_L / M_{UL})^{\alpha n} + (M_T / M_{UT})^{\alpha n}$ is given in table below.

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	M_{UL}	M_{UT}	Capacity ratio
1.2.1	G - I (a) (Case 1)	121482	-782	188	-383807	6884	Live load leading with Wind accompanying	464773	198420	0.77
1.2.2	G - I (a) (Case 2)	120984	-161	198	-387642	6900		464858	205704	0.75
1.2.3	G - I (a) (Case 3)	114936	-1217	198	-353309	6900		465722	189194	0.79
1.2.4	G - I (a) (Case 4)	113003	-1019	0	-363977	0		457649	187833	0.80
1.2.5	G - I (a) (Case 5)	113003	-1019	0	-363977	0		457649	187833	0.80
1.2.6	G - I (a) (Case 6)	113003	-1019	0	-363977	0		457649	187833	0.80
1.2.7	G - I (a) (Case 7)	113003	-1019	0	-363977	0		457649	187833	0.80
1.2.8	G - I (a) (Case 8)	113003	-1019	0	-363977	0		457649	187833	0.80
1.2.9	G - I (a) (Case 9)	113003	-1019	0	-363977	0		457649	187833	0.80
1.2.10	G - I (a) (Case 10)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.1	G - I (b) (Case 1)	121244	-1015	322	-369579	11487	Wind Leading	465738	197488	0.77
1.3.2	G - I (b) (Case 2)	120862	-539	330	-372519	11499		465803	203084	0.76
1.3.3	G - I (b) (Case 3)	116225	-1349	330	-346198	11499		466534	190447	0.79
1.3.4	G - I (b) (Case 4)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.5	G - I (b) (Case 5)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.6	G - I (b) (Case 6)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.7	G - I (b) (Case 7)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.8	G - I (b) (Case 8)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.9	G - I (b) (Case 9)	113003	-1019	0	-363977	0		457649	187833	0.80
1.3.10	G - I (b) (Case 10)	113003	-1019	0	-363977	0		457649	187833	0.80
1.4.1	G - II (a) (Case 1)	116361	-364	-555	-394720	7381	Seismic combination - EQV	453604	198511	0.78
1.4.2	G - II (a) (Case 2)	116295	-281	-554	-395231	7383		453628	199482	0.78
1.4.3	G - II (a) (Case 3)	115489	-422	-554	-390653	7383		453844	197280	0.79
1.4.4	G - II (a) (Case 4)	115489	-422	-554	-390653	7383		453027	197333	0.79
1.4.5	G - II (a) (Case 5)	115489	-422	-554	-390653	7383		453027	197333	0.79
1.4.6	G - II (a) (Case 6)	115489	-422	-554	-390653	7383		453027	197333	0.79
1.4.7	G - II (a) (Case 7)	115489	-422	-554	-390653	7383		453027	197333	0.79
1.4.8	G - II (a) (Case 8)	115489	-422	-554	-390653	7383		453027	197333	0.79
1.4.9	G - II (a) (Case 9)	115489	-422	-554	-390653	7383		453027	197333	0.79
1.4.10	G - II (a) (Case 10)	115489	-422	-554	-390653	7383		453027	197333	0.79

1.5.1	G - II (b) (Case 1)	115141	381	-555	-407380	7381	Seismic combination - EQT	452645	204457	0.77
1.5.2	G - II (b) (Case 2)	115075	463	-554	-407892	7383		452667	205427	0.76
1.5.3	G - II (b) (Case 3)	114269	323	-554	-403314	7383		452881	203226	0.77
1.5.4	G - II (b) (Case 4)	114269	323	-554	-403314	7383		452064	203276	0.77
1.5.5	G - II (b) (Case 5)	114269	323	-554	-403314	7383		452064	203276	0.77
1.5.6	G - II (b) (Case 6)	114269	323	-554	-403314	7383		452064	203276	0.77
1.5.7	G - II (b) (Case 7)	114269	323	-554	-403314	7383		452064	203276	0.77
1.5.8	G - II (b) (Case 8)	114269	323	-554	-403314	7383		452064	203276	0.77
1.5.9	G - II (b) (Case 9)	114269	323	-554	-403314	7383		452064	203276	0.77
1.5.10	G - II (b) (Case 10)	114269	323	-554	-403314	7383		452064	203276	0.77
1.6.1	G - II (c) (Case 1)	114742	-514	-1846	-383277	24607	Seismic combination - EQL	449340	197875	0.80
1.6.2	G - II (c) (Case 2)	114675	-431	-1845	-383788	24609		449368	198845	0.80
1.6.3	G - II (c) (Case 3)	113869	-572	-1845	-379211	24609		449609	196645	0.80
1.6.4	G - II (c) (Case 4)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.6.5	G - II (c) (Case 5)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.6.6	G - II (c) (Case 6)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.6.7	G - II (c) (Case 7)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.6.8	G - II (c) (Case 8)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.6.9	G - II (c) (Case 9)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.6.10	G - II (c) (Case 10)	113869	-572	-1845	-379211	24609		448799	196697	0.80
1.7.1	G - III (a) (Case 1)	86582	-687	-5	-278443	-8	Accidental load combination - Live load leading	464234	223775	0.61
1.7.2	G - III (a) (Case 2)	86333	-376	0	-280360	0		464205	225945	0.60
1.7.3	G - III (a) (Case 3)	83309	-904	0	-263194	0		464326	219963	0.62
1.7.4	G - III (a) (Case 4)	83309	-904	0	-263194	0		461744	220060	0.62
1.7.5	G - III (a) (Case 5)	83309	-904	0	-263194	0		461744	220060	0.62
1.7.6	G - III (a) (Case 6)	83309	-904	0	-263194	0		461744	220060	0.62
1.7.7	G - III (a) (Case 7)	83309	-904	0	-263194	0		461744	220060	0.62
1.7.8	G - III (a) (Case 8)	83309	-904	0	-263194	0		461744	220060	0.62
1.7.9	G - III (a) (Case 9)	83309	-904	0	-263194	0		461744	220060	0.62
1.7.10	G - III (a) (Case 10)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.1	G - III (b) (Case 1)	84181	-846	-1	-267261	-2	Accidental load combination - Live load accompanying	462409	221297	0.62
1.8.2	G - III (b) (Case 2)	84115	-763	0	-267772	0		462402	221965	0.61
1.8.3	G - III (b) (Case 3)	83309	-904	0	-263194	0		462433	220035	0.62
1.8.4	G - III (b) (Case 4)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.5	G - III (b) (Case 5)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.6	G - III (b) (Case 6)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.7	G - III (b) (Case 7)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.8	G - III (b) (Case 8)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.9	G - III (b) (Case 9)	83309	-904	0	-263194	0		461744	220060	0.62
1.8.10	G - III (b) (Case 10)	83309	-904	0	-263194	0		461744	220060	0.62

1.9.1	G - IV (a) (Case 1)	116568	-2770	-7	-344252	-12	Thermal load Leading	475349	151783	0.87
1.9.2	G - IV (a) (Case 2)	116186	-2294	0	-347192	0		475389	158619	0.85
1.9.3	G - IV (a) (Case 3)	111549	-3103	0	-320870	0		475946	143190	0.88
1.9.4	G - IV (a) (Case 4)	111549	-3103	0	-320870	0		472034	143585	0.89
1.9.5	G - IV (a) (Case 5)	111549	-3103	0	-320870	0		472034	143585	0.89
1.9.6	G - IV (a) (Case 6)	111549	-3103	0	-320870	0		472034	143585	0.89
1.9.7	G - IV (a) (Case 7)	111549	-3103	0	-320870	0		472034	143585	0.89
1.9.8	G - IV (a) (Case 8)	111549	-3103	0	-320870	0		472034	143585	0.89
1.9.9	G - IV (a) (Case 9)	111549	-3103	0	-320870	0		472034	143585	0.89
1.9.10	G - IV (a) (Case 10	111549	-3103	0	-320870	0		472034	143585	0.89
1.10.1	G - IV (b) (Case 1)	118677	-1835	-10	-368610	-15	Live Load Leading & Thermal load accompanying	470538	172259	0.83
1.10.2	G - IV (b) (Case 2)	118179	-1214	0	-372445	0		470590	181179	0.80
1.10.3	G - IV (b) (Case 3)	112131	-2270	0	-338113	0		471378	161078	0.85
1.10.4	G - IV (b) (Case 4)	112131	-2270	0	-338113	0		466288	161601	0.85
1.10.5	G - IV (b) (Case 5)	112131	-2270	0	-338113	0		466288	161601	0.85
1.10.6	G - IV (b) (Case 6)	112131	-2270	0	-338113	0		466288	161601	0.85
1.10.7	G - IV (b) (Case 7)	112131	-2270	0	-338113	0		466288	161601	0.85
1.10.8	G - IV (b) (Case 8)	112131	-2270	0	-338113	0		466288	161601	0.85
1.10.9	G - IV (b) (Case 9)	112131	-2270	0	-338113	0		466288	161601	0.85
1.10.10	G - IV (b) (Case 10	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.1	G - V (b) (Case 1)	118573	-1070	0	-371507	0	Live load (SPV)	470673	176043	0.82
1.11.2	G - V (b) (Case 2)	118244	-969	0	-373337	0		467789	143104	0.90
1.11.3	G - V (b) (Case 3)	112131	-2270	0	-338113	0		471161	162074	0.84
1.11.4	G - V (b) (Case 4)	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.5	G - V (b) (Case 5)	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.6	G - V (b) (Case 6)	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.7	G - V (b) (Case 7)	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.8	G - V (b) (Case 8)	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.9	G - V (b) (Case 9)	112131	-2270	0	-338113	0		466288	161601	0.85
1.11.10	G - V (b) (Case 10)	112131	-2270	0	-338113	0		466288	161601	0.85

1.12.1	G - VI (a) (Case 1)	114936	-1217	198	-353309	6900	Congestion loading: Live loading Leading / Wind accompanying	460646	189586	0.80
1.12.2	G - VI (a) (Case 2)	114936	-1217	198	-353309	6900		460646	189586	0.80
1.12.3	G - VI (a) (Case 3)	113003	-1019	0	-363977	0		457649	187833	0.80
1.12.4	G - VI (a) (Case 4)	113003	-1019	0	-363977	0		457649	187833	0.80
1.12.5	G - VI (a) (Case 5)	113003	-1019	0	-363977	0		457649	187833	0.80
1.12.6	G - VI (a) (Case 6)	113003	-1019	0	-363977	0		457649	187833	0.80
1.13.1	G - VI (b) (Case 1)	116225	-1349	330	-346198	11499	Congestion loading: Wind loading Leading / Live Load accompanying	462641	190748	0.79
1.13.2	G - VI (b) (Case 2)	116225	-1349	330	-346198	11499		462641	190748	0.79
1.13.3	G - VI (b) (Case 3)	113003	-1019	0	-363977	0		457649	187833	0.80
1.13.4	G - VI (b) (Case 4)	113003	-1019	0	-363977	0		457649	187833	0.80
1.13.5	G - VI (b) (Case 5)	113003	-1019	0	-363977	0		457649	187833	0.80
1.13.6	G - VI (b) (Case 6)	113003	-1019	0	-363977	0		457649	187833	0.80

9.2.5.5 Check for Shear (Cl 10.3.2, IRC 112)

Check for Shear along Traffic Direction

Thickness of the web (across traffic)		=	3000	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	50	mm
Effective depth in the longitudinal direction		=	5920	mm
Effective depth in the transverse direction		=	2920	mm
Area of tension steel in bott. Flange	A_{st}	=	55292	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	9	nos.
Spacing of stirrups	s	=	150	mm
C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	707	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	3103	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.18	
Percentage of Main reinforcement	ρ_1	=	0.0031	
	σ_{cp}	=	4.63	
	V_{min}	=	0.30	=0.031×(1.18^1.5)×55^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	18314 kN	Provide min. Shear reinf.

Therefore provide 9 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0016	=707/(3000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0011	Safe

Check for Shear across Traffic Direction

Thickness of the web (across traffic)		=	3000	mm
Thickness of the web (along traffic)		=	6000	mm
Clear Cover		=	50	mm
Effective depth in the longitudinal direction		=	5920	mm
Effective depth in the transverse direction		=	2920	mm
Area of tension steel in bott. Flange	A_{st}	=	130691	mm^2
Diameter of stirrup		=	10	mm
Minimum shear legs to be provided in width of section	n_{st}	=	21	nos.
Spacing of shear legs	s	=	150	mm

C/S area of one leg	A_{st}	=	79	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1649	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Max Shear force	V_{Ed}	=	1846	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.26	
Percentage of Main reinforcement	ρ_1	=	0.0075	
	σ_{cp}	=	4.63	
	V_{min}	=	0.33	=0.031×(1.26^1.5)×55^0.5
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	20558 kN	Provide min. Shear reinf.

Therefore provide 21 shear legs at 150 mm spacing

Check for min. Shear Reinforcement (Cl 10.3.3.5 of IRC: 112 - 2011)

Shear reinforcement ratio provided	ρ_w	=	0.0018	=1649/(6000×150)
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0011	Safe

9.2.5.6 Serviceability condition

		Steel	Concrete
Allowable stresses Rare combination in MPa	=	**400**	**26.4**
Allowable stresses Quasi combination in MPa	=	**400**	**19.8**

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	Crack Width (mm)	Stress in Concrete (Mpa)	Stress in Steel (Mpa)
3.1.2	G - I (Case 1)	90383	-286	125	-265081	4589	Live load leading and wind accompanying		21.71	270.24
3.1.3	G - I (Case 2)	90051	128	132	-267638	4600			21.05	256.87
3.1.4	G - I (Case 3)	86019	-576	132	-244749	4600			22.07	285.20
3.1.5	G - I (Case 4)	84730	-445	0	-251861	0			22.39	294.95
3.1.6	G - I (Case 5)	84730	-445	0	-251861	0			22.39	294.95
3.1.7	G - I (Case 6)	84730	-445	0	-251861	0			22.39	294.95
3.1.8	G - I (Case 7)	84730	-445	0	-251861	0			22.39	294.95
3.1.9	G - I (Case 8)	84730	-445	0	-251861	0			22.39	294.95
3.1.10	G - I (Case 9)	84730	-445	0	-251861	0			22.39	294.95
3.1.11	G - I (Case 10)	84730	-445	0	-251861	0			22.39	294.95

3.2.1	G - II (Case 1)	88513	-988	-6	-254950	-10	Live load leading and thermal load accompanying	Crack width check is not required as per annexure B of IRC:6-2017	22.83	306.90
3.2.2	G - II (Case 2)	88180	-574	0	-257507	0			22.18	293.33
3.2.3	G - II (Case 3)	84149	-1278	0	-234618	0			23.16	322.25
3.2.4	G - II (Case 4)	84149	-1278	0	-234618	0			23.40	326.40
3.2.5	G - II (Case 5)	84149	-1278	0	-234618	0			23.40	326.40
3.2.6	G - II (Case 6)	84149	-1278	0	-234618	0			23.40	326.40
3.2.7	G - II (Case 7)	84149	-1278	0	-234618	0			23.40	326.40
3.2.8	G - II (Case 8)	84149	-1278	0	-234618	0			23.40	326.40
3.2.9	G - II (Case 9)	84149	-1278	0	-234618	0			23.40	326.40
3.2.10	G - II (Case 10)	84149	-1278	0	-234618	0			23.40	326.40
3.3.1	G - III (Case 1)	90151	-447	215	-255257	7658	Wind Leading		21.81	271.41
3.3.2	G - III (Case 2)	89902	-136	220	-257175	7666			21.32	261.37
3.3.3	G - III (Case 3)	86878	-664	220	-240008	7666			22.08	282.61
3.3.4	G - III (Case 4)	84730	-445	0	-251861	0			22.39	294.95
3.3.5	G - III (Case 5)	84730	-445	0	-251861	0			22.39	294.95
3.3.6	G - III (Case 6)	84730	-445	0	-251861	0			22.39	294.95
3.3.7	G - III (Case 7)	84730	-445	0	-251861	0			22.39	294.95
3.3.8	G - III (Case 8)	84730	-445	0	-251861	0			22.39	294.95
3.3.9	G - III (Case 9)	84730	-445	0	-251861	0			22.39	294.95
3.3.10	G - III (Case 10)	84730	-445	0	-251861	0			22.39	294.95
3.4.1	G - IV (Case 1)	87034	-1616	-5	-238372	-8	Thermal load Leading		23.63	332.98
3.4.2	G - IV (Case 2)	86785	-1306	0	-240290	0			23.15	322.73
3.4.3	G - IV (Case 3)	83761	-1834	0	-223123	0			23.87	344.61
3.4.4	G - IV (Case 4)	83761	-1834	0	-223123	0			24.06	347.69
3.4.5	G - IV (Case 5)	83761	-1834	0	-223123	0			24.06	347.69
3.4.6	G - IV (Case 6)	83761	-1834	0	-223123	0			24.06	347.69
3.4.7	G - IV (Case 7)	83761	-1834	0	-223123	0			24.06	347.69
3.4.8	G - IV (Case 8)	83761	-1834	0	-223123	0			24.06	347.69
3.4.9	G - IV (Case 9)	83761	-1834	0	-223123	0			24.06	347.69
3.4.10	G - IV (Case 10)	83761	-1834	0	-223123	0			24.06	347.69

3.5.1	G - V (Case 1)	89750	-235	0	-263657	0	SPV Leading		22.31	293.41
3.5.2	G - V (Case 2)	89465	-147	0	-265248	0			24.97	361.26
3.5.3	G - V (Case 3)	84149	-1278	0	-234618	0			22.97	319.19
3.5.4	G - V (Case 4)	84149	-1278	0	-234618	0			23.40	326.40
3.5.5	G - V (Case 5)	84149	-1278	0	-234618	0			23.40	326.40
3.5.6	G - V (Case 6)	84149	-1278	0	-234618	0			23.40	326.40
3.5.7	G - V (Case 7)	84149	-1278	0	-234618	0			23.40	326.40
3.5.8	G - V (Case 8)	84149	-1278	0	-234618	0			23.40	326.40
3.5.9	G - V (Case 9)	84149	-1278	0	-234618	0			23.40	326.40
3.5.10	G - V (Case 10)	84149	-1278	0	-234618	0			23.40	326.40
3.6.1	G - VI (a)(Case 1)	86019	-576	132	-244749	4600	Congestion loading: Live loading Leading / Wind accompanying		22.31	289.43
3.6.2	G - VI (a)(Case 2)	86019	-576	132	-244749	4600			22.31	289.43
3.6.3	G - VI (a)(Case 3)	84730	-445	0	-251861	0			22.39	294.95
3.6.4	G - VI (a)(Case 4)	84730	-445	0	-251861	0			22.39	294.95
3.6.5	G - VI (a)(Case 5)	84730	-445	0	-251861	0			22.39	294.95
3.6.6	G - VI (a)(Case 6)	84730	-445	0	-251861	0			22.39	294.95
3.7.1	G - VI (b)(Case 1)	86878	-664	220	-240008	7666	Congestion loading: Wind loading Leading / Live Load accompanying		22.26	285.77
3.7.2	G - VI (b)(Case 2)	86878	-664	220	-240008	7666			22.26	285.77
3.7.3	G - VI (b)(Case 3)	84730	-445	0	-251861	0			22.39	294.95
3.7.4	G - VI (b)(Case 4)	84730	-445	0	-251861	0			22.39	294.95
3.7.5	G - VI (b)(Case 5)	84730	-445	0	-251861	0			22.39	294.95
3.7.6	G - VI (b)(Case 6)	84730	-445	0	-251861	0			22.39	294.95
4.1.1	G - V	84246	-1139	0	-237492	0	Quasi-permanent Combination		23.24	321.12

9.2.5.7 Structural design of Upper pylon at stay cable anchorage zone at Mid location

(Applicable for shortest cable anchorage location to longest cable anchorage location on pylon)

Pier dim. along traffic	=	8000	mm
Pier dim. across traffic	=	3000	mm
Grade of Steel f_{yk}	=	500	mpa
Grade of Concrete f_{ck}	=	55	mpa
f_{ctm}	=	3.75	mpa
f_{cd}	=	24.57	mpa
Clear cover	=	50	mm

Along traffic				**Across traffic**			
Layer-1				Layer-1			
Dia of bar	=	32	mm	Dia of bar	=	32	mm
No. of bars	=	60	nos	No. of bars	=	24	nos
Layer-2				Layer-2			
Dia of bar	=	40	mm	Dia of bar	=	40	mm
No. of bars	=	0	nos	No. of bars	=	0	nos
Total no. of bars	=	168	nos				

% Reinf. Assumed	=	0.56	%
Area of Steel	=	135114	mm^2

Minimum % of Reinforcement:

$A_{s,min}$ =	$0.10*N_{ED}/f_{yd}$	= 11338 mm^2	(CL. 16.2.2 of IRC:112-2011)
	(or) $0.002A_c$	= 48000 mm^2	
	$A_{s,min}$	= 48000 mm^2	< Ast Provided
$A_{s,max}$ =	$0.04 * A_c$	= 960000 mm^2	> Ast Provided

9.2.5.8 Flexural design

The section capacity is found out in two orthogonal directions (i.e. M_{UL} & M_{UT}) for the provided reinforcement

(Refer to P-M curves). The capacity interaction ratio $(M_L / M_{UL})^{\alpha n} + (M_T / M_{UT})^{\alpha n}$ is given in table below.

S.No	Description	P (kN)	H_L (kN)	H_T (kN)	M_L (kN-m)	M_T (kN-m)	Remarks	M_{UL}	M_{UT}	Capacity ratio
1.2.1	G - I (a) (Case 1)	48793	90866	-481	-186289	4912	Live load leading with Wind accompanying	376161	129889	0.50
1.2.2	G - I (a) (Case 2)	48498	90826	-383	-191773	5345		375230	128294	0.51
1.2.3	G - I (a) (Case 3)	47025	90645	-128	-188074	6716		370741	127432	0.51
1.2.4	G - I (a) (Case 4)	43191	90601	0	-171393	0		360851	125136	0.48
1.2.5	G - I (a) (Case 5)	43191	90601	0	-171393	0		360851	125136	0.48
1.2.6	G - I (a) (Case 6)	43191	90601	0	-171393	0		360851	125136	0.48
1.2.7	G - I (a) (Case 7)	43191	90601	0	-171393	0		360851	125136	0.48
1.2.8	G - I (a) (Case 8)	43191	90601	0	-171393	0		360851	125136	0.48
1.2.9	G - I (a) (Case 9)	43191	90601	0	-171393	0		360851	125136	0.48
1.2.10	G - I (a) (Case 10)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.1	G - I (b) (Case 1)	49297	90842	-406	-185945	9988	Wind Leading	376637	130465	0.50
1.3.2	G - I (b) (Case 2)	49070	90811	-331	-190150	10320		375924	129384	0.51
1.3.3	G - I (b) (Case 3)	47941	90672	-135	-187313	11371		372494	128723	0.51
1.3.4	G - I (b) (Case 4)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.5	G - I (b) (Case 5)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.6	G - I (b) (Case 6)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.7	G - I (b) (Case 7)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.8	G - I (b) (Case 8)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.9	G - I (b) (Case 9)	43191	90601	0	-171393	0		360851	125136	0.48
1.3.10	G - I (b) (Case 10)	43191	90601	0	-171393	0		360851	125136	0.48
1.4.1	G - II (a) (Case 1)	46155	91228	-612	-199592	7116	Seismic combination - EQV	368170	123558	0.54
1.4.2	G - II (a) (Case 2)	46115	91222	-599	-200323	7174		368045	123330	0.55
1.4.3	G - II (a) (Case 3)	45919	91198	-565	-199830	7356		367449	123217	0.55
1.4.4	G - II (a) (Case 4)	45676	91198	-554	-198070	7383		366747	123358	0.54
1.4.5	G - II (a) (Case 5)	45676	91198	-554	-198070	7383		366747	123358	0.54
1.4.6	G - II (a) (Case 6)	45676	91198	-554	-198070	7383		366747	123358	0.54
1.4.7	G - II (a) (Case 7)	45676	91198	-554	-198070	7383		366747	123358	0.54
1.4.8	G - II (a) (Case 8)	45676	91198	-554	-198070	7383		366747	123358	0.54
1.4.9	G - II (a) (Case 9)	45676	91198	-554	-198070	7383		366747	123358	0.54
1.4.10	G - II (a) (Case 10)	45676	91198	-554	-198070	7383		366747	123358	0.54

1.5.1	G - II (b) (Case 1)	44935	91972	-612	-212253	7116	Seismic combination - EQT	364645	119004	0.58
1.5.2	G - II (b) (Case 2)	44896	91967	-599	-212984	7174		364521	118779	0.59
1.5.3	G - II (b) (Case 3)	44699	91943	-565	-212491	7356		363914	118666	0.59
1.5.4	G - II (b) (Case 4)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.5.5	G - II (b) (Case 5)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.5.6	G - II (b) (Case 6)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.5.7	G - II (b) (Case 7)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.5.8	G - II (b) (Case 8)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.5.9	G - II (b) (Case 9)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.5.10	G - II (b) (Case 10)	44456	91942	-554	-210731	7383		363202	118808	0.58
1.6.1	G - II (c) (Case 1)	44535	91078	-1904	-188149	24343	Seismic combination - EQL	357828	124417	0.54
1.6.2	G - II (c) (Case 2)	44496	91073	-1891	-188881	24400		357691	124192	0.55
1.6.3	G - II (c) (Case 3)	44299	91048	-1857	-188387	24583		357044	124076	0.55
1.6.4	G - II (c) (Case 4)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.6.5	G - II (c) (Case 5)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.6.6	G - II (c) (Case 6)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.6.7	G - II (c) (Case 7)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.6.8	G - II (c) (Case 8)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.6.9	G - II (c) (Case 9)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.6.10	G - II (c) (Case 10)	44056	91048	-1845	-186627	24609		356328	124213	0.54
1.7.1	G - III (a) (Case 1)	33098	67032	-219	-128639	-1001	Accidental load combination - Live load leading	330444	-117302	0.39
1.7.2	G - III (a) (Case 2)	32951	67012	-171	-131381	-784		330031	-116909	0.40
1.7.3	G - III (a) (Case 3)	32214	66921	-43	-129531	-99		327870	-116204	0.40
1.7.4	G - III (a) (Case 4)	31303	66920	0	-122931	0		325067	115665	0.38
1.7.5	G - III (a) (Case 5)	31303	66920	0	-122931	0		325067	115665	0.38
1.7.6	G - III (a) (Case 6)	31303	66920	0	-122931	0		325067	115665	0.38
1.7.7	G - III (a) (Case 7)	31303	66920	0	-122931	0		325067	115665	0.38
1.7.8	G - III (a) (Case 8)	31303	66920	0	-122931	0		325067	115665	0.38
1.7.9	G - III (a) (Case 9)	31303	66920	0	-122931	0		325067	115665	0.38
1.7.10	G - III (a) (Case 10)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.1	G - III (b) (Case 1)	31782	66950	-59	-124453	-267	Accidental load combination - Live load accompanying	326504	-116109	0.38
1.8.2	G - III (b) (Case 2)	31742	66945	-46	-125184	-209		326390	-116002	0.38
1.8.3	G - III (b) (Case 3)	31546	66921	-11	-124691	-26		325815	-115810	0.38
1.8.4	G - III (b) (Case 4)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.5	G - III (b) (Case 5)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.6	G - III (b) (Case 6)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.7	G - III (b) (Case 7)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.8	G - III (b) (Case 8)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.9	G - III (b) (Case 9)	31303	66920	0	-122931	0		325067	115665	0.38
1.8.10	G - III (b) (Case 10)	31303	66920	0	-122931	0		325067	115665	0.38

1.9.1	G - IV (a) (Case 1)	45990	89315	-336	-149567	-1535	Thermal load Leading	368723	-130124	0.41
1.9.2	G - IV (a) (Case 2)	45764	89285	-262	-153772	-1203		368132	-129503	0.42
1.9.3	G - IV (a) (Case 3)	44635	89145	-66	-150936	-152		365066	-128516	0.41
1.9.4	G - IV (a) (Case 4)	43238	89144	0	-140815	0		360990	127856	0.39
1.9.5	G - IV (a) (Case 5)	43238	89144	0	-140815	0		360990	127856	0.39
1.9.6	G - IV (a) (Case 6)	43238	89144	0	-140815	0		360990	127856	0.39
1.9.7	G - IV (a) (Case 7)	43238	89144	0	-140815	0		360990	127856	0.39
1.9.8	G - IV (a) (Case 8)	43238	89144	0	-140815	0		360990	127856	0.39
1.9.9	G - IV (a) (Case 9)	43238	89144	0	-140815	0		360990	127856	0.39
1.9.10	G - IV (a) (Case 10	43238	89144	0	-140815	0		360990	127856	0.39
1.10.1	G - IV (b) (Case 1)	46809	89950	-439	-164462	-2002	Live Load Leading & Thermal load accompanying	370997	-129695	0.44
1.10.2	G - IV (b) (Case 2)	46514	89910	-341	-169947	-1569		370227	-128885	0.46
1.10.3	G - IV (b) (Case 3)	45042	89729	-86	-166247	-198		366233	-127612	0.45
1.10.4	G - IV (b) (Case 4)	43219	89726	0	-153046	0		360934	126768	0.42
1.10.5	G - IV (b) (Case 5)	43219	89726	0	-153046	0		360934	126768	0.42
1.10.6	G - IV (b) (Case 6)	43219	89726	0	-153046	0		360934	126768	0.42
1.10.7	G - IV (b) (Case 7)	43219	89726	0	-153046	0		360934	126768	0.42
1.10.8	G - IV (b) (Case 8)	43219	89726	0	-153046	0		360934	126768	0.42
1.10.9	G - IV (b) (Case 9)	43219	89726	0	-153046	0		360934	126768	0.42
1.10.10	G - IV (b) (Case 10	43219	89726	0	-153046	0		360934	126768	0.42
1.11.1	G - V (b) (Case 1)	46865	90099	-451	-163794	-2059	Live load (SPV)	371148	-129815	0.44
1.11.2	G - V (b) (Case 2)	45066	89634	-131	-167665	-554		366236	-127513	0.46
1.11.3	G - V (b) (Case 3)	44449	89735	7	-165583	261		364509	127025	0.45
1.11.4	G - V (b) (Case 4)	43219	89726	0	-153046	0		360934	126768	0.42
1.11.5	G - V (b) (Case 5)	43219	89726	0	-153046	0		360934	126768	0.42
1.11.6	G - V (b) (Case 6)	43219	89726	0	-153046	0		360934	126768	0.42
1.11.7	G - V (b) (Case 7)	43219	89726	0	-153046	0		360934	126768	0.42
1.11.8	G - V (b) (Case 8)	43219	89726	0	-153046	0		360934	126768	0.42
1.11.9	G - V (b) (Case 9)	43219	89726	0	-153046	0		360934	126768	0.42
1.11.10	G - V (b) (Case 10)	43219	89726	0	-153046	0		360934	126768	0.42
1.12.1	G - VI (a) (Case 1)	45203	90642	-42	-174873	6914	Congestion loading: Live loading Leading / Wind accompanying	365462	127026	0.48
1.12.2	G - VI (a) (Case 2)	45203	90642	-42	-174873	6914		365462	127026	0.48
1.12.3	G - VI (a) (Case 3)	43191	90601	0	-171393	0		360851	125136	0.48
1.12.4	G - VI (a) (Case 4)	43191	90601	0	-171393	0		360851	125136	0.48
1.12.5	G - VI (a) (Case 5)	43191	90601	0	-171393	0		360851	125136	0.48
1.12.6	G - VI (a) (Case 6)	43191	90601	0	-171393	0		360851	125136	0.48
1.13.1	G - VI (b) (Case 1)	46544	90670	-70	-177193	11523	Congestion loading: Wind loading Leading / Live Load accompanying	368470	128272	0.49
1.13.2	G - VI (b) (Case 2)	46544	90670	-70	-177193	11523		368470	128272	0.49
1.13.3	G - VI (b) (Case 3)	43191	90601	0	-171393	0		360851	125136	0.48
1.13.4	G - VI (b) (Case 4)	43191	90601	0	-171393	0		360851	125136	0.48
1.13.5	G - VI (b) (Case 5)	43191	90601	0	-171393	0		360851	125136	0.48
1.13.6	G - VI (b) (Case 6)	43191	90601	0	-171393	0		360851	125136	0.48

10 Design Standards

The design and constructions of the precast segmental concrete viaducts shall conform to and in conformance with the requirements stipulated in the following standard specifications and code of practice unless otherwise mentioned in this document.

IRC: 5-1998	Standard Specifications and Code of Practices for Road Bridges, Section I – General Features of Design (Seventh Revision)
IRC: 6-2017	Standard Specifications and Code of Practices for Road Bridges, Section II –Loads & Stresses (Revised Edition)
IRC: 78-2014	Standard Specifications and Code of Practice for Road Bridges, Section VII Foundations and Substructure (Second Revision)
IRC: 83(III)-2002	Standard Specifications and Code of Practice for Road Bridges, Section IX-Bearings, Part III: POT, POT-CUM-PTFE, PIN AND METALLIC GUIDE BEARINGS
IRC: 87-1984	Guidelines for the Design & Erection of False work for Road Bridges
IRC: 112-2011	Code of Practice for Concrete Road Bridges
IS: 1893-2002	Criteria for Earthquake Resistant Design of Structures
IS: 2911-2010 (I/2)	Design and Construction of Pile Foundations – Bored CIP Piles
IS: 2911-1985 (IV)	Design and Construction of Pile Foundations - Load Test on Piles
IS: 6006-1983	Specifications for Uncoated Stress Relieved Strand for Prestressed Concrete
IS: 2090-1983	Specification for High Tensile Steel Bars used in Prestressed Concrete
IS: 14268-1995	Uncoated stress relieved low relaxation seven-ply strand for prestressed concrete.
IRC: SP 65-2005	Guidelines for Design and Construction of Segmental Bridges
IRC: SP 66-2005	Guidelines for Design of Continuous Bridges
IRC: SP 51-1999	Guidelines for Load Testing of Bridges
IRC-SP-115-2018	Guidelines for Design of Integral Bridges

IRC Notifications and Amendments

Notification #36 dated 31 January 2008 for IRC:SP 51-1999

Notification #59 dated 28 November 2009 for IRC:SP 65-2005

Notification #1 dated 01 August 2013 for IRC:112-2011

Notification #1 dated January 2014 for IRC:6-2014

Publications, Ministry of Road Transport & Highways

MoRTH, Specifications for Road and Bridge Works, 2001 (Fifth Revision)

Other Codes and Publications

ACI 318-08	Building Code Requirements for Structural Concrete

Post Tensioning Institute (PTI)	Recommendations for Cable Stay Design, Testing and Installation, 5th edition, 2007
SETRA	Stay Cable Recommendations of French Interministerial Commission on Pre-stressing, June 2002 in English
AASHTO	Guide Specifications for Design and Construction of Segmental Concrete Bridges, Second edition, 1999, and 2003 Interims
AASHTO	LRFD Bridge Design Specifications, 5th Edition, 2010

In the absence of any definite provisions any particular issues shall be in conformity with the sound engineering practice

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

Client:	**Roads and Bridges Development Corporation of Kerala Limited (RBDCK)**		
Project:	Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches	**Project No.:** C1193601	
Title:	Design of Approach Structure	**Document No.:** DN 102	**Rev.:** 0

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File path: iZ:\Bridges\2019\C1193601 - DPR-PONNANI CABLE STAYED Br\Working\Calculations\Structures\Viaduct\PDP\DN.docx

Notes:

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Revision Details:

Rev.	Date	Details	Prepared Init.	Prepared Sign.	Checked Init.	Checked Sign.	Approved Init.	Approved Sign.
0	12/03/2020	First Submission	PDP		NRY		PML	

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Staad r and oad o nation or Dap ra
Design of In r dia Dap ra
Design data
Rein or n a Top
Cross ion dna
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Design Para r
Design of Pier a oo o
Design a Top of Pier
Design Para r
Design of Pier a oo o

Sta d Rel d d d r d sign

Abutment and Design Pile Founda on for Ed Pier - Type-B

Calcula on of Pile Reac on
Input Data
Cross or a Pro r
Pile Load or Ser ra Design ULS Condition
Pile Load or Ser ceability Varia on SLS Condition
Design of Pile Cap
Longitudina Dir on Design Para r
Transver Dir on Design Para r
Cross or Pen n Sear
Calcula on of Pile Cap Cra d
Calcula on of Cra d Transver Dir on
Calcula on of Cra d Longitudina Dir on
Design of Pile
Input Data
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Ca a on o P ap Cra d
Ca a on o Cra d Tran r Dr on
Ca a on o Cra d Lon d na Dr on
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1 Introduction

Road and Rail Development Corporation of Kerala Ltd (RDDC) was formed to promote and develop the Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches in Coastal Corridor in Malappuram District of Kerala State, India. The scope of work includes construction approach roads and bridge proper proposed at Ponnani.

This document describes the analysis and design of typical span options of Approach Structure.

1.1 Superstructure Arrangement

The proposed span arrangement consists of 3 x 30m simply supported RCC girder bridge with deck slab. The pier cap for the bridge is designed as a continuous beam. The typical pier cap for the proposed bridge is designed for end reaction of girder and intermediate reaction of girder. The foundation system consists of pile foundation. The pile foundation is designed for Extreme load combination.

Single span arrangement is proposed and the bridge consists of 3 spans. The typical arrangement consists of two abutments and two piers.

1.2 Assumptions

The girder is designed for RL to GL clearance from top of pier cap and the same is considered for all spans. The design is carried out for worst load combination.

Span Unit	30m x 3 Nos
Clearance RL to GL	3.0m to 4.0m
Foundation Type	Pile

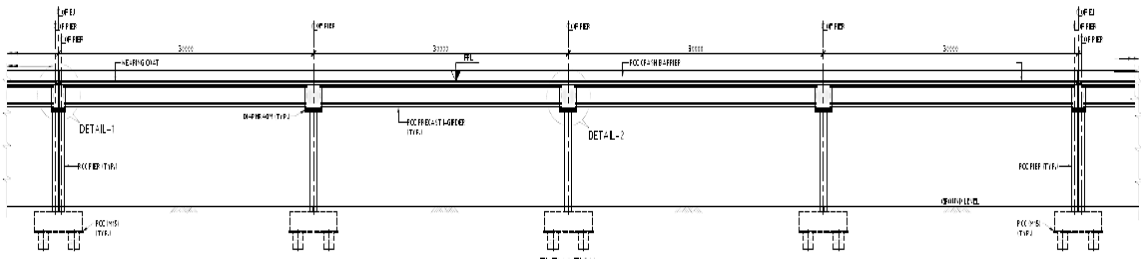
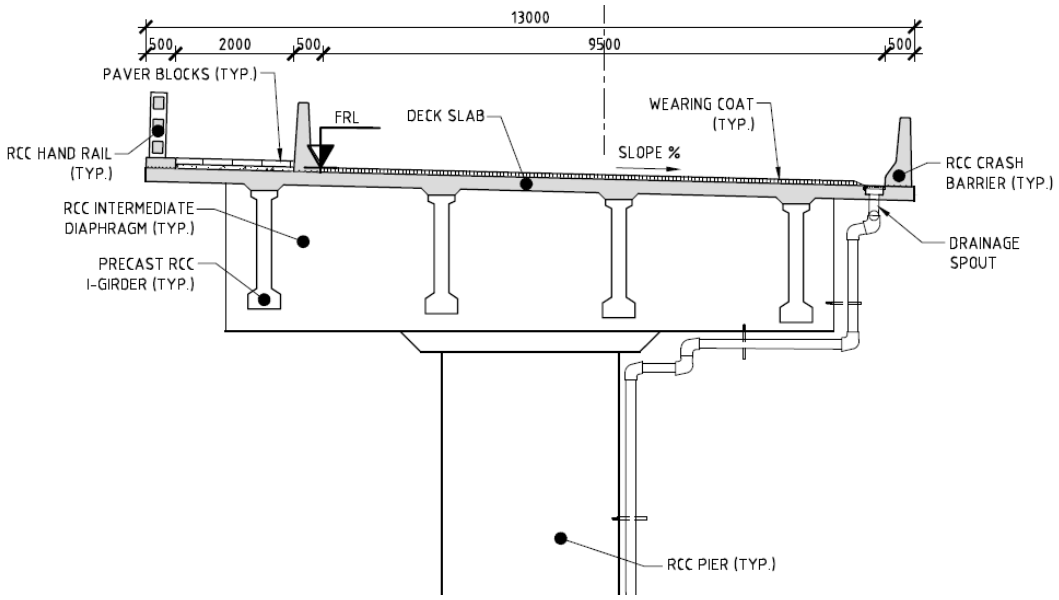


Figure 1 Typical Superstructure Arrangement



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2 Design Basis

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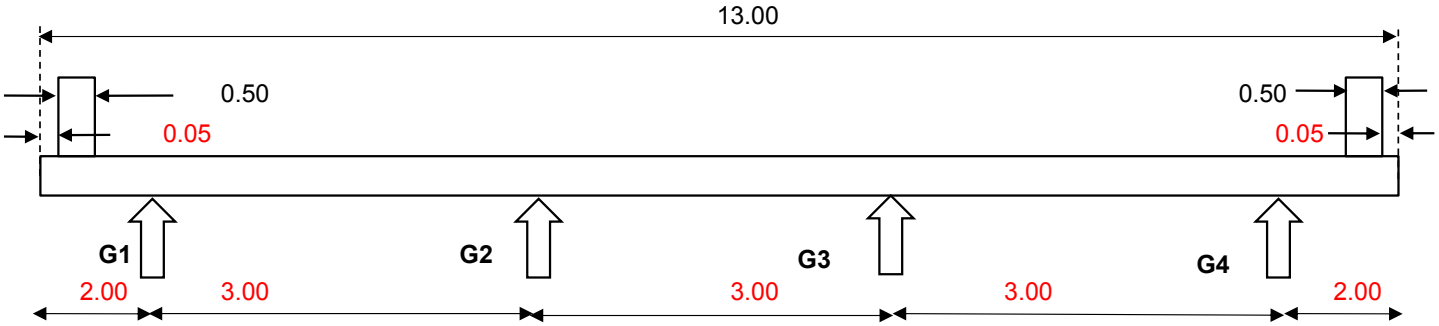
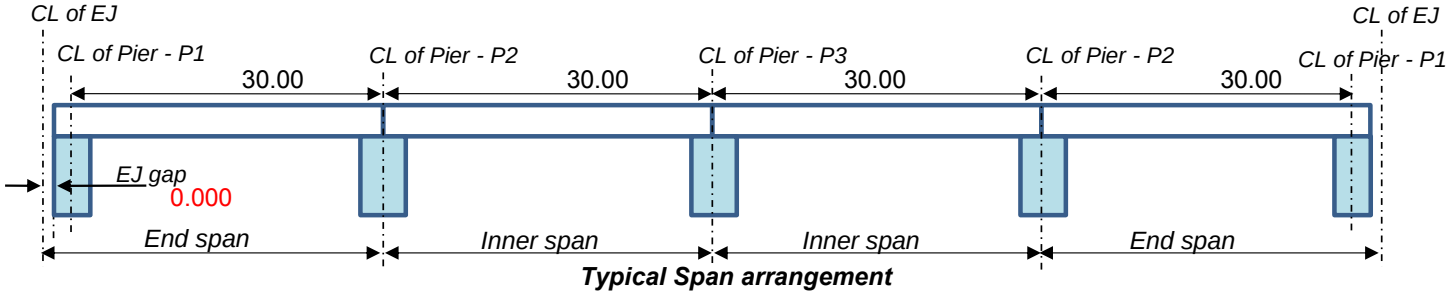
2.2 ***Structural configuration***

Total length of integral unit	4 X 30	=	120.00	m
Length of end span (EJ to C/L of pier)		=	30.0	m
Length of Inner span (C/L of pier to C/L of pier)		=	30.0	m
Width of end Pier		=	0.68	m
Width of inner Pier		=	0.80	m
Height of pier above ground level (Max)		=	8.985	m
Total height of pier from pilecap top		=	9.735	m
Spacing of temporary support from centre of the end pier		=	1.00	m
Spacing of temporary support from centre of the inner pier		=	1.00	m
Spacing of girder in transverse direction		=	3.00	m
Width of crash barrier		=	0.50	m
Height of crash barrier		=	1.10	m
Width of median		=	0.00	m
Depth of the girder		=	2.00	m
Depth of diaphragm		=	2.15	m
Depth of the diaphragm (Including deck slab)	=2.15+0.230	=	2.38	m
Width of End diaphragm		=	0.98	m
Width of inner diaphragm		=	2.00	m
Total number of main girders		=	4.0	Nos
Total width of deck slab		=	13.00	m
Thickness of deck slab		=	0.230	m
Thickness of haunch due to 2.5% cross slope (assumed)		=	0.060	m
Thickness of wearing coat		=	0.075	m
Density of concrete		=	25	kN/m^3
Density of wearing coat		=	22	kN/m^3

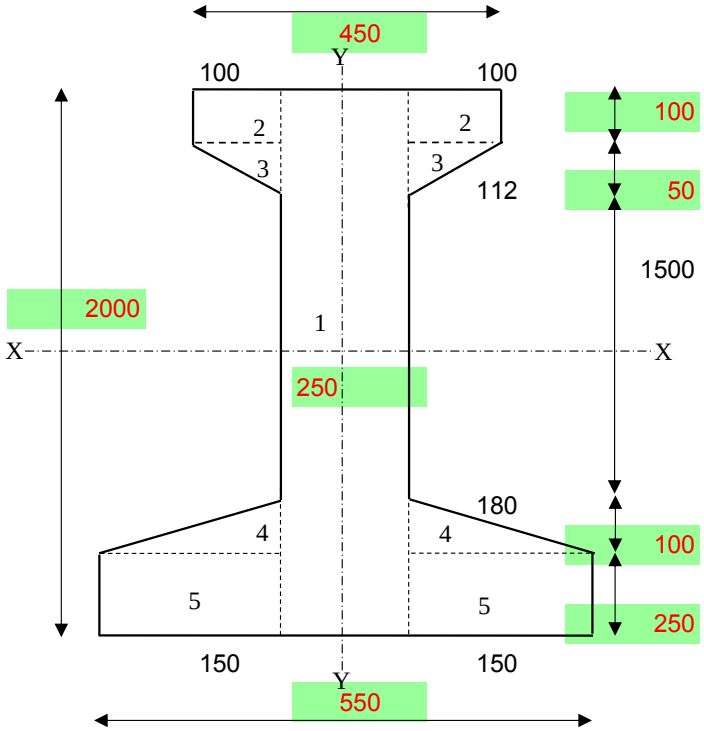


Typical cross section of superstructure



Typical Span arrangement

2.3 Sectional Properties of Precast Girder



Typical cross section of the girder

Properties about X - X

Part	B	H	Area	Y_{top}	$A*Y_{top}$	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^3	mm	mm^4	mm^4	mm^4
1	250	2000	5.00E+05	1000	5.00E+08	86.11	1.67E+11	3.71E+09	1.70E+11
2	100	100	2.00E+04	50	1.00E+06	1036.11	1.67E+07	2.15E+10	2.15E+10
3	100	50.0	5.00E+03	117	5.83E+05	969.44	6.94E+05	4.70E+09	4.70E+09
4	150	100	1.50E+04	1717	2.58E+07	630.56	8.33E+06	5.96E+09	5.97E+09
5	150	250	7.50E+04	1875	1.41E+08	788.89	3.91E+08	4.67E+10	4.71E+10
Total			6.15E+05		6.68E+08		1.67E+11	8.25E+10	2.50E+11

Total area ;	A		=	615000	mm^2
Moment of inertia	I_{NA}		=	2.50E+11	mm^4
Depth of NA from Top ;	Y_t	=6.68E+08/6.15E+05	=	1086	mm
Depth of NA from Bottom ;	Y_b	=2000-1086	=	914	mm
Section Modulus ;	Z_{top}	=2.50E+11/1086	=	2.30E+08	mm^3
Section Modulus ;	Z_{bot}	=2.50E+11/914	=	2.73E+08	mm^3

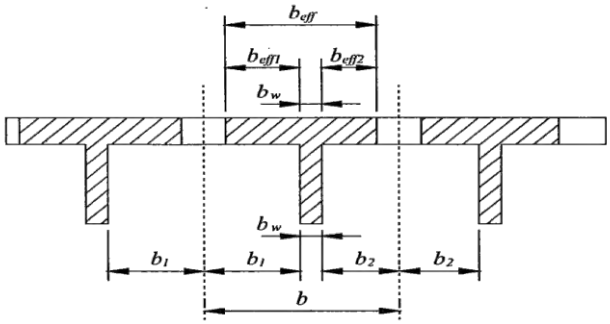
Properties about Y - Y

Part	B	H	Area	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^4	mm^4	mm^4
1	250	2000	5.00E+05	0	2.60E+09	0.00E+00	2.60E+09
2	100	100	2.00E+04	175	1.67E+07	6.13E+08	6.29E+08
3	100	50	5.00E+03	158	2.78E+06	1.25E+08	1.28E+08
4	150	100	1.50E+04	175	1.88E+07	4.59E+08	4.78E+08
5	150	250	7.50E+04	200	1.41E+08	3.00E+09	3.14E+09
Total			6.15E+05		2.78E+09	4.20E+09	6.98E+09

2.4 Composite Sectional Properties of Girder

2.4.1 Composite Section at Mid Span for Girder-1 (End girder)

The effective flange width for the composite section is computed as per Cl. 7.6.1.2 of IRC: 112-2011 as below:



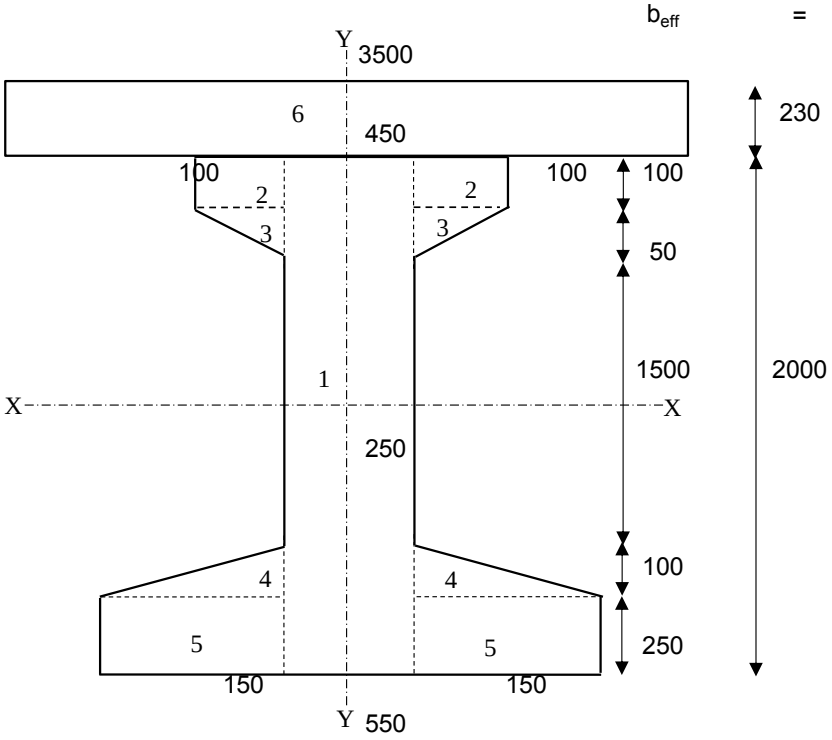
Effective flange width ;

$b_{eff} = \Sigma\, b_{eff,i} + b_w$ <= b

with $b_{eff,i} = 0.2 * b_i + 0.1 * l_0$ <= $0.2 * l_0$

and $b_{eff,i}$ <= b_i

l_0	=	21	m
b	=	3.5	m
D	=	0.230	m
b_1	=	1.875	m
b_2	=	1.375	m
$b_{eff,1}$	=	1.875	m
$b_{eff,2}$	=	1.375	m
b_{eff}	=	3.500	m



Properties about X - X

Part	B	H	Area	Y_{top}	$A*Y_{top}$	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^3	mm	mm^4	mm^4	mm^4
1	250	2000	500000	1230	6.15E+08	595	1.67E+11	1.77E+11	3.44E+11
2	100	100	20000	280	5.60E+06	355	1.67E+07	2.52E+09	2.54E+09
3	100	50	5000	347	1.73E+06	289	6.94E+05	4.16E+08	4.17E+08
4	150	100	15000	1947	2.92E+07	1311	8.33E+06	2.58E+10	2.58E+10
5	150	250	75000	2105	1.58E+08	1470	3.91E+08	1.62E+11	1.62E+11
6	3500	230	805000	115	9.26E+07	520	3.55E+09	2.18E+11	2.21E+11
			1.42E+06		9.02E+08		1.71E+11	5.85E+11	7.56E+11

Total area ;	A		=	1420000	mm^2
Moment of inertia	I_{NA}		=	7.56E+11	mm^4
Depth of NA from Top ;	Y_t	=9.02E+08/1.42E+06	=	635	mm

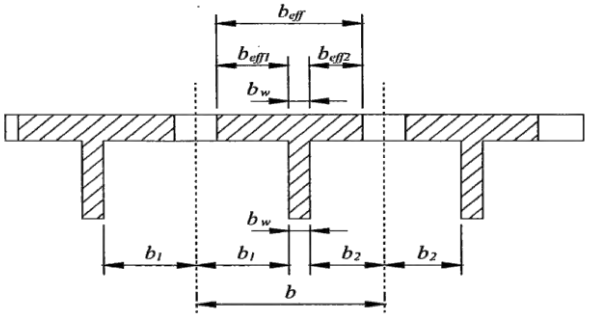
Depth of NA from Bottom ;	Y_b	=230+2000-635	=	1595	mm
Section Modulus ;	Z_{top}	=7.56E+11/635	=	1.19E+09	mm³
Section Modulus ;	Z_{bot}	=7.56E+11/1595	=	4.74E+08	mm³

Properties about Y - Y

Part	B	H	Area	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^4	mm^4	mm^4
1	250	2000	500000	0	2.60E+09	0.00E+00	2.60E+09
2	100	100	20000	175	1.67E+07	6.13E+08	6.29E+08
3	100	50	5000	158	2.78E+06	1.25E+08	1.28E+08
4	150	100	15000	175	1.88E+07	4.59E+08	4.78E+08
5	150	250	75000	200	1.41E+08	3.00E+09	3.14E+09
6	3500	230	805000	0	8.22E+11	0.00E+00	8.22E+11
			1.42E+06		8.25E+11		8.29E+11

2.4.2 *Composite Section at Mid Span for Girder-2 (Inner Girder)*

The effective flange width for the composite section is computed as per Cl. 7.6.1.2 of IRC: 112-2011 as below:



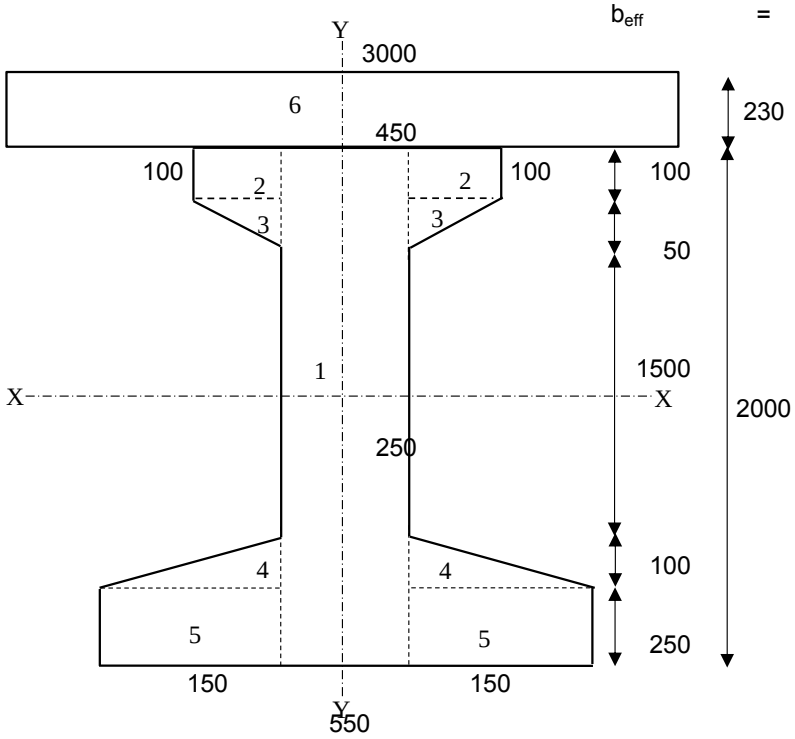
Effective flange width ;

$b_{eff} = \Sigma\, b_{eff,i} + b_w$ <= b

with $b_{eff,i} = 0.2 * b_i + 0.1 * l_0$ <= $0.2 * l_0$

and $b_{eff,i}$ <= b_i

l_0	=	21	m
b	=	3.000	m
D	=	0.230	m
b_1	=	1.375	m
b_2	=	1.375	m
$b_{eff,1}$	=	1.375	m
$b_{eff,2}$	=	1.375	m
b_{eff}	=	3.000	m



Properties about X - X

Part	B	H	Area	Y_{top}	$A*Y_{top}$	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^3	mm	mm^4	mm^4	mm^4
1	250	2000	500000	1230	6.15E+08	549	1.67E+11	1.51E+11	3.17E+11
2	100	100	20000	280	5.60E+06	401	1.67E+07	3.22E+09	3.23E+09
3	100	50	5000	347	1.73E+06	334	6.94E+05	5.59E+08	5.60E+08
4	150	100	15000	1947	2.92E+07	1266	8.33E+06	2.40E+10	2.40E+10
5	150	250	75000	2105	1.58E+08	1424	3.91E+08	1.52E+11	1.52E+11
6	3000	230	690000	115	7.94E+07	566	3.04E+09	2.21E+11	2.24E+11
			1.31E+06		8.89E+08		1.70E+11	5.52E+11	7.22E+11

Total area ;	A		=	1305000	mm^2
Moment of inertia	I_{NA}		=	7.22E+11	mm^4
Depth of NA from Top ;	Y_t	=8.89E+08/1.31E+06	=	681	mm
Depth of NA from Bottom ;	Y_b	=230+2000-681	=	1549	mm
Section Modulus ;	Z_{top}	=7.22E+11/681	=	1.06E+09	mm^3
Section Modulus ;	Z_{bot}	=7.22E+11/1549	=	4.66E+08	mm^3

Properties about Y - Y

Part	B	H	Area	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^4	mm^4	mm^4
1	250	2000	500000	0	2.60E+09	0.00E+00	2.60E+09
2	100	100	20000	175	1.67E+07	6.13E+08	6.29E+08
3	100	50	5000	158	2.78E+06	1.25E+08	1.28E+08
4	150	100	15000	175	1.88E+07	4.59E+08	4.78E+08
5	150	250	75000	200	1.41E+08	3.00E+09	3.14E+09
6	3000	230	690000	0	5.18E+11	0.00E+00	5.18E+11
			1.31E+06		5.20E+11		5.24E+11

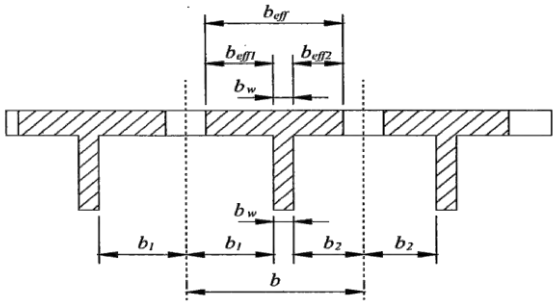
2.4.3 Composite Section at Mid Span for Girder-3 (Inner most girder)

The effective flange width for the composite section is computed as per Cl. 7.6.1.2 of IRC: 112-2011 as below:

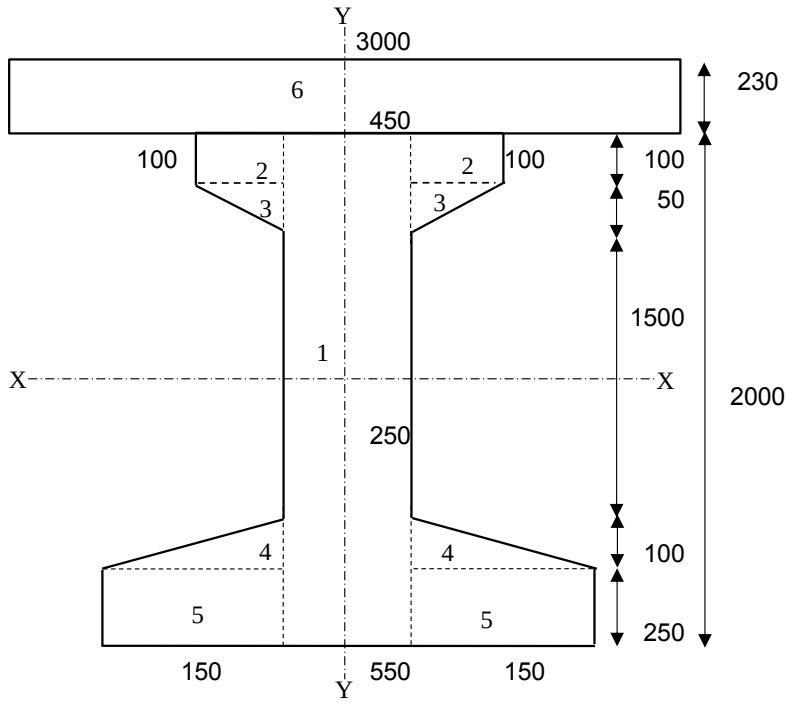
Effective flange width $b_{eff} = \Sigma\, b_{eff,i} + b_w$ <= b

with $b_{eff,i} = 0.2 * b_i + 0.1 * l_0$ <= $0.2 * l_0$

and $b_{eff,i}$ <= b_i



l_0	=	21	m
b	=	3.000	m
D	=	0.230	m
b_1	=	1.625	m
b_2	=	1.125	m
$b_{eff,1}$	=	1.625	m
$b_{eff,2}$	=	1.125	m
b_{eff}	=	3.000	m



Properties about X - X

Part	B	H	Area	Y_{top}	$A*Y_{top}$	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^3	mm	mm^4	mm^4	mm^4
1	250	2000	500000	1230	6.15E+08	549	1.67E+11	1.51E+11	3.17E+11
2	100	100	20000	280	5.60E+06	401	1.67E+07	3.22E+09	3.23E+09
3	100	50	5000	347	1.73E+06	334	6.94E+05	5.59E+08	5.60E+08
4	150	100	15000	1946.6667	2.92E+07	1266	8.33E+06	2.40E+10	2.40E+10
5	150	250	75000	2105	1.58E+08	1424	3.91E+08	1.52E+11	1.52E+11
6	3000	230	690000	115	7.94E+07	566	3.04E+09	2.21E+11	2.24E+11
			1.31E+06		8.89E+08		1.70E+11	5.52E+11	7.22E+11

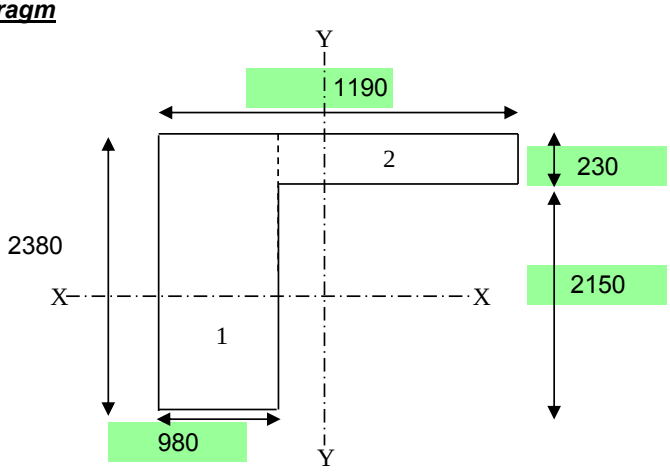
Total area ;	A		=	1305000	mm^2
Moment of inertia	I_{NA}		=	7.22E+11	mm^4
Depth of NA from Top ;	Y_t	=8.89E+08/1.31E+06	=	681	mm
Depth of NA from Bottom ;	Y_b	=230+2000-681	=	1549	mm
Section Modulus ;	Z_{top}	=7.22E+11/681	=	1.06E+09	mm^3
Section Modulus ;	Z_{bot}	=7.22E+11/1549	=	4.66E+08	mm^3

Properties about Y - Y

Part	B	H	Area	h	I_{self}	Ah^2	I_{NA}
	mm	mm	mm^2	mm	mm^4	mm^4	mm^4
1	250	2000	500000	0	2.60E+09	0.00E+00	2.60E+09
2	100	100	20000	175	1.67E+07	6.13E+08	6.29E+08
3	100	50	5000	158	2.78E+06	1.25E+08	1.28E+08
4	150	100	15000	175	1.88E+07	4.59E+08	4.78E+08
5	150	250	75000	200	1.41E+08	3.00E+09	3.14E+09
6	3000	230	690000	0	5.18E+11	0.00E+00	5.18E+11
			1.31E+06		5.20E+11		5.24E+11

2.5 Calculation of section Properties of the Diaphragm

2.5.1 *For End Diaphragm*

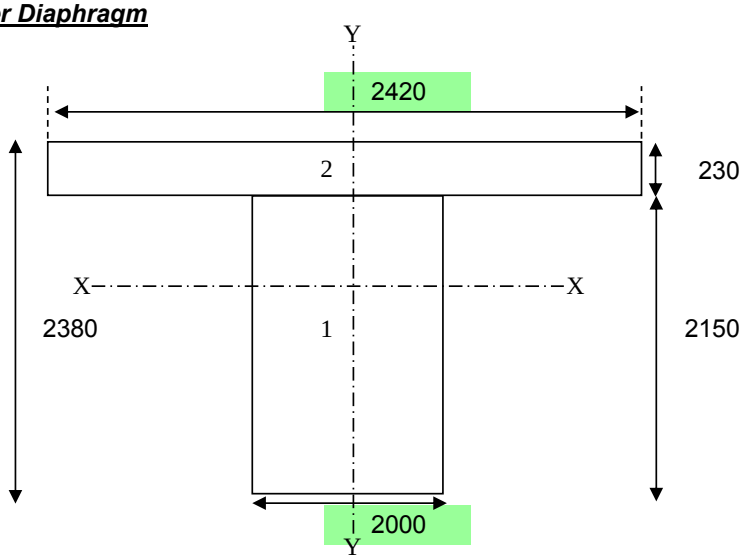


Properties about X - X

Part	B	H	Area	Y_{top}	$A*Y_{top}$	h	I_{self}	Ah^2	I_{xx}	K
	mm	mm	mm^2	mm	mm^3	mm	mm^4	mm^4	mm^4	mm^4
1	980	2380	2.33E+06	1190	2.78E+09	21.81	1.10E+12	1.11E+09	1.10E+12	7.47E+11
2	210	230	4.83E+04	115	5.55E+06	1053.19	2.13E+08	5.36E+10	5.38E+10	8.52E+08
Total			2.38E+06		2.78E+09		1.10E+12	5.47E+10	1.16E+12	7.48E+11

Total area ;	A		=	2380700	mm^2
Moment of inertia	I_{xx}		=	1.16E+12	mm^4
Depth of NA from Top ;	Y_t	=2.78E+09/2.38E+06	=	1168	mm
Depth of NA from Bottom ;	Y_b	=2380-1168	=	1212	mm
Section Modulus ;	Z_{top}	=1.16E+12/1168	=	9.89E+08	mm^3
Section Modulus ;	Z_{bot}	=1.16E+12/1212	=	9.54E+08	mm^3
Torsional Constant	K		=	7.48E+11	mm^4
Moment of inertia	I_{yy}		=	2.04E+11	mm^4

2.5.2 *For Inner Diaphragm*



Properties about X - X

Part	B	H	Area	Y_{top}	$A*Y_{top}$	h	I_{self}	Ah^2	I_{xx}	K
	mm	mm	mm^2	mm	mm^3	mm	mm^4	mm^4	mm^4	mm^4
1	2000	2150	4.30E+06	1305	5.61E+09	136.38	1.66E+12	8.00E+10	1.74E+12	5.73E+12
2	2420	230	5.57E+05	115	6.40E+07	1053.62	2.45E+09	6.18E+11	6.20E+11	9.81E+09
Total			4.86E+06		5.68E+09		1.66E+12	6.98E+11	2.36E+12	5.74E+12

Total area ;	A		=	4856600	mm^2
Moment of inertia	I_{xx}		=	2.36E+12	mm^4
Depth of NA from Top ;	Y_t	=5.68E+09/4.86E+06	=	1169	mm
Depth of NA from Bottom ;	Y_b	=2380-1169	=	1211	mm
Section Modulus ;	Z_{top}	=2.36E+12/1169	=	2.02E+09	mm^3
Section Modulus ;	Z_{bot}	=2.36E+12/1211	=	1.95E+09	mm^3
Torsional Constant	K		=	5.74E+12	mm^4
Moment of inertia	I_{yy}		=	1.70E+12	mm^4

2.6 Load calculation for analysis

2.6.1 Dead load

Self weight of girder

Cross sectional area of the girder		=	0.615	m^2
C/S area of haunch (0.06m thk) over girder for cross slope of deck slab		=	0.027	m^2
Load per meter run		=	16.05	kN/m
	Say	=	***16.10***	***kN/m***

Bending moment due to self wt. of girder placed over temporary support

For End span

Distance between temporary support	=30.000-1.00-1.00	=	28.000	m
Bending moment		=	*1577.80*	*kNm*
	Say	=	***1,577.80***	***kNm***

For Inner span

Distance between temporary support	=30.00-1.00-1.00	=	28.00	m
Bending moment		=	*1577.80*	*kNm*
	Say	=	***1577.80***	***kNm***

Reactions due to self weight of the precast girder

For End span

Length of precast girder	=(30.0-0.000-0.98-2.00/2)+0.23×2	=	28.480	m
Total weight of precast girder		=	458.53	kN
Reactions due to self weight of precast girder		=	*229.26*	*kN*
	Say	=	***229.30***	***kN***

For Inner span

Length of precast girder	=(30.0-2.00/2-2.00/2)+0.23×2	=	28.46	m
Total weight of precast girder		=	458.21	kN
Reactions due to self weight of precast girder		=	*229.10*	*kN*
	Say	=	***229.20***	***kN***

Self weight of diaphragm

For End Diaphragm

Cross sectional area of end diaphragm		=	2.381	m^2
Load per meter run	=2.381×25	=	59.52	kN/m
	Say	=	***59.60***	***kN/m***

For Inner Diaphragm

Cross sectional area of Inner diaphragm	=(2000×2150)/1000000	=	4.300	m^2
Load per meter run =4.300×25		=	107.50	kN/m
	Say	=	***107.50***	***kN/m***

Dead load of deck slab

For End Girder-G1

Cross sectional area of concrete over girder-G1	=(2.00+3.00/2)×0.230	=	0.81	m^2
Load per meter run		=	20.13	kN/m
	Say	=	***20.20***	***kN/m***

For Inner Girder-G2

Cross sectional area of concrete over girder-G2	=(3.0/2+3.0/2)×0.230	=	0.690	m^2
Load per meter run		=	17.25	kN/m
	Say	=	***17.30***	***kN/m***

For Inner Girder-G3

Cross sectional area of concrete over girder-G3	=(3.0/2+3.0/2)×0.230	=	0.690	m^2
Load per meter run		=	17.25	kN/m
	Say	=	***17.30***	***kN/m***

2.6.2 Superimposed Dead load

Due to crash barrier

Area of end crash barrier	=	0.36	m^2
Load per meter run	=	*9.00*	***kN/m***
Service load per meter run (assumed)	=	1.10	*kN/m*
Total load due to end crash barrier	=	***10.10***	*kN/m*

Due to Wearing coat

Thickness of wearing coat		=	0.075	m

For End Girder-G1

C/S area of wearing coat over girder-G1	*=(2.00-0.05-0.50+3.00/2)×0.075*	=	0.2213	m^2
Load per meter run		=	4.87	kN/m
	Say	=	***4.90***	***kN/m***

For Inner Girder-G2

C/S area of wearing coat over girder-G2	*=(3.00/2+3.00/2)×0.075*	=	0.2250	m^2
Load per meter run		=	4.95	kN/m
	Say	=	***5.00***	***kN/m***

For Inner Girder-G3

C/S area of wearing coat over girder-G3	*=(3.00/2+3.00/2-0.0/2)×0.075*	=	0.2250	m^2
Load per meter run		=	4.95	kN/m
	Say	=	***5.00***	***kN/m***

2.6.3 Live Load

The live loads (LL) are taken as per IRC: 6-2017. The following load cases are considered in the analysis.

- LL1 - One 70R vehicle placed nearer to crash barrier on Left Carriageway
- LL2 - One Class A vehicle placed nearer to crash barrier on Left Carriageway
- LL3 - One 70R vehicle placed nearer to crash barrier on Left Carriageway and one Class A vehicles placed nearer to median on Right Carriageway
- LL4 - Special vehicle
- LL5 - Three Class A vehicles placed nearer to crash barrier on Left Carriageway

2.6.4 Longitudinal forces (Braking force) due to live load

Braking force due to live load is calculated as per Cl:211.2 of IRC 6:2017.

Sl No.	Live Load combination	Braking load				Total force (kN)	Force per pier (kN)
1	70R most eccentric	20% x 1000+10% x 1000 x 2				400	80.00
2	Class A most eccentric	20% x 554+10% x 554 x 2				222	44.32
3	70R + 1-Class A	(20% x 1000+10% x 1000 x 2) + 5% x 554 x 1 x 3				483	96.62
4	SV					0	0.00
5	3- Class A	(20% x 554+10% x 554 x 2)+ 5% x 554 x 1 x 3				305	60.94

Longitudinal Moment due to Braking force of live load

As per Cl:211.3 of IRC 6:2017. Braking force will act at a distance of 1.2m from road surface

Sl No.	Live Load combination	Longitudinal Moment due to Braking force	Force per pier	
1	70R most eccentric	=80.00×1.2	96.00	kNm
2	Class A most eccentric	=44.32×1.2	53.18	kNm
3	70R + 1-Class A	=96.62×1.2	115.94	kNm
4	SV		0.00	kNm
5	3- Class A	=60.94×1.2	73.13	kNm

2.6.5 Wind load

2.6.5.1 Wind without live load

Total Length of the superstructure		=	120	m
Width of Deck Slab		=	13.00	m

a) Wind Load on Superstructre

Height of the Crash barrier		=	1.10	m
Total depth of super str. exposed to wind	=2.38+2.5/100×(3.00+3.00+3.00/2)	=	2.380	m
Height of structure above ground level	=8.99+2.380+1.10	=	12.47	m

From *Table 12 of IRC:6-2017*

Hourly Mean Wind Speed - Plain terrain - For 12.465 m height		=	28.49	m/sec
Hourly Mean Wind Pressure		=	487.76	N/m^2
Basic Wind Speed Considered		=	33	m/sec

From *appendix A of IS:875 part-3*

Actual wind speed at the location of the structure			=	39.00	m/sec
Hourly Mean wind Pressure	=487.76×39^2/33^2	P_Z	=	681	N/m^2
Hourly Mean wind Speed	=28.49×39/33	V_Z	=	34	m/sec

1.Vertical Wind force As per Cl:209.3.5 of IRC 6-2017

			F_V	=	P_z . A_3 . G . C_L	
			A_3	=	Plan area	
			120×13.0	=	1560	m^2
Lift Coefficient			C_L	=	0.75	
Gust factor			G	=	2	
Total vertical Wind load	=681×1560×2×0.75/1000			=	**1594**	**kN**
			F_V	=	**1.02**	**kN/m²**
For End Girder-G1						
Exposed width for wind over girder-G1	=(2.00+3.00/2)			=	4	m
Load per meter run	=4×1.022			=	3.58	kN/m
			Say	=	***3.60***	***kN/m***
For Inner Girder-G2						
Exposed width for wind over girder-G2	=(3.00/2+3.00/2)			=	3.0	m
Load per meter run	=3.0×1.022			=	3.07	kN/m
			Say	=	***3.10***	***kN/m***
For Inner Girder-G3						
Exposed width for wind over girder-G3	=(3.00/2+3.00/2)			=	3.00	m
Load per meter run	=3.00×1.022			=	3.07	kN/m
			Say	=	***3.10***	***kN/m***
2.Transverse Wind Force	As per Cl:209.3.3 of IRC 6-2017					
			F_T	=	$P_Z.A_1.G.C_D$	
Where			A_1	=	Solid area	
Solid area (Exposed area in transverse dirction)	=(1.10+2.38)×120			=	418	m^2
			G	=	Gust factor	
				=	2	
			C_D	=	Drag Coefficient	
width/ depth	b/d	=13.00/(1.10+2.380)		=	3.74	
				=	1.413	
			C_D	=	2.12	

Total Transverse wind force	=681×417.6×2×2.12/1000	=	1206.1	kN
Total Transverse wind force per unit length	=1206.1/120	=	**10.05**	**kN/m**
Exposed area for end pier	=(30.00/2)×(2.38+1.10)	=	52.20	m^2
Exposed area for inner pier	=(30.00/2+30.00/2)×(2.38+1.10)	=	104.40	m^2
Transverse wind force on end pier	=681×52.20×2×2.12/1000	=	**150.8**	kN
Transverse wind force on inner pier	=681×104.40×2×2.12/1000	=	**301.5**	kN

3. Longitudinal Wind Force	F_L	= 25% of Transverse wind force			
Total Longitudinal wind force		=0.25×1206.1	=	301.5	kN
Longitudinal wind force on end pier		=0.25×150.8	=	**37.7**	**kN**
Longitudinal wind force on inner pier		=0.25×301.5	=	**75.4**	**kN**

b) **Wind force on Substructure**

End pier

Total height of Pier above Ground		=	8.99	m
Width of Pier		=	0.68	m
Transverse wind force on pier				
Effective Size of the pier	3.00	x	0.68	m

t/b	=3.00/0.68	=	4.41	
H/b	=8.99/0.68	=	13.21	
Exposed area	=8.99×0.68	=	6.11	m^2
Drag coefficent		=	0.90	
Transverse wind force on pier	=681×6.11×2×0.90/1000	=	**7.49**	kN
Longitudinal wind force on pier				
t/b	=0.68/3.00	=	0.23	
H/b	=8.99/3.00	=	3.00	
Exposed area	=8.99×3.00	=	26.96	
Drag coefficent		=	1.45	
Longitudinal wind force on pier	=681×26.96×2×1.45/1000	=	**53.24**	kN

Inner pier

Total height of Pier above Ground		=	8.99	m
Width of Pier		=	0.80	m
Transverse wind force on pier				
Effective Size of the pier	3.00	x	0.80	m
t/b	=3.00/0.80	=	3.75	
H/b	=8.99/0.80	=	11.23	
Exposed area	=8.99×0.80	=	7.19	m^2
Drag coefficent		=	0.90	
Transverse wind force on pier	=681×7.19×2×0.90/1000	=	**8.81**	kN
Longitudinal wind force on pier				
t/b	=0.80/3.00	=	0.27	
H/b	=8.99/3.00	=	3.00	
Exposed area	=8.99×3.00	=	26.96	
Drag coefficent		=	1.45	
Longitudinal wind force on pier	=681×26.96×2×1.45/1000	=	**53.24**	kN

2.6.5.2 Wind with live load

Total Length of the superstructure	=	120	m
Width of Deck Slab	=	13.0	m

a) Wind Load on Superstructre and Live Load

Height of the Crash barrier	=	1.10	m
Total depth of superstructure exposed to wind	=	2.380	m
Height of exposed structure above ground level	=	12.47	m
Height of vehicle	=	3	m
Exposed height of vehicle =3.00-1.10	=	1.90	m
Exposed height for Live Load =12.47+1.90	=	14.37	m
Distance of wind force due to live load from road surface	=	1.5	m
CG of super structure from top of the deck slab	=	0.68	m
Distance of wind force due to live load from CG of superstructure	=	2.256	m
=0.68+0.075+1.50			

From *Table 12 of IRC:6-2017*

Hourly Mean Wind Speed - Plain terrain

For Superstructure of 12.465 m height			=	28.49	m/sec
For Live Load of 14.365 m height			=	29.02	m/sec
Hourly Mean Wind Pressure					
For Superstructure			=	487.76	N/m^2
For Live Load			=	506.30	N/m^2
Basic Wind Speed Considered			=	33	m/sec

As per cl. 209.3 of IRC: 6 - 2017

wind speed considering live load over superstructure			=	39	m/sec
Hourly Mean wind Pressure					
For Superstructure	=488×39^2/33^2	P_Z	=	681	N/m^2
For Live Load	=506.30×39^2/33^2	P_Z	=	707	N/m^2

1. Vertical force As per Cl:209.3.5 of IRC 6-2014

		F_V	=	P_z . A_3 . G . C_L	
		A_3	=	Plan area	
		120×13.0	=	1560	m^2
Lift Coefficient		C_L	=	0.75	
Gust factor		G	=	2	
Total vertical Wind load	=707×1560×2×0.75/1000		=	**1655**	**kN**
(Maximum Pz is considered for conservative side.)		F_V	=	**1.061**	**kN/m^2**

For End Girder-G1

Exposed width for wind over girder-G1			=	4	m
Load per meter run	=4×1.061		=	3.71	kN/m
		Say	=	***3.80***	***kN/m***

For Inner Girder-G2

Exposed width for wind over girder-G2			=	3.0	m
Load per meter run	=3.0×1.061		=	3.18	kN/m
		Say	=	***3.20***	***kN/m***

For Inner Girder-G3

Exposed width for wind over girder-G3			=	3.00	m
Load per meter run	=3.0×1.061		=	3.18	kN/m
		Say	=	***3.20***	***kN/m***

2.Transverse Wind Force As per Cl:209.3.3 of IRC 6-2017

		F_T	=	$P_Z.A_1.G.C_D$	
Where		A_1	=	Solid area	
Solid area (Exposed area in transverse dirction)	=(2.380+1.10)×120		=	417.6	m^2
		G	=	Gust factor	
			=	2	
		C_D	=	Drag Coefficient	
width/ depth	b/d =13.0/(2.380+1.10)		=	3.74	
			=	1.41	

For Superstructure	C_D	=	2.12
For Live Load	C_D	=	1.20

For Superstructure

Total Transverse wind force	=681×417.6×2×2.12/1000	=	1206.1	kN
Total Transverse wind force per unit length	=1206.1/120	=	10.1	kN/m
Exposed area for end pier	*=(30.0/2)×(2.380+1.10)*	=	*52.200*	m^2
Exposed area for inner pier	*=(30.0/2+30.0/2)×(2.380+1.10)*	=	*104.400*	m^2
Transverse wind force on end pier	*=681×52.2×2.0×2.12/1000*	=	***150.8***	*kN*
Transverse wind force on inner pier	*=681×104.4×2.0×2.12/1000*	=	***301.5***	*kN*

For Live Load

Total Transverse wind force	=707×(1.90×120)×2×1.20/1000	=	387.0	kN
Total Transverse wind force per unit length	=387.0/120	=	3.225	kN/m
Exposed area of vehicle for end pier	*=(30.0/2)×1.90*	=	*28.500*	m^2
Exposed area vehicle for inner pier	*=(30.0/2+30.0/2)×1.90*	=	*57.000*	m^2
Trans. wind force due to live load on end pier	*=707×28.500×2×1.20/1000*	=	***48.4***	*kN*
Trans. wind force due to live load on inner pier	*=707×57.000×2×1.20/1000*	=	***96.7***	*kN*

Total Transverse wind force due to Super structure & live load	=10.1+3.2	=	**13.30**	**kN/m**
Transverse Moment due to wind due to live load on end pier	=48.4×2.256	=	**109.1**	**kNm**
Transverse Moment due to wind due to live load on inner pier	=96.7×2.256	=	**218.2**	**kNm**

3. Longitudinal Wind Force

F_L = 25% of Total transverse wind force due to super structure & due to live load

	=0.25×1206.1+0.25×387.0	=	398.3	kN
Longitudinal wind force on end pier	=0.25×150.8+0.25×48.4	=	**49.78**	**kN**
Longitudinal wind force on inner pier	=0.25×301.5+0.25×96.7	=	**99.6**	**kN**

b) **Wind force on Substructure**

End pier

Total height of Pier above Ground			=	8.99	m
Width of Pier			=	0.68	m
Transverse wind force on pier					
Effective Size of the pier		3.00	x	0.68	m
t/b	=3.00/0.68		=	4.41	
H/b	=8.99/0.68		=	13.21	
Exposed area	=8.99×0.68		=	6.11	m^2
Drag coefficent			=	0.90	
Transverse wind force on pier	=681×6.11×2×0.90/1000		=	**7.49**	kN
Longitudinal wind force on pier					
t/b	=0.68/3.00		=	0.23	
H/b	=8.99/3.00		=	3.00	
Exposed area	=8.99×3.00		=	26.96	
Drag coefficent			=	1.45	

Longitudinal wind force on pier	=681×26.96×2×1.45/1000		=	**53.24**	kN

Inner pier

Total height of Pier above Ground			=	8.99	m
Width of Pier			=	0.80	m
Transverse wind force on pier					
Effective Size of the pier		3.00	x	0.80	m
t/b	=3.00/0.80		=	3.75	
H/b	=8.99/0.80		=	11.23	
Exposed area	=8.99×0.80		=	7.19	m^2
Drag coefficent			=	0.90	
Transverse wind force on pier	=681×7.19×2×0.90/1000		=	**8.81**	kN
Longitudinal wind force on pier					
t/b	=0.80/3.00		=	0.27	
H/b	=8.99/3.00		=	3.00	
Exposed area	=8.99×3.00		=	26.96	
Drag coefficent			=	1.45	
Longitudinal wind force on pier	=681×26.96×2×1.45/1000		=	**53.24**	kN

2.6.6 Temperature load

As per Cl:215.2 of IRC 6-2017

Maximum air shade temperature			=	38.1	°C
Minimum air shade temperature			=	13.80	°C
Mean of minimum or maximum air shade temperature			=	+/-10	°C
Total variation in temperature		=38.1+13.80	=	51.90	°C
Mean variation of temperature		=51.90/2	=	25.95	°C
Temperature Rise	=38.1-25.95+10		**=**	**22.15**	**°C**
Temperature Fall	=13.80-25.95-10		**=**	**-22.15**	**°C**

2.6.7 Calculation of Seismic Forces

Horizontal Seismic Forces:

F_{eq} = A_h x (Dead Load + Appropriate Live Load)

A_h = Horizontal Seismic Coefficient

$$A_h = \frac{\left(\frac{Z}{2}\right) \left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)}$$

I = Importance factor

I = 1.2

Z = Zone Factor as given in table 5 (Interim Specifications)

Zone No = III

Z = 0.16

R = Response reduction factor

R = 3 It is proposed to provide ductile details of bridges as per section 17 of IRC: 112-2011, thus R= 3 shall be adopted.

$$T = 2.0 \sqrt{\frac{D}{1000\ F}}$$

F = Stiffness of structure as a whole

= In a STAAD model lateral forces of 100 kN are applied at all support nodes and the deflection at top is obtained from staad file.

= Then Stiffness of the whole structure = Force(5*100=500)/deflection.

2.6.7.1 Calculation of Seismic Coefficient - Transverse

Force applied at top = 5x100 kN		=	500	kN
Deflection at top		=	1.2115	mm
Stiffness of pier = F	=500/1.2115	=	**413**	KN/mm
Dead Load from Superstructure (DL + SIDL)		=	24240	kN
Live Load from Superstructure		=	997.2	kN
Weight of end pier	=(3.00×0.68×9.74)×25	=	496.74	kN
Weight of inner pier	=(3.00×0.80×9.74)×25	=	584.40	kN
Total of Dead+SIDL+Live load	D	=	**25237**	kN
Time period	T	=	0.495	sec
For soft soils (N<10)	S_a/g	=	2.500	
	A_h	=	0.0800	
For calculation purposes, seismic coefficient has been taken as			**0.0800**	

Calculation of seismic transverse forces on each pier

Due to Dead Load + SIDL	=24240×0.080/5	=	**387.8**	**kN**
Due to 70R most ecc	=(20/100)×(1000×1×3)×0.080/5	=	**9.60**	**kN**
Due to Class A most ecc	=(20/100)×(554×1×3)×0.080/5	=	**5.32**	**kN**
Due to 70R + 1 Class A		=	**14.92**	**kN**
Due to 3 lanes of Class A		=	**15.96**	**kN**
Due to DL of end pier (each)	=496.74×0.0800	=	**39.7**	**kN**
Due to DL of inner pier (each)	=584.4×0.0800	=	**46.8**	**kN**

2.6.7.2 Calculation of Seismic Coefficient - Longitudinal

Force applied at top = 5x100 kN		=	500	kN
Deflection at top		=	5.013	mm
Stiffness of pier = F =500/5.013		=	100	KN/mm
Dead Load from Superstructure (DL + SIDL)		=	24240	kN
Live Load from Superstructure		=	0	kN
Total of Dead+SIDL	D	=	**24240**	kN
	Time period T	=	0.986	sec
For soft soils (N<10)	S_a/g	=	1.379	
	A_h	=	0.0441	
For calculation purposes, seismic coefficient has been taken as			**0.044**	

Calculation of seismic longitudinal forces on each pier

Due to Dead Load + SIDL	=24240/5×0.044	=	**214.0**	kN
Due to DL of end pier(each)	=496.74×0.044	=	**21.9**	kN
Due to DL of inner pier(each)	=584.4×0.044	=	**25.8**	kN

2.6.8 Differential Shrinkage

As per Cl:7.7.2.1 of IRC 112-2011 & As per Cl: 7.4.3.5 of BS-5400 Part-3-1990

Hogging restraint moment due to differential shrinkage

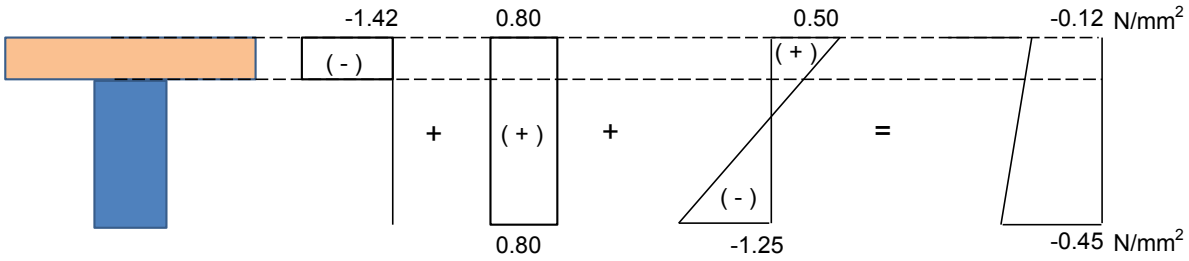
$$M_{cs} = \varepsilon_{diff} E_{cf} A_{cf} \alpha_{cent} \emptyset$$

Where

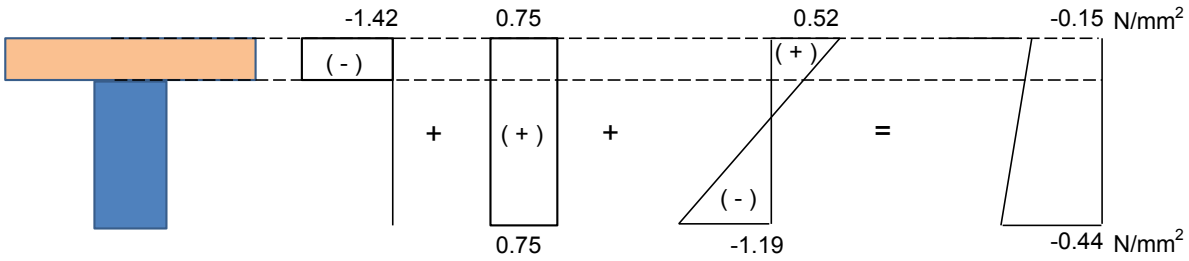
ε_{diff}	Differential shrinkage strain	=	0.0001
E_{cf}	Modulus of elasticity of the flange concrete.	=	33000 N/mm^2
A_{cf}	Area of the effective concrete flange.		
α_{cent}	Distance of the centroid of the concrete flange from the centroid of the composite section		
$\emptyset$	Reduction coeff to allow for creep, taken as 0.43.	=	0.43

Sectional properties at mid span of composite section of girder and slab

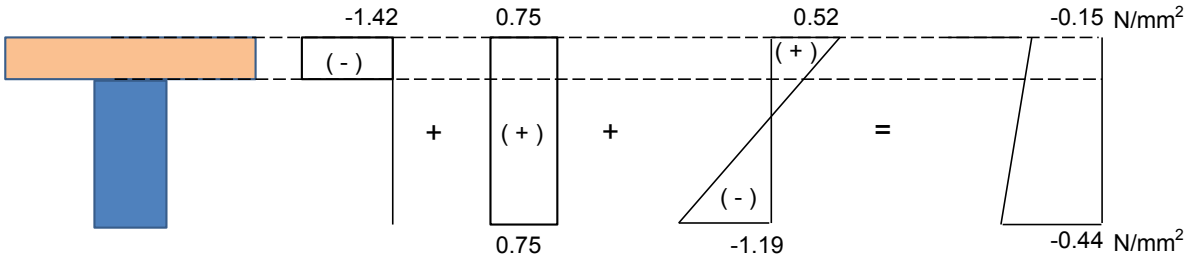
Descreption	Girder - G1	Girder - G2	Girder - G3
Depth of comp. section - in mm	2230	2230	2230
Effective flange width- in mm	3500	3000	3000
Flange thickness- in mm	230	230	230
Flange area- in mm^2	805000	690000	690000
Total area- in mm^2	1420000	1305000	1305000
Depth of NA from top of slab- in mm	635	681	681
Section Modulus Z_{Top} - in mm^3	1190376919	1059786135	1059786135
Section Modulus Z_{Bottom} - in mm^3	474120039	465963017	465963017
Force in kN =(0.0001×33000×0.43×805000)/1000	1142	979	979
α_{cent} - in mm =635-230/2	520	566	566
Moment in kNm =1142.295×(520.200/1000)	594	554	554
Say	**595**	**555**	**555**



Stresses due to Differential Shrinkage For Girder - G1



Stresses due to Differential Shrinkage For Girder - G2



Stresses due to Differential Shrinkage For Girder - G3

2.6.9 Differential settlement

The support settlement considered is 6mm. For deriving the forces due to this effect long term modulus of elasticity has been considered as 50% of short term modulus of elasticity.

2.6.10 Temperature Gradient

2.6.10.1 Stress Calculations due to Positive Temperature Differences - For Girder G1

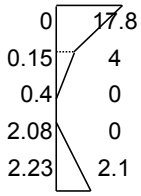
(Ref: Fig 10 (a) of IRC:6-2014)

h = 2230 mm h_2 = 250 mm

h_1 = 150 mm h_3 = 150 mm

Thermal Expansion of concrete = 1.20E-05 / °C Young's Modulus = 17000 Mpa

Fiber No	Dist. Of fiber from the top	Temperature at fiber	Width of fiber	Stress due temp. resistance	Force	Total force between fibers	CG of Force from top of Slab	Moment of force about Top of Slab
units		°C	m	MPa	MN/m	MN	m	MN-m
1	0	17.80	3.500	3.631	12.709	0	0.000	0.000
2	0.150	4.00	3.500	0.816	2.856	1.167	0.059	0.069
3	0.230	2.72	3.500	0.555	1.942	0.192	0.187	0.036
4	0.230	2.72	0.450	0.555	0.250	0.000	0.230	0.000
5	0.250	2.40	0.450	0.490	0.220	0.005	0.240	0.001
6	0.330	1.12	0.450	0.228	0.103	0.013	0.285	0.004
7	0.330	1.12	0.250	0.228	0.057	0.000	0.330	0.000
8	1.100	0.00	0.250	0.000	0.000	0.022	0.587	0.013
9	0.198	3.23	0.250	0.659	0.165	-0.018	0.259	-0.005
10	0.198	3.23	0.550	0.659	0.363	0.000	0.198	0.000
11	2.080	0.00	0.550	0.000	0.000	0.341	0.825	0.282
12	2.230	2.10	0.550	0.428	0.236	0.018	2.130	0.038



	Sum	=	0.437	MN-m
Total force	=SUM(0:0.018)	=	1.7402	MN
		=	**1740.2**	**kN**
Cg of force from the top of the section	=0.437/1.7	=	0.251	m
CG of the section from top		=	0.635	m
Moment due to temp. effect	=1.740×(0.635-0.251)	=	0.668	MN-m
		=	**668**	**kN-m**

Sectional Properties

Depth	m	2.230
Area	(m^2)	1.420
Section Modulus from Top of Slab Zt	(m^3)	0.828
Section Modulus from bottom of Girder Zb	(m^3)	0.756

Location	Stress (N/mm^2) due to resisting force	Stress (N/mm^2) due to Equivalent force	Stress (N/mm^2) due to Moment	Stress (N/mm^2)
Top of Slab	3.631	-1.225	-0.806	1.600
Bottom of Girder	0.428	-1.225	0.883	0.086

2.6.10.2 Stress Calculations due to Negative Temperature Differences - For Girder G1

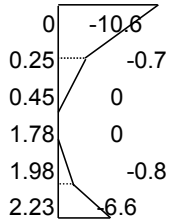
(Ref: Fig 10 (a) of IRC:6-2014)

h = 2230 mm h_2 = 200 mm h_4 = 250 mm

h_1 = 250 mm h_3 = 200 mm

Thermal Expansion for concrete = 1.20E-05 / °c Young's Modulus = 17000 Mpa

Fiber No	Dist. Of fiber from the top	Temp. at fiber	Width of fiber	Stress due temp. resistance	Force	Total force between fibers	CG of Force from top of slab	Moment of force about Top of Slab
units	m	°c	m	Mpa	MN/m	MN	m	MN-m
1	0.000	-10.600	3.500	-2.162	-7.568	0	0.000	0.000
2	0.150	-4.660	3.500	-0.951	-3.327	-0.817	0.065	-0.053
3	0.230	-1.492	3.500	-0.304	-1.065	-0.176	0.183	-0.032
4	0.230	-1.492	0.450	-0.304	-0.137	0.000	0.230	0.000
5	0.250	-0.700	0.450	-0.143	-0.064	-0.002	0.239	0.000
6	0.330	-0.420	0.450	-0.086	-0.039	-0.004	0.287	-0.001
7	0.330	-0.420	0.250	-0.086	-0.021	0.000	0.330	0.000
8	1.100	0.000	0.250	0.000	0.000	-0.008	0.587	-0.005
9	0.198	-2.759	0.250	-0.563	-0.141	0.063	0.499	0.032
10	0.198	-2.759	0.550	-0.563	-0.310	0.000	0.198	0.000
11	2.080	-3.120	0.550	-0.636	-0.350	-0.325	1.120	-0.364
12	2.229	-6.577	0.550	-1.342	-0.738	-0.081	2.146	-0.174
13	2.230	-6.600	0.550	-1.346	-0.741	-0.001	2.229	-0.002



		Sum	=	-0.600 MN-m
Total force			=	-1.3506 MN
			=	**-1350.6 kN**
Cg of force from the top of the section	=-0.600/-1.351		=	0.4442 m
CG of the section from top			=	0.635 m
Moment due to temp. effect	=-1.351×(0.635-0.4442		=	-0.25775 MN-m
			=	**-258 kN-m**

Sectional Properties

Depth	m	2.230
Area	(m^2)	1.420
Section Modulus from Top of Slab Zt	(m^3)	0.828
Section Modulus from bottom of Girder Zb	(m^3)	0.756

Location	Stress (N/mm^2) due to resisting force	Stress (N/mm^2) due to Equivalent force	Stress (N/mm^2) due to Moment	Combined Stress (N/mm^2)
Top of Slab	-2.162	0.951	0.311	-0.900
Bottom of Girder	-1.346	0.951	-0.341	-0.736

2.6.10.3 Stress Calculations due to Positive Temperature Differences - For Girder G2

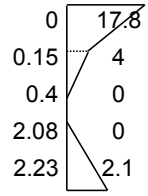
(Ref: Fig 10 (a) of IRC:6-2014)

h = 2230 mm h_2 = 250 mm

h_1 = 150 mm h_3 = 150 mm

Thermal Expansion of concrete = 1.20E-05 / °c Young's Modulus = 17000 Mpa

Fiber No	Dist. Of fiber from the top	Temperature at fiber	Width of fiber	Stress due temp. resistance	Force	Total force between fibers	CG of Force from top of Slab	Moment of force about Top of Slab
units		°c	m	MPa	MN/m	MN	m	MN-m
1	0	17.80	3.000	3.631	10.894	0	0.000	0.000
2	0.150	4.00	3.000	0.816	2.448	1.001	0.059	0.059
3	0.230	2.72	3.000	0.555	1.665	0.165	0.187	0.031
4	0.230	2.72	0.450	0.555	0.250	0.000	0.230	0.000
5	0.250	2.40	0.450	0.490	0.220	0.005	0.240	0.001
6	0.330	1.12	0.450	0.228	0.103	0.013	0.285	0.004
7	0.330	1.12	0.250	0.228	0.057	0.000	0.330	0.000
8	1.100	0.00	0.250	0.000	0.000	0.022	0.587	0.013
9	0.198	3.23	0.250	0.659	0.165	-0.018	0.259	-0.005
10	0.198	3.23	0.550	0.659	0.363	0.000	0.198	0.000
11	2.080	0.00	0.550	0.000	0.000	0.341	1.453	0.496
12	2.230	2.10	0.550	0.428	0.236	0.018	2.130	0.038



		Sum	= 0.637	MN-m
Total force		=SUM(0:0.018)	= 1.546	MN
			= **1546.0**	**kN**
Cg of force from the top of the section		=0.637/1.5	= 0.412	m
CG of the section from top			= 0.681	m
Moment due to temp. effect		=1.546×(0.681-0.41	= 0.416	MN-m
			= **416**	**kN-m**

Sectional Properties

Depth	m	2.230
Area	(m^2)	1.115
Section Modulus from Top of Slab Zt	(m^3)	0.750
Section Modulus from bottom of Girder Zb	(m^3)	0.356

Location	Stress (N/mm^2) due to resisting force	Stress (N/mm^2) due to Equivalent force	Stress (N/mm^2) due to Moment	Combined Stress (N/mm^2)
Top of Slab	3.631	-1.387	-0.555	1.689
Bottom of Girder	0.428	-1.387	1.170	0.212

2.6.10.4 Stress Calculations due to Negative Temperature Differences - For Girder G2

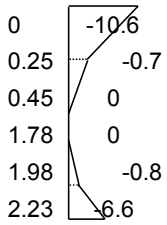
(Ref: Fig 10 (a) of IRC:6-2014)

h = 2230 mm h_2 = 200 mm h_4 = 250 mm

h_1 = 250 mm h_3 = 200 mm

Thermal Expansion for concrete = 1.20E-05 / °c Young's Modulus = 17000 Mpa

Fiber No	Dist. Of fiber from the top	Temp. at fiber	Width of fiber	Stress due temp. resistance	Force	Total force between fibers	CG of Force from top of slab	Moment of force about Top of Slab
units	m	°c	m	Mpa	MN/m	MN	m	MN-m
1	0.000	-10.600	3.000	-2.162	-6.487	0	0.000	0.000
2	0.150	-4.660	3.000	-0.951	-2.852	-0.700	0.065	-0.046
3	0.230	-1.492	3.000	-0.304	-0.913	-0.151	0.183	-0.028
4	0.230	-1.492	0.450	-0.304	-0.137	0.000	0.230	0.000
5	0.250	-0.700	0.450	-0.143	-0.064	-0.002	0.239	0.000
6	0.330	-0.420	0.450	-0.086	-0.039	-0.004	0.287	-0.001
7	0.330	-0.420	0.250	-0.086	-0.021	0.000	0.330	0.000
8	1.100	0.000	0.250	0.000	0.000	-0.008	0.587	-0.005
9	0.198	-2.759	0.250	-0.563	-0.141	0.063	0.499	0.032
10	0.198	-2.759	0.550	-0.563	-0.310	0.000	0.198	0.000
11	2.080	-3.120	0.550	-0.636	-0.350	-0.325	1.120	-0.364
12	2.229	-6.577	0.550	-1.342	-0.738	-0.081	2.146	-0.174
13	2.230	-6.600	0.550	-1.346	-0.741	-0.001	2.229	-0.002



Sum = -0.588 MN-m

Total force = -1.2088 MN

= **-1208.8 kN**

Cg of force from the top of the section =-0.588/-1.209 = 0.4862 m

CG of the section from top = 0.681 m

Moment due to temp. effect =-1.209×(0.681-0.48 = -0.235 MN-m

= **-235 kN-m**

Sectional Properties

Depth	m	2.230
Area	(m^2)	1.115
Section Modulus from Top of Slab Zt	(m^3)	0.750
Section Modulus from bottom of Girder Zb	(m^3)	0.356

Location	Stress (N/mm^2) due to resisting force	Stress (N/mm^2) due to Equivalent force	Stress (N/mm^2) due to Moment	Combined Stress (N/mm^2)
Top of Slab	-2.162	1.084	0.314	-0.764
Bottom of Girder	-1.346	1.084	-0.662	-0.924

4 Design of Girder

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4.1 Self-Weight of Girder

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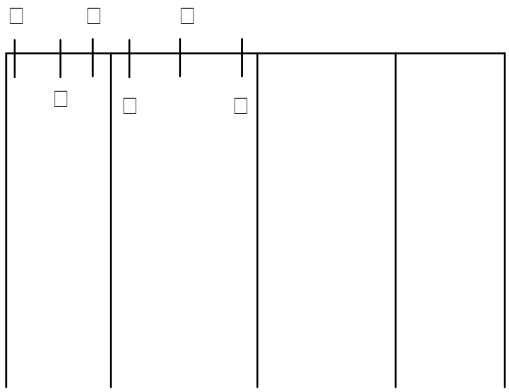


4.2 Design for service condition

The □□□ □ary o□the □oad□ and moments □or the □rd□r□ ar□ □a□□n □ro□ the STAAD o□p□□ and pr□□□n□d be □ow.

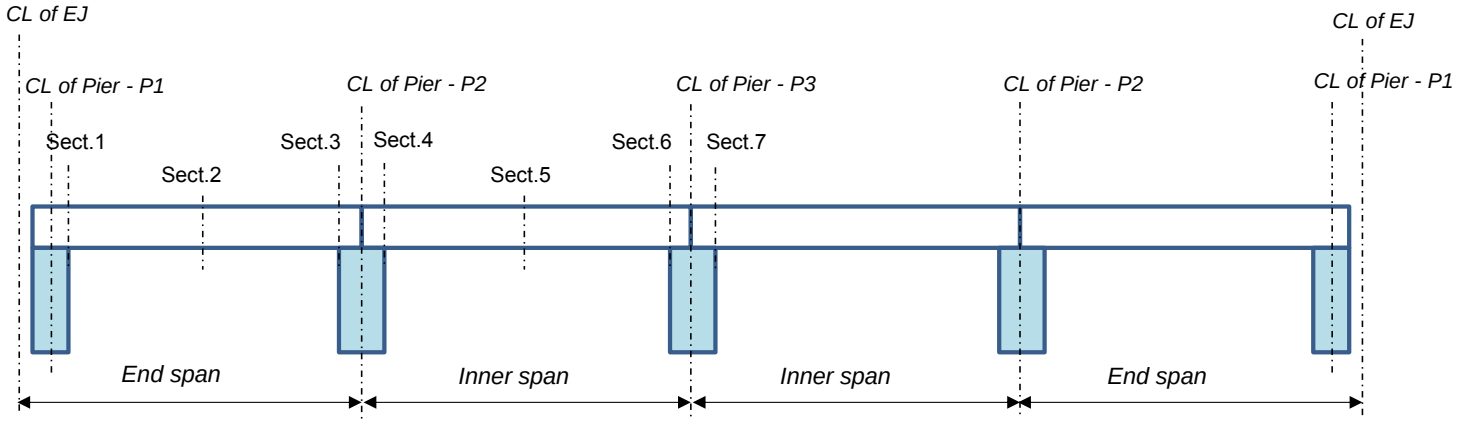
Figu **r**e 4**-**1 **S**chematic **S**ketch **S**howing **L**ocation of **S**ections fo **r M**oments an **d** □o**r**ces

S□□□on	D□□an□□
1	0. □9m □ro□ □nd p□□r
2	15.0m □ro□ □nd p□□r
□	1□□□ □ro□ □nn□r p□□r
4	1□□m □ro□ □nn□r p□□r
5	15□□m □ro□ □nn□r p□□r
6	1.0m □ro□ inner p□□r

3 Staad Results and load combination for Girder 1

Effective length

For end Span		=	30.000 m	
For inner Span		=	30.00 m	
Effective length considered for impact factor calculation		=	30.000 m	
Impact factor for live load	For Class A		1.125	As per Cl: 208.2 of IRC 6-2017
	For 70R wheeled		1.162	As per Cl: 208.3 of IRC 6-2017



Typical Span arrangement showing sections

As per Clause 7.7.2.2 of IRC 112 -2011

Cross Sectional Area Ac	=	615000	mm^2
Perimeter u	=	5034	mm
Notional Size , h = 2Ac/u	=	244	mm
Creep coeff. at 90 days RH	=	80	%
Creep coefficient ϕ	=	1.358	
Reduction coefficient $\alpha 1$	=	0.75	
Moment due to Creep $M_{cr} = (M_{inst.} - M_{as\text{-}built})\ \alpha_1$	=	107.8	kNm

Table -6.9 of IRC 112.2011

t = 90 days	
size	Creep
50	1.5
150	1.4
600	1.2

3.1 *Summary of forces from staad for girder G - 1*

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
1	Dead load DL												
1.1	DL of Girder over temp. support	0	1578	0	0	1578	0	0	0	0	0	0	0
1.2	DL of Girder reaction	-92	907	-1197	-1140	520	-833	-832	-180	258	-226	204	-204
1.3	DL of Diaphragm	0	0	1	1	0	0	0	0	0	0	0	0
1.4	DL of Deck slab	15	1225	-1524	-1517	651	-1052	-1051	-227	335	-293	261	-260
	Total Dead load	-77	3710	-2721	-2656	2749	-1885	-1883	-407	593	-520	465	-465
2	Super Imposed Dead load SIDL												
2.1	Crash barrier CB	-419	744	-1113	-1048	548	-911	-911	-213	253	-235	225	-225
2.2	Wearing Coat WC	19	309	-379	-379	159	-256	-256	-55	83	-72	63	-63
3	Differential Settlement DS	20	212	-442	-443	40	-523	-523	-16	16	-34	34	-34
4	Live load (without impact)												
4.1	LL 70 R _ Most ecc	-481	2199	-1872	-1557	1833	-1475	-1492	-444	469	-477	438	-472
4.2	LL Class A _ Most ecc	-572	1491	-1648	-1407	1227	-1382	-1340	-334	415	-355	394	-353
4.3	LL 1_Class A for 70 R	-596	2232	-2223	-1737	1736	-1879	-1595	-371	497	-406	440	-403
4.4	LL 3 Class A	-181	1990	-1841	-1690	1508	-1509	-1498	-348	440	-385	411	-381
5	Live load With impact	As per clause: 208 of IRC 6-2017											
5.1	LL 70 R _ Most ecc	-559	2554	-2174	-1809	2129	-1713	-1733	-515	544	-555	509	-549
5.2	LL Class A _ Most ecc	-643	1678	-1854	-1583	1380	-1555	-1507	-376	467	-399	443	-397
5.3	LL 1_Class A for 70 R	-604	2260	-2251	-1759	1758	-1902	-1615	-376	504	-411	446	-408
5.4	LL 3 Class A	-203	2239	-2071	-1901	1696	-1698	-1685	-391	495	-433	462	-429
6	Braking force												
6.1	LL 70 R _ Most ecc	-58	-4	59	-57	2	61	-61	-3	-4	-4	-4	-4
6.2	LL Class A _ Most ecc	-32	-2	33	-32	1	34	-34	-2	-2	-2	-2	-2
6.3	LL 70R+1 Class A	-70	-5	71	-69	2	74	-74	-4	-5	-5	-5	-5
6.4	LL 4 Class A	-44	-3	45	-44	2	47	-47	-2	-3	-3	-3	-3

7	Wind load WL												
7.1	Wind load downwards 28.5 m/sec	-71	237	-192	-353	125	-123	-241	-48	57	-60	44	-52
7.2	Wind load downwards 29 m/sec	-51	224	-202	-324	118	-130	-223	-44	55	-56	43	-49
8	Temperature												
8.1	Temperature Rise	-148	-33	111	-41	-11	23	20	-7	-10	-2	-2	2
8.2	Temperature Fall	148	33	-111	41	11	-23	-20	7	10	2	2	-2
9	Differential shrinkage	576	201	-153	-126	-36	59	55	26	25	-6	-7	6
10	Creep	Reduction factor for creep = 0.75 as per Clause 7.7.2.2 of IRC 112 -2011											
	DL of girder with composite action	52	965	-1184	-1184	499	-804	-803					
	Moment due to Creep $M_{cr} = (M_{inst.} - M_{as\text{-}built})\ \alpha_1$	108	-1140	10	-33	-1199	22	22					
11	Seismic force												
11.1	Long.Seismic DL+SIDL	-122	-4	133	-136	2	141	-141	-7	-10	-10	-10	-10
11.2	Trans. Seismic DL+SIDL	9	-3	-14	4	-1	-6	-6	1	1	0	0	0
11.3	Trans. Seismic 70 R_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
11.4	Trans. Seismic Class A_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
11.5	Trans. Seismic 70R+2 CLASS A	0	0	-1	0	0	0	0	0	0	0	0	0
11.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
11.7	Trans. Seismic 4 Class A	0	0	-1	0	0	0	0	0	0	0	0	0
12	Temperature Gradient												
12.1	Positive Gradient	580	193	-161	-113	-32	52	49	27	25	-5	-6	6
12.2	Reverse Gradient	-236	-81	71	44	12	-20	-19	-10	-11	2	2	-2

3.1.1 Load Combination Ultimate Limit State for Girder G 1

As per Table B.2 IRC 6 :2017

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
	Basic combination												
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9											
	Except Live load												
100	1.35 DL+ 1.75 SIDL+0.9 WL 36m/sec	-700.7	6767.6	-6011.2	-5982.3	4841.5	-4333.9	-4437.3	-977.2	1337.7	-1199.5	1082.6	-1089.6
	Including live load												
101	LC 100 + 1.5 x LL 5.1 + 1.5 x LL 6.1	-1627.0	10592.8	-9184.0	-8781.3	8037.6	-6812.1	-7128.2	-1755.3	2147.6	-2037.5	1840.3	-1918.7
102	LC 100 + 1.5 x LL 5.2 + 1.5 x LL 6.2	-1714.3	9280.3	-8742.4	-8405.0	6913.6	-6615.8	-6749.0	-1543.2	2034.7	-1801.9	1743.4	-1688.6
103	LC 100 + 1.5 x LL 5.3 + 1.5 x LL 6.3	-1711.5	10149.3	-9280.8	-8725.0	7482.1	-7076.3	-6970.1	-1546.9	2085.1	-1823.8	1744.0	-1709.6
104	LC 100 + 1.5 x LL 5.4 + 1.5 x LL 6.4	-1071.9	10121.2	-9049.5	-8899.4	7387.8	-6810.9	-7035.1	-1567.9	2075.5	-1854.3	1771.1	-1737.6
	II.Wind load leading 28.5m/sec	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15											

	Except Live load												
110	1.35 DL+ 1.75 SIDL+1.5 WL 28.5m/sec	-743.5	6909.8	-6126.3	-6194.3	4916.7	-4407.7	-4581.9	-1006.0	1371.6	-1235.6	1108.9	-1120.9
	Including live load												
111	LC 110 + 1.15 x LL 5.1 + 1.15 x LL 6.1	-1453.7	9842.5	-8558.8	-8340.2	7367.1	-6307.6	-6645.0	-1602.6	1992.6	-1878.1	1689.9	-1756.5
112	LC 110 + 1.15 x LL 5.2 + 1.15 x LL 6.2	-1520.6	8836.2	-8220.3	-8051.8	6505.4	-6157.1	-6354.2	-1440.0	1906.0	-1697.4	1615.5	-1580.1
113	LC 110 + 1.15 x LL 5.3 + 1.15 x LL 6.3	-1518.5	9502.5	-8633.0	-8297.1	6941.2	-6510.2	-6523.8	-1442.9	1944.7	-1714.3	1616.1	-1596.2
114	LC 110 + 1.15 x LL 5.4 + 1.15 x LL 6.4	-1028.1	9480.9	-8455.7	-8430.8	6868.9	-6306.7	-6573.5	-1458.9	1937.3	-1737.7	1636.8	-1617.7
	II.A. Wind load leading 29m/sec												
115	1.35 DL+ 1.75 SIDL+1.5 WL 29m/sec	-713.2	6890.1	-6141.7	-6150.8	4905.6	-4417.7	-4554.6	-1000.5	1369.3	-1229.7	1106.8	-1116.2
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5											
	Seismic longitudinal Case												
	Except Live load												
116	1.35 DL+ 1.75 SIDL+1.5 Long.Seismic	-818.8	6549.1	-5638.3	-5868.8	4732.1	-4012.1	-4431.6	-944.6	1272.3	-1159.7	1028.6	-1057.2
	Including live load												
117	LC 116 + 0.2 x LL 5.1 + 0.2 x LL 6.1	-942.3	7059.1	-6061.4	-6242.0	5158.2	-4342.5	-4790.4	-1048.4	1380.3	-1271.5	1129.7	-1167.7
118	LC 116 + 0.2 x LL 5.2 + 0.2 x LL 6.2	-953.9	6884.1	-6002.5	-6191.9	5008.4	-4316.4	-4739.8	-1020.1	1365.3	-1240.0	1116.7	-1137.0
119	LC 116 + 0.2 x LL 5.4 + 0.2 x LL 6.4	-868.3	6996.2	-6043.5	-6257.8	5071.6	-4342.4	-4778.0	-1023.4	1370.7	-1247.0	1120.4	-1143.6
	Seismic Transverse Case												
	Except Live load												
120	1.35 DL+ 1.75 SIDL+1.5 Trans.Seismic	-622.4	6550.2	-5860.0	-5657.9	4727.1	-4232.5	-4229.6	-932.5	1288.1	-1144.7	1043.6	-1043.4
	Including live load												
121	LC 120 + 0.2 x LL 5.1 + 0.2 x LL 6.1 + 1.5 x LL 11.3	-745.5	7060.2	-6283.6	-6030.9	5153.2	-4563.2	-4588.7	-1036.2	1396.1	-1256.4	1144.6	-1153.9
122	LC 120 + 0.2 x LL 5.2 + 0.2 x LL 6.2 + 1.5 x LL 11.4	-757.3	6885.2	-6224.5	-5980.8	5003.3	-4536.9	-4538.0	-1007.9	1381.0	-1225.0	1131.7	-1123.2
123	LC 120 + 0.2 x LL 5.3 + 0.2 x LL 6.3 + 1.5 x LL 11.5	-756.6	7001.0	-6296.8	-6023.3	5079.1	-4598.5	-4567.7	-1008.4	1387.8	-1227.9	1131.8	-1126.0
124	LC 120 + 0.2 x LL 5.4 + 0.2 x LL 6.4 + 1.5 x LL 11.7	-671.3	6997.2	-6266.0	-6046.6	5066.5	-4563.2	-4576.4	-1011.2	1386.5	-1232.0	1135.4	-1129.8

Summary of load combination Ultimate Limit State for Girder G 1

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
Basic combination												
I. Live load leading	-1714	10593	-9281	-8899	8038	-7076	-7128	-1755	2148	-2038	1840	-1919
II. Wind load leading 28.5m/sec	-1521	9842	-8633	-8431	7367	-6510	-6645	-1603	1993	-1878	1690	-1756
II.A. Wind load leading 29m/sec	-713	6890	-6142	-6151	4906	-4418	-4555	-1000	1369	-1230	1107	-1116
Seismic combination												
Seismic longitudinal Case	-954	7059	-6074	-6258	5158	-4378	-4790	-1048	1380	-1271	1130	-1168
Seismic Transverse Case	-757	7060	-6297	-6047	5153	-4599	-4589	-1036	1396	-1256	1145	-1154
Design Forces	**-1714**	**10593**	**-9281**	**-8899**	**8038**	**-7076**	**-7128**	**-1755**	**2148**	**-2038**	**1840**	**-1919**

3.1.2 Load Combination Serviceability Limit State for Girder G 1

As per Table B.3 IRC 6 :2017

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
	Rare Combination												
	I. Live load leading with Wind	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage & creep -1											
	Except Live load												
200	1 DL+ 1 SIDL+1 DS +0.6 WL 28.5m/sec.+Diff. shrinkage + creep	187.5	4240.9	-4988.8	-4973.1	2367.3	-3619.4	-3691.9	-705.2	1020.1	-917.8	820.4	-825.4
	Including live load												
201	LC 200 + 1 x LL 5.1 + 1 x LL 6.1	-430.1	6791.0	-7104.0	-6839.1	4498.1	-5271.5	-5485.8	-1224.0	1560.1	-1476.5	1325.6	-1378.1
202	LC 200 + 1 x LL 5.2 + 1 x LL 6.2	-488.3	5916.0	-6809.7	-6588.3	3748.7	-5140.6	-5233.0	-1082.6	1484.9	-1319.4	1260.9	-1224.7
203	LC 200 + 1 x LL 5.3 + 1 x LL 6.3	-486.4	6495.3	-7168.6	-6801.6	4127.8	-5447.6	-5380.4	-1085.1	1518.5	-1334.0	1261.4	-1238.7
204	LC 200 + 1 x LL 5.4 + 1 x LL 6.4	-60.0	6476.6	-7014.4	-6917.9	4064.9	-5270.7	-5423.7	-1099.1	1512.0	-1354.4	1279.4	-1257.4
	IA. Live load leading with Temp Rise	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Temp-0.6, Shrinkage & creep -1											
	Except Live load												
205	1 DL+ 1 SIDL+1 DS +0.6 Temp Rise.+Diff. shrinkage+ creep	230.4	4098.7	-4873.7	-4761.0	2292.1	-3545.6	-3547.3	-676.4	986.2	-881.7	794.0	-794.2

	Including live load												
206	LC 205 + 1 x LL 5.1 + 1 x LL 6.1	-387.2	6648.8	-6988.9	-6627.0	4422.8	-5197.8	-5341.2	-1195.1	1526.2	-1440.4	1299.2	-1346.8
207	LC 205 + 1 x LL 5.2 + 1 x LL 6.2	-445.4	5773.8	-6694.5	-6376.2	3673.5	-5066.8	-5088.4	-1053.8	1450.9	-1283.3	1234.5	-1193.5
208	LC 205 + 1 x LL 5.3 + 1 x LL 6.3	-443.6	6353.1	-7053.4	-6589.6	4052.5	-5373.9	-5235.8	-1056.2	1484.5	-1297.9	1235.0	-1207.5
209	LC 205 + 1 x LL 5.4 + 1 x LL 6.4	-17.1	6334.4	-6899.2	-6705.8	3989.6	-5196.9	-5279.1	-1070.2	1478.1	-1318.2	1253.0	-1226.2
	IB. Live load leading with Temp Fall												
	Except Live load												
210	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	230.4	4098.7	-4873.7	-4761.0	2292.1	-3545.6	-3547.3	-676.4	986.2	-881.7	794.0	-794.2
	Including live load												
211	LC 210 + 1 x LL 5.1 + 1 x LL 6.1	-387.2	6648.8	-6988.9	-6627.0	4422.8	-5197.8	-5341.2	-1195.1	1526.2	-1440.4	1299.2	-1346.8
212	LC 210 + 1 x LL 5.2 + 1 x LL 6.2	-445.4	5773.8	-6694.5	-6376.2	3673.5	-5066.8	-5088.4	-1053.8	1450.9	-1283.3	1234.5	-1193.5
213	LC 210 + 1 x LL 5.3 + 1 x LL 6.3	-443.6	6353.1	-7053.4	-6589.6	4052.5	-5373.9	-5235.8	-1056.2	1484.5	-1297.9	1235.0	-1207.5
214	LC 210 + 1 x LL 5.4 + 1 x LL 6.4	-17.1	6334.4	-6899.2	-6705.8	3989.6	-5196.9	-5279.1	-1070.2	1478.1	-1318.2	1253.0	-1226.2
	IC. Live load leading with Positive Gradient												
	Except Live load												
215	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	230.4	4098.7	-4873.7	-4761.0	2292.1	-3545.6	-3547.3	-676.4	986.2	-881.7	794.0	-794.2
	Including live load												
216	LC 215 + 1 x LL 5.1 + 1 x LL 6.1	-387.2	6648.8	-6988.9	-6627.0	4422.8	-5197.8	-5341.2	-1195.1	1526.2	-1440.4	1299.2	-1346.8
217	LC 215 + 1 x LL 5.2 + 1 x LL 6.2	-445.4	5773.8	-6694.5	-6376.2	3673.5	-5066.8	-5088.4	-1053.8	1450.9	-1283.3	1234.5	-1193.5
218	LC 215 + 1 x LL 5.3 + 1 x LL 6.3	-443.6	6353.1	-7053.4	-6589.6	4052.5	-5373.9	-5235.8	-1056.2	1484.5	-1297.9	1235.0	-1207.5
219	LC 215 + 1 x LL 5.4 + 1 x LL 6.4	-17.1	6334.4	-6899.2	-6705.8	3989.6	-5196.9	-5279.1	-1070.2	1478.1	-1318.2	1253.0	-1226.2
	ID. Live load leading with Reverse Gradient												
	Except Live load												
220	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	230.4	4098.7	-4873.7	-4761.0	2292.1	-3545.6	-3547.3	-676.4	986.2	-881.7	794.0	-794.2
	Including live load												
221	LC 220 + 1 x LL 5.1 + 1 x LL 6.1	-387.2	6648.8	-6988.9	-6627.0	4422.8	-5197.8	-5341.2	-1195.1	1526.2	-1440.4	1299.2	-1346.8
222	LC 220 + 1 x LL 5.2 + 1 x LL 6.2	-445.4	5773.8	-6694.5	-6376.2	3673.5	-5066.8	-5088.4	-1053.8	1450.9	-1283.3	1234.5	-1193.5
223	LC 220 + 1 x LL 5.3 + 1 x LL 6.3	-443.6	6353.1	-7053.4	-6589.6	4052.5	-5373.9	-5235.8	-1056.2	1484.5	-1297.9	1235.0	-1207.5
224	LC 220 + 1 x LL 5.4 + 1 x LL 6.4	-17.1	6334.4	-6899.2	-6705.8	3989.6	-5196.9	-5279.1	-1070.2	1478.1	-1318.2	1253.0	-1226.2
	II. Wind load leading - 28.5 m/sec	Partial safety factor		DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Wind-1 , Live load -0.75,Shrinkage & creep -1									
	Except Live load												
225	1 DL+ 1 SIDL+1 DS+1 WL 28.5 m/sec+Diff. shrinkage	158.9	4335.7	-5065.6	-5114.5	2417.5	-3668.5	-3788.3	-724.5	1042.8	-941.9	838.0	-846.2
	Including live load												

226	LC 225 + 0.75 x LL 5.1 + 0.75 x LL 6.1	-304.2	6248.3	-6652.0	-6514.0	4015.6	-4907.6	-5133.7	-1113.5	1447.8	-1360.9	1216.8	-1260.7
227	LC 225 + 0.75 x LL 5.2 + 0.75 x LL 6.2	-347.9	5592.0	-6431.2	-6325.9	3453.6	-4809.4	-4944.1	-1007.5	1391.3	-1243.1	1168.4	-1145.7
228	LC 225 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-346.5	6026.5	-6700.4	-6485.9	3737.8	-5039.7	-5054.7	-1009.4	1416.5	-1254.1	1168.7	-1156.2
229	LC 225 + 0.75 x LL 5.4 + 0.75 x LL 6.4	-26.7	6012.5	-6584.8	-6573.1	3690.7	-4907.0	-5087.1	-1019.9	1411.7	-1269.3	1182.2	-1170.2
	II.A. Wind load leading 29 m/sec												
230	1 DL+ 1 SIDL+1 DS+1 WL - 29 m/sec+Diff. shrinkage+ creep	179.1	4322.5	-5075.8	-5085.5	2410.1	-3675.2	-3770.1	-720.8	1041.2	-938.0	836.5	-843.1
	III. Temperature load leading	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75,Shrinkage & creep -1											
	Temperature rise Case												
	Except Live load												
231	1 DL+ 1 SIDL+1 DS+ 1 Temp. rise +Diff. shrinkage + creep	82.6	4066.0	-4762.3	-4802.0	2280.8	-3522.7	-3527.5	-683.2	975.9	-883.6	791.6	-791.9
	Including live load												
232	LC 231 + 0.75 x LL 5.1 + 0.75 x LL 6.1	-380.5	5978.6	-6348.7	-6201.5	3878.8	-4761.9	-4872.9	-1072.2	1380.9	-1302.7	1170.4	-1206.4
233	LC 231 + 0.75 x LL 5.2 + 0.75 x LL 6.2	-424.2	5322.3	-6127.9	-6013.4	3316.8	-4663.7	-4683.3	-966.2	1324.5	-1184.8	1122.0	-1091.4
234	LC 231 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-422.8	5756.9	-6397.0	-6173.4	3601.1	-4893.9	-4793.9	-968.0	1349.7	-1195.8	1122.3	-1101.9
235	LC 231 + 0.75 x LL 5.4 + 0.75 x LL 6.4	-103.0	5742.8	-6281.4	-6260.6	3553.9	-4761.2	-4826.4	-978.5	1344.9	-1211.1	1135.8	-1115.9
	Temperature Fall Case												
	Except Live load												
236	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall +Diff. shrinkage + creep	378.1	4131.3	-4985.1	-4720.1	2303.4	-3568.5	-3567.0	-669.6	996.4	-879.7	796.5	-796.5
	Including live load												
237	LC 236 + 0.75 x LL 5.1 + 0.75 x LL 6.1	-85.1	6043.9	-6571.5	-6119.6	3901.4	-4807.6	-4912.5	-1058.6	1401.4	-1298.7	1175.3	-1211.0
238	LC 236 + 0.75 x LL 5.2 + 0.75 x LL 6.2	-128.7	5387.6	-6350.7	-5931.5	3339.4	-4709.4	-4722.9	-952.6	1345.0	-1180.9	1126.9	-1096.0
239	LC 236 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-127.3	5822.2	-6619.9	-6091.5	3623.7	-4939.7	-4833.5	-954.5	1370.2	-1191.9	1127.2	-1106.4
240	LC 236 + 0.75 x LL 5.4 + 0.75 x LL 6.4	192.5	5808.1	-6504.3	-6178.7	3576.5	-4807.0	-4865.9	-965.0	1365.4	-1207.1	1140.7	-1120.5

	Positive Temperature Gradient Case												
	Except Live load												
241	1 DL+ 1 SIDL+1 DS + 1 Positive Gradient+Diff. shrinkage + creep	810.2	4291.8	-5034.8	-4873.8	2260.5	-3493.7	-3498.5	-649.5	1010.9	-887.1	788.1	-788.5
	Including live load												
242	LC 241 + 0.75 x LL 5.1 + 0.75 x LL 6.1	347.0	6204.4	-6621.2	-6273.3	3858.5	-4732.9	-4844.0	-1038.5	1415.9	-1306.2	1167.0	-1203.0
243	LC 241 + 0.75 x LL 5.2 + 0.75 x LL 6.2	303.4	5548.1	-6400.4	-6085.2	3296.6	-4634.7	-4654.4	-932.5	1359.5	-1188.3	1118.5	-1088.0
244	LC 241 + 0.75 x LL 5.3 + 0.75 x LL 6.3	304.8	5982.6	-6669.6	-6245.2	3580.8	-4864.9	-4764.9	-934.4	1384.7	-1199.3	1118.8	-1098.5
245	LC 241 + 0.75 x LL 5.4 + 0.75 x LL 6.4	624.6	5968.6	-6554.0	-6332.4	3533.6	-4732.2	-4797.4	-944.8	1379.9	-1214.5	1132.3	-1112.5
	Reverse Temperature Gradient Case												
	Except Live load												
246	1 DL+ 1 SIDL+1 DS + 1 Reverse Gradient+Diff. shrinkage + creep	-5.3	4017.5	-4802.4	-4717.0	2304.5	-3566.1	-3565.9	-686.8	975.5	-879.6	796.4	-796.4
	Including live load												
247	LC 246 + 0.75 x LL 5.1 + 0.75 x LL 6.1	-468.5	5930.1	-6388.8	-6116.5	3902.5	-4805.2	-4911.4	-1075.8	1380.5	-1298.6	1175.2	-1210.9
248	LC 246 + 0.75 x LL 5.2 + 0.75 x LL 6.2	-512.1	5273.8	-6168.1	-5928.4	3340.5	-4707.0	-4721.8	-969.8	1324.1	-1180.8	1126.8	-1095.9
249	LC 246 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-510.7	5708.4	-6437.2	-6088.4	3624.8	-4937.3	-4832.3	-971.7	1349.3	-1191.8	1127.1	-1106.3
250	LC 246 + 0.75 x LL 5.4 + 0.75 x LL 6.4	-190.9	5694.3	-6321.6	-6175.6	3577.6	-4804.6	-4864.8	-982.2	1344.5	-1207.0	1140.6	-1120.4
	Quasi permanent Combination	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5 ,Shrinkage & creep -1											
251	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinkage+ creep	156.5	4082.3	-4818.0	-4781.5	2286.4	-3534.2	-3537.4	-679.8	981.1	-882.7	792.8	-793.0
252	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkage+ creep	304.2	4115.0	-4929.4	-4740.5	2297.7	-3557.0	-3557.2	-673.0	991.3	-880.7	795.2	-795.3
253	2 DL+ 1 SIDL+1 DS + 0.5 +ve Grad+ Diff. Shrinkage+ creep	520.3	4195.2	-4954.2	-4817.4	2276.3	-3519.7	-3522.9	-662.9	998.6	-884.4	791.1	-791.3
254	3 DL+ 1 SIDL+1 DS + 0.5 Rev Grad+ Diff. Shrinkage+ creep	112.5	4058.1	-4838.1	-4739.0	2298.3	-3555.8	-3556.6	-681.6	980.9	-880.6	795.2	-795.3

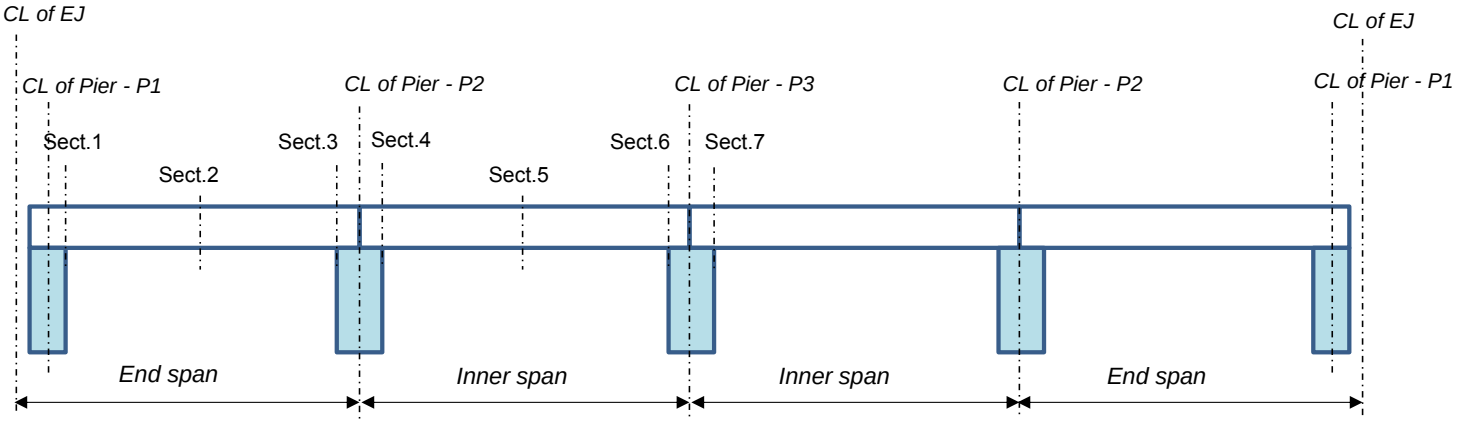
Summary of load combinaton Serviceability Limit State for Girder G 1

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
Rare Combination												
I. Live load leading with Wind/Temp	-488	6791	-7169	-6918	4498	-5448	-5486	-1224	1560	-1477	1326	-1378
II. Wind load leading 28.5 m/sec	-348	6248	-6700	-6573	4016	-5040	-5134	-1114	1448	-1361	1217	-1261
II.A. Wind load leading 29 m/sec	179	4323	-5076	-5085	2410	-3675	-3770	-721	1041	-938	837	-843
III. Temperature load leading	810	6204	-6670	-6332	3903	-4940	-4913	-1076	1416	-1306	1175	-1211
Design Forces	***810***	***6791***	***-7169***	***-6918***	***4498***	***-5448***	***-5486***	***-1224***	***1560***	***-1477***	***1326***	***-1378***
Quasi permanent Combination	**520**	**4195**	**-4954**	**-4817**	**2298**	**-3557**	**-3557**	**-682**	**999**	**-884**	**795**	**-795**

3.2 Staad Results and load combination for Girder 2

Effective length

For end Span	=	30.000 m	
For inner Span	=	30.00 m	
Effective length considered for impact factor calculation	=	30.000 m	
Impact factor for live load	For Class A	1.125	As per Cl: 208.2 of IRC 6-2017
	For 70R wheeled	1.162	As per Cl: 208.3 of IRC 6-2017



Typical Span arrangement showing sections

As per Clause 7.7.2.2 of IRC 112 -2011

Cross Sectional Area Ac	=	615000	mm^2
Perimeter u	=	5034	mm
Notional Size , h = 2Ac/u	=	244	mm
Creep coeff. at 90 days RH	=	80	%
Creep coefficient ϕ	=	1.358	
Reduction coefficient $\alpha 1$	=	0.75	
Moment due to Creep $M_{cr} = (M_{inst.} - M_{as\text{-}built})\ \alpha_1$	=	75.1	kNm

Table -6.9 of IRC 112.2011

t = 90 days	
size	Creep
50	1.5
150	1.4
600	1.2

3.2.1 *Summary of forces from staad for girder G - 2*

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
1	Dead load DL												
1.1	DL of Girder over temp. support	0	1578	0	0	1578	0	0	0	0	0	0	0
1.2	DL of Girder reaction	-143	892	-1178	-1139	521	-833	-832	-183	255	-226	204	-204
1.3	DL of Diaphragm	-1	0	1	1	0	0	0	0	0	0	0	0
1.4	DL of Deck slab	0	1115	-1377	-1383	582	-932	-932	-205	302	-264	232	-232
	Total Dead load	-143	3585	-2554	-2521	2681	-1765	-1765	-388	558	-490	436	-436
2	Super Imposed Dead load SIDL												
2.1	Crash barrier CB	454	-104	325	259	-218	380	380	88	-80	84	-93	93
2.2	Wearing Coat WC	-15	308	-387	-387	166	-267	-267	-59	85	-75	66	-66
3	Differential Settlement DS	-53	198	-433	-433	37	-508	-508	-18	17	-34	34	-34
4	Live load (without impact)												
4.1	LL 70 R _ Most ecc	-237	1464	-1084	-944	1230	-882	-891	-342	343	-354	326	-350
4.2	LL Class A _ Most ecc	277	373	-354	-373	227	-308	-303	25	48	-39	36	-35
4.1a	LL 2_Class A for 70 R	-845	2296	-1851	-1899	1871	-1655	-1726	-556	573	-594	538	-580
4.3	LL 70R+1 Class A	0	0	0	0	0	0	0	0	0	0	0	0
4.4	LL 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
4.5	LL 4 Class A	-117	1625	-1478	-1432	1205	-1250	-1241	-260	324	-293	296	-289
5	Live load With impact	As per clause: 208 of IRC 6-2017											
5.1	LL 70 R _ Most ecc	-275	1701	-1260	-1097	1429	-1024	-1035	-398	398	-411	379	-406
5.2	LL Class A _ Most ecc	311	420	-398	-420	255	-346	-341	28	55	-43	41	-39
5.3	LL 70R+1 Class A	-856	2325	-1874	-1923	1895	-1676	-1747	-563	580	-601	545	-587
5.4	LL 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
5.5	LL 4 Class A	-131	1828	-1663	-1611	1356	-1406	-1396	-292	364	-330	333	-325
6	Braking force												
6.1	LL 70 R _ Most ecc	-126	-10	91	-76	2	81	-81	-8	-7	-6	-6	-6
6.2	LL Class A _ Most ecc	-70	-5	50	-42	1	45	-45	-5	-4	-3	-3	-3
6.3	LL 70R+2 Class A	-152	-12	110	-92	2	97	-97	-10	-9	-7	-7	-7
6.4	LL 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
6.5	LL 4 Class A	-96	-7	69	-58	2	61	-61	-6	-6	-4	-4	-4

7	Wind load WL												
7.1	Wind load downwards 28.5 m/sec	-109	205	-160	-336	109	-90	-246	-46	49	-55	37	-48
7.2	Wind load downwards 29 m/sec	-85	198	-173	-310	105	-102	-225	-43	49	-52	37	-46
8	Temperature												
8.1	Temperature Rise	-312	-48	174	-61	-14	29	25	-19	-16	-3	-3	3
8.2	Temperature Fall	312	48	-174	61	14	-29	-25	19	16	3	3	-3
9	Differential shrinkage	545	196	-168	-129	-27	51	52	24	28	-9	-6	6
10	Creep	Reduction factor for creep = 0.75 as per Clause 7.7.2.2 of IRC 112 -2011											
	DL of girder with composite action	-42	952	-1194	-1193	513	-823	-823					
	Moment due to Creep $M_{cr} = (M_{inst.} - M_{as\text{-}built})\ \alpha_1$	75	-1139	-12	-41	-1190	7	7					
11	Seismic force												
11.1	Long.Seismic DL+SIDL	-264	-15	203	-180	2	186	-186	-18	-16	-13	-13	-13
11.2	Trans. Seismic DL+SIDL	2	-1	-4	1	0	-2	-2	0	0	0	0	0
11.3	Trans. Seismic 70 R_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
11.4	Trans. Seismic Class A_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
11.5	Trans. Seismic 70R+2 CLASS A	0	0	0	0	0	0	0	0	0	0	0	0
11.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
11.7	Trans. Seismic 4 Class A	0	0	0	0	0	0	0	0	0	0	0	0
12	Temperature Gradient												
12.1	Positive Gradient	497	180	-160	-110	-25	45	46	22	26	-7	-5	5
12.2	Reverse Gradient	-253	-82	87	43	9	-16	-17	-12	-13	3	2	-2

3.2.1.1 Load Combination Ultimate Limit State for Girder G 2

As per Table B.2 IRC 6 :2017

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
	Basic combination												
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9											
	Except Live load												
100	1.35 DL+ 1.75 SIDL+0.9 WL 28.5m/sec	296.5	5423.6	-3831.9	-4032.4	3714.3	-2418.5	-2558.1	-549.2	838.0	-728.9	612.8	-622.9
	Including live load												
101	LC 100 + 1.5 x LL 5.1 + 1.5 x LL 6.1	-304.8	7959.8	-5585.0	-5792.2	5860.1	-3834.1	-4231.9	-1158.4	1424.7	-1353.6	1172.7	-1241.0
102	LC 100 + 1.5 x LL 5.2 + 1.5 x LL 6.2	658.6	6045.7	-4353.2	-4725.6	4098.6	-2870.8	-3137.0	-513.9	913.8	-798.7	669.3	-686.3
103	LC 100 + 1.5 x LL 5.3 + 1.5 x LL 6.3	-1215.1	8893.3	-6479.0	-7054.7	6559.7	-4785.8	-5324.9	-1409.2	1694.7	-1641.1	1419.8	-1513.9
104	LC 100 + 1.5 x LL 5.4 + 1.5 x LL 6.4	296.5	5423.6	-3831.9	-4032.4	3714.3	-2418.5	-2558.1	-549.2	838.0	-728.9	612.8	-622.9
105	LC 100 + 1.5 x LL 5.5 + 1.5 x LL 6.5	-44.3	8154.1	-6222.5	-6535.6	5750.1	-4436.0	-4744.9	-996.7	1376.1	-1230.6	1105.2	-1117.5

	II.Wind load leading 28.5m/sec	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15											
	Except Live load												
111	1.35 DL+ 1.75 SIDL+1.5 WL 28.5m/sec	231.3	5546.8	-3928.1	-4233.9	3779.8	-2472.3	-2705.4	-576.5	867.5	-761.8	635.0	-651.9
	Including live load												
112	LC 111 + 1.15 x LL 5.1 + 1.15 x LL 6.1	-229.8	7491.1	-5272.2	-5583.1	5424.9	-3557.5	-3988.7	-1043.6	1317.2	-1240.7	1064.2	-1125.7
113	LC 111 + 1.15 x LL 5.2 + 1.15 x LL 6.2	508.9	6023.7	-4327.8	-4765.4	4074.4	-2819.0	-3149.3	-549.5	925.5	-815.3	678.3	-700.4
114	LC 111 + 1.15 x LL 5.3 + 1.15 x LL 6.3	-927.6	8206.8	-5957.6	-6551.0	5961.3	-4287.1	-4826.7	-1235.9	1524.2	-1461.2	1253.6	-1335.0
115	LC 111 + 1.15 x LL 5.4 + 1.15 x LL 6.4	231.3	5546.8	-3928.1	-4233.9	3779.8	-2472.3	-2705.4	-576.5	867.5	-761.8	635.0	-651.9
116	LC 111 + 1.15 x LL 5.5 + 1.15 x LL 6.5	-30.0	7640.1	-5760.9	-6153.0	5340.6	-4018.9	-4382.0	-919.7	1280.0	-1146.4	1012.5	-1031.0
	II.A. Wind load leading 29m/sec												
122	1.35 DL+ 1.75 SIDL+1.5 WL 29m/sec	266.9	5536.1	-3947.2	-4195.4	3773.8	-2490.7	-2674.7	-572.1	867.0	-757.5	634.8	-648.2
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5											
	Seismic longitudinal Case												
	Except Live load												
123	1.35 DL+ 1.75 SIDL+1.5 Long.Seismic	-1.6	5217.0	-3382.9	-4000.7	3619.7	-2059.5	-2615.6	-535.2	770.3	-699.6	559.5	-599.6
	Including live load												
124	LC 123 + 0.2 x LL 5.1 + 0.2 x LL 6.1	-81.8	5555.2	-3616.7	-4235.4	3905.8	-2248.3	-2838.8	-616.4	848.5	-782.9	634.2	-682.0
125	LC 123 + 0.2 x LL 5.2 + 0.2 x LL 6.2	46.7	5300.0	-3452.4	-4093.1	3671.0	-2119.8	-2692.8	-530.5	780.4	-708.9	567.0	-608.0
126	LC 123 + 0.2 x LL 5.3 + 0.2 x LL 6.3	-203.1	5679.6	-3735.9	-4403.7	3999.1	-2375.1	-2984.5	-649.8	884.5	-821.3	667.1	-718.4
127	LC 123 + 0.2 x LL 5.4 + 0.2 x LL 6.4	-1.6	5217.0	-3382.9	-4000.7	3619.7	-2059.5	-2615.6	-535.2	770.3	-699.6	559.5	-599.6
128	LC 123 + 0.2 x LL 5.5 + 0.2 x LL 6.5	-47.0	5581.1	-3701.7	-4334.5	3891.2	-2328.5	-2907.2	-594.8	842.1	-766.5	625.2	-665.5
	Seismic Transverse Case												
	Except Live load												
129	1.35 DL+ 1.75 SIDL+1.5 Trans.Seismic	397.4	5237.7	-3693.8	-3728.7	3615.6	-2340.9	-2340.1	-507.9	794.2	-679.6	579.8	-579.7
	Including live load												
130	LC 129 + 0.2 x LL 5.1 + 0.2 x LL 6.1 + 1.5 x LL 11.3	317.3	5575.8	-3927.7	-3963.4	3901.7	-2529.7	-2563.3	-589.1	872.5	-762.8	654.4	-662.1
131	LC 129 + 0.2 x LL 5.2 + 0.2 x LL 6.2 + 1.5 x LL 11.4	445.7	5320.6	-3763.4	-3821.1	3666.9	-2401.3	-2417.3	-503.2	804.3	-688.9	587.3	-588.2
132	LC 129 + 0.2 x LL 5.3 + 0.2 x LL 6.3 + 1.5 x LL 11.5	195.9	5700.2	-4047.0	-4131.7	3995.0	-2656.7	-2709.1	-622.5	908.5	-801.2	687.4	-698.5
133	LC 129 + 0.2 x LL 5.4 + 0.2 x LL 6.4 + 1.5 x LL 11.6	397.4	5237.7	-3693.8	-3728.7	3615.6	-2340.9	-2340.1	-507.9	794.2	-679.6	579.8	-579.7
134	LC 129 + 0.2 x LL 5.5 + 0.2 x LL 6.5 + 1.5 x LL 11.7	352.1	5601.7	-4012.8	-4062.4	3887.0	-2610.0	-2631.8	-567.5	866.0	-746.4	645.4	-645.7

Summary of load combination Ultimate Limit State for Girder G 2

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
Basic combination												
I. Live load leading	-1215	8893	-6479	-7055	6560	-4786	-5325	-1409	1695	-1641	1420	-1514
II. Wind load leading 28.5 m/sec	-928	8207	-5958	-6551	5961	-4287	-4827	-1236	1524	-1461	1254	-1335
II.A. Wind load leading 29 m/sec	267	5536	-3947	-4195	3774	-2491	-2675	-572	867	-757	635	-648
Seismic combination												
Seismic longitudinal Case	-203	5680	-3736	-4404	3999	-2375	-2984	-650	885	-821	667	-718
Seismic Transverse Case	446	5700	-4047	-4132	3995	-2657	-2709	-623	908	-801	687	-699
Design Forces	**-1215**	**8893**	**-6479**	**-7055**	**6560**	**-4786**	**-5325**	**-1409**	**1695**	**-1641**	**1420**	**-1514**

3.2.1.2 Load Combination Serviceability Limit State for Girder G 2 As per Table B.3 IRC 6 :2017

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
	Rare Combination												
	I. Live load leading with Wind	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage & creep -1											
	Except Live load												
200	1 DL+ 1 SIDL+1 DS +0.6 WL 28.5m/sec.+Diff. shrinkage + creep	795.9	3229.5	-3403.5	-3530.2	1548.5	-2209.8	-2301.1	-391.5	653.9	-571.8	473.4	-479.5
	Including live load												
201	LC 200 + 1 x LL 5.1 + 1 x LL 6.1	395.0	4920.2	-4572.3	-4703.4	2979.0	-3153.6	-3417.0	-797.7	1045.0	-988.2	846.6	-891.5
202	LC 200 + 1 x LL 5.2 + 1 x LL 6.2	1037.3	3644.2	-3751.1	-3992.3	1804.7	-2511.4	-2687.0	-368.0	704.4	-618.3	511.1	-521.7
203	LC 200 + 1 x LL 5.3 + 1 x LL 6.3	-211.8	5542.6	-5168.3	-5545.1	3445.4	-3788.0	-4145.7	-964.9	1225.0	-1179.9	1011.4	-1073.5
204	LC 200 + 1 x LL 5.4 + 1 x LL 6.4	795.9	3229.5	-3403.5	-3530.2	1548.5	-2209.8	-2301.1	-391.5	653.9	-571.8	473.4	-479.5
205	LC 200 + 1 x LL 5.5 + 1 x LL 6.5	568.7	5049.8	-4997.3	-5199.0	2905.7	-3554.8	-3759.0	-689.9	1012.6	-906.2	801.6	-809.2
	IA. Live load leading with Temp Rise	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Temp-0.6, Shrinkage & creep -1											
	Except Live load												
206	1 DL+ 1 SIDL+1 DS +0.6 Temp Rise.+Diff. shrinkage+ creep	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6

	Including live load												
207	LC 206 + 1 x LL 5.1 + 1 x LL 6.1	460.3	4797.1	-4476.0	-4501.9	2913.5	-3099.8	-3269.6	-770.3	1015.6	-955.4	824.5	-862.6
208	LC 206 + 1 x LL 5.2 + 1 x LL 6.2	1102.6	3521.1	-3654.8	-3790.8	1739.2	-2457.6	-2539.7	-340.7	675.0	-585.4	488.9	-492.8
209	LC 206 + 1 x LL 5.3 + 1 x LL 6.3	-146.6	5419.4	-5072.1	-5343.6	3380.0	-3734.3	-3998.3	-937.5	1195.6	-1147.0	989.2	-1044.6
210	LC 206 + 1 x LL 5.4 + 1 x LL 6.4	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
211	LC 206 + 1 x LL 5.5 + 1 x LL 6.5	634.0	4926.6	-4901.1	-4997.5	2840.2	-3501.1	-3611.6	-662.5	983.2	-873.3	779.5	-780.3
	IB. Live load leading with Temp Fall												
	Except Live load												
212	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
	Including live load												
213	LC 212 + 1 x LL 5.1 + 1 x LL 6.1	460.3	4797.1	-4476.0	-4501.9	2913.5	-3099.8	-3269.6	-770.3	1015.6	-955.4	824.5	-862.6
214	LC 212 + 1 x LL 5.2 + 1 x LL 6.2	1102.6	3521.1	-3654.8	-3790.8	1739.2	-2457.6	-2539.7	-340.7	675.0	-585.4	488.9	-492.8
215	LC 212 + 1 x LL 5.3 + 1 x LL 6.3	-146.6	5419.4	-5072.1	-5343.6	3380.0	-3734.3	-3998.3	-937.5	1195.6	-1147.0	989.2	-1044.6
216	LC 212 + 1 x LL 5.4 + 1 x LL 6.4	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
217	LC 212 + 1 x LL 5.5 + 1 x LL 6.5	634.0	4926.6	-4901.1	-4997.5	2840.2	-3501.1	-3611.6	-662.5	983.2	-873.3	779.5	-780.3
	IC. Live load leading with Positive Gradient												
	Except Live load												
218	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
	Including live load												
219	LC 218 + 1 x LL 5.1 + 1 x LL 6.1	460.3	4797.1	-4476.0	-4501.9	2913.5	-3099.8	-3269.6	-770.3	1015.6	-955.4	824.5	-862.6
220	LC 218 + 1 x LL 5.2 + 1 x LL 6.2	1102.6	3521.1	-3654.8	-3790.8	1739.2	-2457.6	-2539.7	-340.7	675.0	-585.4	488.9	-492.8
221	LC 218 + 1 x LL 5.3 + 1 x LL 6.3	-146.6	5419.4	-5072.1	-5343.6	3380.0	-3734.3	-3998.3	-937.5	1195.6	-1147.0	989.2	-1044.6
222	LC 218 + 1 x LL 5.4 + 1 x LL 6.4	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
223	LC 218 + 1 x LL 5.5 + 1 x LL 6.5	634.0	4926.6	-4901.1	-4997.5	2840.2	-3501.1	-3611.6	-662.5	983.2	-873.3	779.5	-780.3
	ID. Live load leading with Reverse Gradient												
	Except Live load												
224	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
	Including live load												
225	LC 224 + 1 x LL 5.1 + 1 x LL 6.1	460.3	4797.1	-4476.0	-4501.9	2913.5	-3099.8	-3269.6	-770.3	1015.6	-955.4	824.5	-862.6
226	LC 224 + 1 x LL 5.2 + 1 x LL 6.2	1102.6	3521.1	-3654.8	-3790.8	1739.2	-2457.6	-2539.7	-340.7	675.0	-585.4	488.9	-492.8
227	LC 224 + 1 x LL 5.3 + 1 x LL 6.3	-146.6	5419.4	-5072.1	-5343.6	3380.0	-3734.3	-3998.3	-937.5	1195.6	-1147.0	989.2	-1044.6
228	LC 224 + 1 x LL 5.4 + 1 x LL 6.4	861.2	3106.3	-3307.3	-3328.7	1483.0	-2156.1	-2153.8	-364.2	624.5	-538.9	451.2	-450.6
229	LC 224 + 1 x LL 5.5 + 1 x LL 6.5	634.0	4926.6	-4901.1	-4997.5	2840.2	-3501.1	-3611.6	-662.5	983.2	-873.3	779.5	-780.3

	II. Wind load leading - 28.5 m/sec	Partial safety factor		DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Wind-1 , Live load -0.75,Shrinkage & creep -1									
	Except Live load												
230	1 DL+ 1 SIDL+1 DS+1 WL 28.5 m/sec+Diff. shrinkage	752.4	3311.6	-3467.7	-3664.6	1592.2	-2245.7	-2399.3	-409.8	673.5	-593.7	488.1	-498.8
	Including live load												
231	LC 230 + 0.75 x LL 5.1 + 0.75 x LL 6.1	451.7	4579.6	-4344.2	-4544.5	2665.1	-2953.4	-3236.2	-714.4	966.9	-906.0	768.1	-807.8
232	LC 230 + 0.75 x LL 5.2 + 0.75 x LL 6.2	933.4	3622.6	-3728.4	-4011.2	1784.3	-2471.8	-2688.8	-392.2	711.4	-628.5	516.4	-530.5
233	LC 230 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-3.4	5046.4	-4791.3	-5175.7	3014.9	-3429.3	-3782.7	-839.8	1101.9	-1049.8	891.6	-944.3
234	LC 230 + 0.75 x LL 5.4 + 0.75 x LL 6.4	752.4	3311.6	-3467.7	-3664.6	1592.2	-2245.7	-2399.3	-409.8	673.5	-593.7	488.1	-498.8
235	LC 230 + 0.75 x LL 5.5 + 0.75 x LL 6.5	582.0	4676.8	-4663.0	-4916.2	2610.1	-3254.4	-3492.7	-633.6	942.6	-844.5	734.3	-746.1
	II.A. Wind load leading 29 m/sec												
236	1 DL+ 1 SIDL+1 DS+1 WL - 29 m/sec+Diff. shrinkage+ creep	776.1	3304.4	-3480.4	-3638.9	1588.2	-2257.9	-2378.8	-406.9	673.2	-590.8	488.0	-496.3
	III. Temperature load leading	Partial safety factor		DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75,Shrinkage & creep -1									
	Temperature rise Case												
	Except Live load												
237	1 DL+ 1 SIDL+1 DS+ 1 Temp. rise +Diff. shrinkage + creep	549.1	3058.2	-3133.8	-3389.4	1469.2	-2127.5	-2129.1	-383.4	608.6	-542.4	448.2	-447.8
	Including live load												
238	LC 237 + 0.75 x LL 5.1 + 0.75 x LL 6.1	248.4	4326.3	-4010.3	-4269.3	2542.1	-2835.3	-2966.0	-688.0	901.9	-854.7	728.1	-756.8
239	LC 237 + 0.75 x LL 5.2 + 0.75 x LL 6.2	730.1	3369.2	-3394.4	-3736.0	1661.4	-2353.7	-2418.6	-365.8	646.5	-577.3	476.5	-479.4
240	LC 237 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-206.7	4793.0	-4457.4	-4900.5	2891.9	-3311.2	-3512.5	-813.4	1036.9	-998.5	851.7	-893.3
241	LC 237 + 0.75 x LL 5.4 + 0.75 x LL 6.4	549.1	3058.2	-3133.8	-3389.4	1469.2	-2127.5	-2129.1	-383.4	608.6	-542.4	448.2	-447.8
242	LC 237 + 0.75 x LL 5.5 + 0.75 x LL 6.5	378.7	4423.4	-4329.1	-4641.0	2487.1	-3136.2	-3222.5	-607.2	877.6	-793.2	694.4	-695.0
	Temperature Fall Case												
	Except Live load												
243	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall +Diff. shrinkage + creep	1173.3	3154.5	-3480.8	-3268.1	1496.8	-2184.7	-2178.5	-344.9	640.4	-535.4	454.2	-453.4
	Including live load												
244	LC 243 + 0.75 x LL 5.1 + 0.75 x LL 6.1	872.6	4422.6	-4357.4	-4148.0	2569.7	-2892.5	-3015.4	-649.5	933.7	-847.7	734.2	-762.4
245	LC 243 + 0.75 x LL 5.2 + 0.75 x LL 6.2	1354.4	3465.6	-3741.5	-3614.7	1688.9	-2410.8	-2467.9	-327.3	678.2	-570.3	482.5	-485.0
246	LC 243 + 0.75 x LL 5.3 + 0.75 x LL 6.3	417.5	4889.3	-4804.4	-4779.2	2919.5	-3368.3	-3561.9	-774.9	1068.7	-991.5	857.7	-898.9
247	LC 243 + 0.75 x LL 5.4 + 0.75 x LL 6.4	1173.3	3154.5	-3480.8	-3268.1	1496.8	-2184.7	-2178.5	-344.9	640.4	-535.4	454.2	-453.4
248	LC 243 + 0.75 x LL 5.5 + 0.75 x LL 6.5	1002.9	4519.7	-4676.1	-4519.7	2514.7	-3193.4	-3271.9	-568.7	909.4	-786.2	700.4	-700.6

	Positive Temperature Gradient Case												
	Except Live load												
249	1 DL+ 1 SIDL+1 DS + 1 Positive Gradient+Diff. shrinkage + creep	1358.4	3285.9	-3467.7	-3439.2	1458.4	-2111.5	-2107.9	-342.6	650.1	-546.2	446.3	-445.2
	Including live load												
250	LC 249 + 0.75 x LL 5.1 + 0.75 x LL 6.1	1057.7	4554.0	-4344.2	-4319.1	2531.3	-2819.3	-2944.8	-647.2	943.5	-858.5	726.2	-754.2
251	LC 249 + 0.75 x LL 5.2 + 0.75 x LL 6.2	1539.4	3596.9	-3728.3	-3785.8	1650.5	-2337.7	-2397.4	-325.0	688.0	-581.1	474.6	-476.9
252	LC 249 + 0.75 x LL 5.3 + 0.75 x LL 6.3	602.6	5020.7	-4791.2	-4950.4	2881.1	-3295.1	-3491.4	-772.6	1078.5	-1002.3	849.8	-890.7
253	LC 249 + 0.75 x LL 5.4 + 0.75 x LL 6.4	1358.4	3285.9	-3467.7	-3439.2	1458.4	-2111.5	-2107.9	-342.6	650.1	-546.2	446.3	-445.2
254	LC 249 + 0.75 x LL 5.5 + 0.75 x LL 6.5	1188.0	4651.1	-4663.0	-4690.8	2476.3	-3120.2	-3201.3	-566.4	919.1	-797.0	692.5	-692.5
	Reverse Temperature Gradient Case												
	Except Live load												
255	1 DL+ 1 SIDL+1 DS + 1 Reverse Gradient+Diff. shrinkage + creep	608.5	3024.0	-3220.3	-3285.3	1491.8	-2172.6	-2170.9	-376.1	611.7	-535.8	453.0	-452.6
	Including live load												
256	LC 255 + 0.75 x LL 5.1 + 0.75 x LL 6.1	307.8	4292.1	-4096.9	-4165.2	2564.7	-2880.4	-3007.8	-680.7	905.0	-848.1	732.9	-761.6
257	LC 255 + 0.75 x LL 5.2 + 0.75 x LL 6.2	789.6	3335.1	-3481.0	-3631.9	1684.0	-2398.7	-2460.4	-358.5	649.6	-570.7	481.3	-484.3
258	LC 255 + 0.75 x LL 5.3 + 0.75 x LL 6.3	-147.3	4758.9	-4543.9	-4796.4	2914.5	-3356.2	-3554.4	-806.1	1040.0	-991.9	856.5	-898.1
259	LC 255 + 0.75 x LL 5.4 + 0.75 x LL 6.4	608.5	3024.0	-3220.3	-3285.3	1491.8	-2172.6	-2170.9	-376.1	611.7	-535.8	453.0	-452.6
260	LC 255 + 0.75 x LL 5.5 + 0.75 x LL 6.5	438.1	4389.3	-4415.6	-4536.9	2509.7	-3181.3	-3264.3	-599.9	880.7	-786.6	699.2	-699.9
	Quasi permanent Combination	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5 ,Shrinkage & creep -1											
261	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinkage+ creep	705.1	3082.3	-3220.5	-3359.0	1476.1	-2141.8	-2141.4	-373.8	616.5	-540.6	449.7	-449.2
262	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkage+ creep	1017.3	3130.4	-3394.1	-3298.4	1489.9	-2170.4	-2166.1	-354.5	632.4	-537.1	452.7	-452.0
263	2 DL+ 1 SIDL+1 DS + 0.5 +ve Grad+ Diff. Shrinkage+ creep	1109.8	3196.1	-3387.5	-3384.0	1470.7	-2133.8	-2130.9	-353.4	637.3	-542.5	448.8	-447.9
264	3 DL+ 1 SIDL+1 DS + 0.5 Rev Grad+ Diff. Shrinkage+ creep	734.9	3065.2	-3263.8	-3307.0	1487.4	-2164.4	-2162.4	-370.1	618.1	-537.3	452.1	-451.6

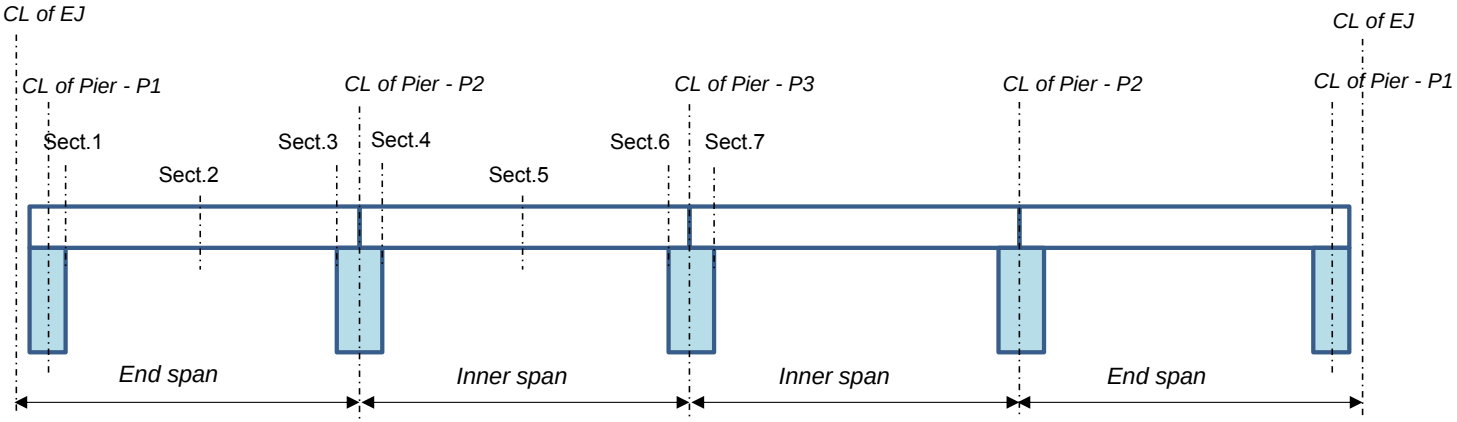
Summary of load combinaton Serviceability Limit State for Girder G 2

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
Rare Combination												
I. Live load leading with Wind/Temp	1103	5543	-5168	-5545	3445	-3788	-4146	-965	1225	-1180	1011	-1074
II. Wind load leading 28.5 m/sec	933	5046	-4791	-5176	3015	-3429	-3783	-840	1102	-1050	892	-944
II.B. Wind load leading 29 m/sec	776	3304	-3480	-3639	1588	-2258	-2379	-407	673	-591	488	-496
III. Temperature load leading	1539	5021	-4804	-4950	2920	-3368	-3562	-813	1078	-1002	858	-899
Design Forces	***1539***	***5543***	***-5168***	***-5545***	***3445***	***-3788***	***-4146***	***-965***	***1225***	***-1180***	***1011***	***-1074***
Quasi permanent Combination	**1110**	**3196**	**-3394**	**-3384**	**1490**	**-2170**	**-2166**	**-374**	**637**	**-543**	**453**	**-452**

3.3 Staad Results and load combination for Girder 3

Effective length

For end Span	=	30.000 m	
For inner Span	=	30.00 m	
Effective length considered for impact factor calculation	=	30.000 m	
Impact factor for live load	For Class A	1.125	As per Cl: 208.2 of IRC 6-2017
	For 70R wheeled	1.162	As per Cl: 208.3 of IRC 6-2017



Typical Span arrangement showing sections

As per Clause 7.7.2.2 of IRC 112 -2011

Cross Sectional Area Ac	=	615000	mm^2
Perimeter u	=	5034	mm
Notional Size , h = 2Ac/u	=	244	mm
Creep coeff. at 90 days RH	=	80	%
Creep coefficient ϕ	=	1.358	
Reduction coefficient $\alpha 1$	=	0.75	
Moment due to Creep $M_{cr} = (M_{inst.} - M_{as\text{-}built})\ \alpha_1$	=	75.0	kNm

Table -6.9 of IRC 112.2011

t = 90 days	
size	Creep
50	1.5
150	1.4
600	1.2

3.3.1 *Summary of forces from staad for girder G - 3*

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
1	Dead load DL												
1.1	DL of Girder over temp. support	0	1578	0	0	1578	0	0	0	0	0	0	0
1.2	DL of Girder reaction	-142	892	-1179	-1139	521	-832	-832	-183	256	-226	204	-204
1.3	DL of Diaphragm	-1	0	1	1	0	0	0	0	0	0	0	0
1.4	DL of Deck slab	0	1114	-1378	-1384	582	-932	-932	-205	302	-264	232	-232
	Total Dead load	-142	3585	-2556	-2523	2681	-1764	-1765	-388	558	-490	436	-436
2	Super Imposed Dead load SIDL												
2.1	Crash barrier CB	454	-104	325	259	-218	380	380	92	-80	85	-93	93
2.2	Wearing Coat WC	-15	309	-389	-388	167	-268	-268	-59	85	-75	67	-67
3	Differential Settlement DS	-53	198	-433	-433	37	-508	-508	-18	17	-34	34	-34
4	Live load (without impact)												
4.1	LL 70 R _ Most ecc	341	462	-409	-521	337	428	428	42	50	49	-60	59
4.2	LL Class A _ Most ecc	209	99	214	-252	-99	247	244	18	-13	21	-23	23
4.1a	LL 2_Class A for 70 R	-304	1386	-1111	-1062	1073	-935	-902	-216	246	-229	230	-225
4.3	LL 70R+1 Class A	0	0	0	0	0	0	0	0	0	0	0	0
4.4	LL 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
4.5	LL 4 Class A	-242	1528	-1324	-1329	1186	-1172	-1161	-292	378	-317	358	-314
5	Live load With impact	As per clause: 208 of IRC 6-2017											
5.1	LL 70 R _ Most ecc	396	537	-475	-605	391	497	497	49	58	57	-70	68
5.2	LL Class A _ Most ecc	235	112	241	-283	-112	278	275	20	-15	24	-26	26
5.3	LL 70R+1 Class A	-308	1403	-1124	-1075	1086	-946	-913	-219	249	-232	233	-228
5.4	LL 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
5.5	LL 4 Class A	-272	1719	-1490	-1495	1334	-1319	-1306	-328	425	-357	403	-353
6	Braking force												
6.1	LL 70 R _ Most ecc	-126	-10	91	-76	2	81	-81	-8	-7	-6	-6	-6
6.2	LL Class A _ Most ecc	-70	-5	50	-42	1	45	-45	-5	-4	-3	-3	-3
6.3	LL 70R+2 Class A	-152	-12	110	-92	2	97	-97	-10	-9	-7	-7	-7
6.4	LL 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
6.5	LL 4 Class A	-96	-7	69	-58	2	61	-61	-6	-6	-4	-4	-4

7	Wind load WL												
7.1	Wind load downwards 28.5 m/sec	-98	201	-183	-331	108	-99	-256	-45	50	-54	38	-49
7.2	Wind load downwards 29 m/sec	-78	195	-188	-307	104	-109	-232	-42	50	-52	37	-46
8	Temperature												
8.1	Temperature Rise	-312	-48	173	-61	-14	29	25	-19	-16	-3	-3	3
8.2	Temperature Fall	312	48	-173	61	14	-29	-25	19	16	3	3	-3
9	Differential shrinkage	544	194	-111	-72	-29	48	52	24	20	-1	-6	6
10	Creep	Reduction factor for creep = 0.75 as per Clause 7.7.2.2 of IRC 112 -2011											
	DL of girder with composite action	-42	952	-1195	-1194	513	-823	-823					
	Moment due to Creep $M_{cr} = (M_{inst.} - M_{as\text{-}built})\ \alpha_1$	75	-1139	-12	-41	-1190	7	7					
11	Seismic force												
11.1	Long.Seismic DL+SIDL	-264	-15	203	-180	2	186	-186	-18	-16	-13	-13	-13
11.2	Trans. Seismic DL+SIDL	-2	1	4	-1	0	2	2	0	0	0	0	0
11.3	Trans. Seismic 70 R_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
11.4	Trans. Seismic Class A_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
11.5	Trans. Seismic 70R+2 CLASS A	0	0	0	0	0	0	0	0	0	0	0	0
11.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
11.7	Trans. Seismic 4 Class A	0	0	0	0	0	0	0	0	0	0	0	0
12	Temperature Gradient												
12.1	Positive Gradient	496	178	-119	-68	-26	43	46	22	20	-2	-5	5
12.2	Reverse Gradient	-252	-82	63	20	10	-15	-17	-12	-10	0	2	-2

3.3.1.1 Load Combination Ultimate Limit State for Girder G 3

As per Table B.2 IRC 6 :2017

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
	Basic combination												
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9											
	Except Live load												
100	1.35 DL+ 1.75 SIDL+0.9 WL 28.5m/sec	306.2	5421.2	-3856.3	-4032.4	3714.2	-2427.4	-2568.9	-544.1	839.2	-728.7	613.1	-623.3
	Including live load												
101	LC 100 + 1.5 x LL 5.1 + 1.5 x LL 6.1	711.8	6211.8	-4432.4	-5055.2	4304.0	-1561.2	-1944.2	-483.3	915.6	-652.3	499.1	-529.7
102	LC 100 + 1.5 x LL 5.2 + 1.5 x LL 6.2	553.5	5581.0	-3419.2	-4520.8	3548.3	-1943.5	-2223.7	-521.3	810.4	-698.0	569.4	-588.7
103	LC 100 + 1.5 x LL 5.3 + 1.5 x LL 6.3	-383.1	7508.0	-5378.4	-5783.4	5347.4	-3700.7	-4084.9	-887.4	1199.6	-1086.9	952.4	-975.1
104	LC 100 + 1.5 x LL 5.4 + 1.5 x LL 6.4	306.2	5421.2	-3856.3	-4032.4	3714.2	-2427.4	-2568.9	-544.1	839.2	-728.7	613.1	-623.3
105	LC 100 + 1.5 x LL 5.5 + 1.5 x LL 6.5	-246.0	7988.0	-5986.8	-6363.0	5717.8	-4313.2	-4619.5	-1045.8	1468.7	-1270.4	1211.4	-1159.6

	II.Wind load leading 28.5m/sec	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15											
	Except Live load												
111	1.35 DL+ 1.75 SIDL+1.5 WL 28.5m/sec	247.3	5541.6	-3966.2	-4231.2	3778.7	-2487.1	-2722.2	-571.0	869.3	-761.3	635.6	-652.7
	Including live load												
112	LC 111 + 1.15 x LL 5.1 + 1.15 x LL 6.1	558.2	6147.7	-4407.9	-5015.3	4230.9	-1823.0	-2243.3	-524.4	927.9	-702.8	548.2	-580.9
113	LC 111 + 1.15 x LL 5.2 + 1.15 x LL 6.2	436.8	5664.0	-3631.1	-4605.6	3651.6	-2116.1	-2457.6	-553.5	847.2	-737.8	602.1	-626.1
114	LC 111 + 1.15 x LL 5.3 + 1.15 x LL 6.3	-281.2	7141.4	-5133.1	-5573.7	5030.8	-3463.2	-3884.5	-834.2	1145.7	-1036.0	895.8	-922.4
115	LC 111 + 1.15 x LL 5.4 + 1.15 x LL 6.4	247.3	5541.6	-3966.2	-4231.2	3778.7	-2487.1	-2722.2	-571.0	869.3	-761.3	635.6	-652.7
116	LC 111 + 1.15 x LL 5.5 + 1.15 x LL 6.5	-176.1	7509.5	-5599.5	-6018.0	5314.9	-3932.8	-4294.3	-955.7	1352.0	-1176.7	1094.3	-1063.8
	II.A. Wind load leading 29m/sec												
122	1.35 DL+ 1.75 SIDL+1.5 WL 29m/sec	277.7	5533.2	-3974.1	-4194.5	3773.5	-2501.2	-2687.1	-567.0	868.2	-757.2	635.2	-648.7
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5											
	Seismic longitudinal Case												
	Except Live load												
123	1.35 DL+ 1.75 SIDL+1.5 Long.Seismic	-1.4	5218.8	-3386.9	-4004.7	3621.0	-2059.5	-2617.3	-530.8	770.3	-699.6	559.2	-599.4
	Including live load												
124	LC 123 + 0.2 x LL 5.1 + 0.2 x LL 6.1	52.7	5324.2	-3463.7	-4141.1	3699.6	-1944.0	-2534.0	-522.7	780.5	-689.5	544.0	-586.9
125	LC 123 + 0.2 x LL 5.2 + 0.2 x LL 6.2	31.5	5240.1	-3328.6	-4069.8	3598.9	-1994.9	-2571.3	-527.7	766.5	-695.5	553.4	-594.8
126	LC 123 + 0.2 x LL 5.3 + 0.2 x LL 6.3	-93.3	5497.0	-3589.8	-4238.2	3838.7	-2229.2	-2819.4	-576.5	818.4	-747.4	604.5	-646.3
127	LC 123 + 0.2 x LL 5.4 + 0.2 x LL 6.4	-1.4	5218.8	-3386.9	-4004.7	3621.0	-2059.5	-2617.3	-530.8	770.3	-699.6	559.2	-599.4
128	LC 123 + 0.2 x LL 5.5 + 0.2 x LL 6.5	-75.1	5561.0	-3670.9	-4315.4	3888.1	-2310.9	-2890.7	-597.7	854.3	-771.9	639.0	-670.9
	Seismic Transverse Case												
	Except Live load												
129	1.35 DL+ 1.75 SIDL+1.5 Trans.Seismic	391.7	5242.0	-3685.2	-3735.6	3617.8	-2335.0	-2335.9	-503.9	793.6	-679.7	579.1	-579.2
	Including live load												
130	LC 129 + 0.2 x LL 5.1 + 0.2 x LL 6.1 + 1.5 x LL 11.3	445.7	5347.4	-3761.8	-3872.0	3696.4	-2219.4	-2252.5	-495.8	803.8	-669.6	563.9	-566.7
131	LC 129 + 0.2 x LL 5.2 + 0.2 x LL 6.2 + 1.5 x LL 11.4	424.6	5263.3	-3626.8	-3800.7	3595.6	-2270.4	-2289.8	-500.9	789.7	-675.6	573.3	-574.5
132	LC 129 + 0.2 x LL 5.3 + 0.2 x LL 6.3 + 1.5 x LL 11.5	299.7	5520.3	-3887.9	-3969.1	3835.5	-2504.6	-2537.9	-549.7	841.6	-727.5	624.3	-626.1
133	LC 129 + 0.2 x LL 5.4 + 0.2 x LL 6.4 + 1.5 x LL 11.6	391.7	5242.0	-3685.2	-3735.6	3617.8	-2335.0	-2335.9	-503.9	793.6	-679.7	579.1	-579.2
134	LC 129 + 0.2 x LL 5.5 + 0.2 x LL 6.5 + 1.5 x LL 11.7	318.0	5584.3	-3969.0	-4046.4	3884.9	-2586.3	-2609.2	-570.8	877.5	-752.0	658.9	-650.7

Summary of load combination Ultimate Limit State for Girder G 3

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
Basic combination												
I. Live load leading	712	7988	-5987	-6363	5718	-4313	-4619	-1046	1469	-1270	1211	-1160
II. Wind load leading 28.5m/sec	558	7509	-5600	-6018	5315	-3933	-4294	-956	1352	-1177	1094	-1064
II.A. Wind load leading 29m/sec	278	5533	-3974	-4194	3773	-2501	-2687	-567	868	-757	635	-649
Seismic combination												
Seismic longitudinal Case	-93	5561	-3671	-4315	3888	-2311	-2891	-598	854	-772	639	-671
Seismic Transverse Case	446	5584	-3969	-4046	3885	-2586	-2609	-571	878	-752	659	-651
Design Forces	**712**	**7988**	**-5987**	**-6363**	**5718**	**-4313**	**-4619**	**-1046**	**1469**	**-1270**	**1211**	**-1160**

3.3.1.2 Load Combination Serviceability Limit State for Girder G 3 As per Table B.3 IRC 6 :2017

Load Case - LC	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
	Rare Combination												
	I. Live load leading with Wind	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage & creep -1											
	Except Live load												
200	1 DL+ 1 SIDL+1 DS +0.6 WL 28.5m/sec.+Diff. shrinkage + creep	801.1	3226.3	-3362.7	-3472.9	1546.6	-2217.9	-2308.6	-387.5	647.0	-563.9	473.3	-479.8
	Including live load												
201	LC 200 + 1 x LL 5.1 + 1 x LL 6.1	1071.5	3753.3	-3746.8	-4154.7	1939.9	-1640.5	-1892.2	-347.0	698.0	-513.0	397.3	-417.3
202	LC 200 + 1 x LL 5.2 + 1 x LL 6.2	966.0	3332.7	-3071.4	-3798.5	1436.1	-1895.3	-2078.5	-372.3	627.8	-543.4	444.2	-456.7
203	LC 200 + 1 x LL 5.3 + 1 x LL 6.3	341.6	4617.4	-4377.5	-4640.3	2635.4	-3066.8	-3319.3	-616.4	887.3	-802.8	699.5	-714.3
204	LC 200 + 1 x LL 5.4 + 1 x LL 6.4	801.1	3226.3	-3362.7	-3472.9	1546.6	-2217.9	-2308.6	-387.5	647.0	-563.9	473.3	-479.8
205	LC 200 + 1 x LL 5.5 + 1 x LL 6.5	433.0	4937.4	-4783.1	-5026.6	2882.4	-3475.1	-3675.7	-722.0	1066.8	-925.1	872.2	-837.3
	IA. Live load leading with Temp Rise	Partial safety factor DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Temp-0.6, Shrinkage & creep -1											
	Except Live load												
206	1 DL+ 1 SIDL+1 DS +0.6 Temp Rise.+Diff. shrinkage+ creep	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5

	Including live load												
207	LC 206 + 1 x LL 5.1 + 1 x LL 6.1	1130.5	3633.0	-3636.9	-3955.9	1875.3	-1580.8	-1738.8	-320.1	667.9	-480.4	374.8	-388.0
208	LC 206 + 1 x LL 5.2 + 1 x LL 6.2	1024.9	3212.4	-2961.5	-3599.7	1371.5	-1835.6	-1925.1	-345.4	597.7	-510.8	421.7	-427.4
209	LC 206 + 1 x LL 5.3 + 1 x LL 6.3	400.5	4497.1	-4267.6	-4441.4	2570.9	-3007.1	-3165.9	-589.5	857.2	-770.1	677.0	-685.0
210	LC 206 + 1 x LL 5.4 + 1 x LL 6.4	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
211	LC 206 + 1 x LL 5.5 + 1 x LL 6.5	492.0	4817.1	-4673.2	-4827.8	2817.8	-3415.4	-3522.3	-695.1	1036.6	-892.4	849.6	-808.0
	IB. Live load leading with Temp Fall												
	Except Live load												
212	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
	Including live load												
213	LC 212 + 1 x LL 5.1 + 1 x LL 6.1	1130.5	3633.0	-3636.9	-3955.9	1875.3	-1580.8	-1738.8	-320.1	667.9	-480.4	374.8	-388.0
214	LC 212 + 1 x LL 5.2 + 1 x LL 6.2	1024.9	3212.4	-2961.5	-3599.7	1371.5	-1835.6	-1925.1	-345.4	597.7	-510.8	421.7	-427.4
215	LC 212 + 1 x LL 5.3 + 1 x LL 6.3	400.5	4497.1	-4267.6	-4441.4	2570.9	-3007.1	-3165.9	-589.5	857.2	-770.1	677.0	-685.0
216	LC 212 + 1 x LL 5.4 + 1 x LL 6.4	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
217	LC 212 + 1 x LL 5.5 + 1 x LL 6.5	492.0	4817.1	-4673.2	-4827.8	2817.8	-3415.4	-3522.3	-695.1	1036.6	-892.4	849.6	-808.0
	IC. Live load leading with Positive Gradient												
	Except Live load												
218	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
	Including live load												
219	LC 218 + 1 x LL 5.1 + 1 x LL 6.1	1130.5	3633.0	-3636.9	-3955.9	1875.3	-1580.8	-1738.8	-320.1	667.9	-480.4	374.8	-388.0
220	LC 218 + 1 x LL 5.2 + 1 x LL 6.2	1024.9	3212.4	-2961.5	-3599.7	1371.5	-1835.6	-1925.1	-345.4	597.7	-510.8	421.7	-427.4
221	LC 218 + 1 x LL 5.3 + 1 x LL 6.3	400.5	4497.1	-4267.6	-4441.4	2570.9	-3007.1	-3165.9	-589.5	857.2	-770.1	677.0	-685.0
222	LC 218 + 1 x LL 5.4 + 1 x LL 6.4	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
223	LC 218 + 1 x LL 5.5 + 1 x LL 6.5	492.0	4817.1	-4673.2	-4827.8	2817.8	-3415.4	-3522.3	-695.1	1036.6	-892.4	849.6	-808.0
	ID. Live load leading with Reverse Gradient												
	Except Live load												
224	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage+ creep	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
	Including live load												
225	LC 224 + 1 x LL 5.1 + 1 x LL 6.1	1130.5	3633.0	-3636.9	-3955.9	1875.3	-1580.8	-1738.8	-320.1	667.9	-480.4	374.8	-388.0
226	LC 224 + 1 x LL 5.2 + 1 x LL 6.2	1024.9	3212.4	-2961.5	-3599.7	1371.5	-1835.6	-1925.1	-345.4	597.7	-510.8	421.7	-427.4
227	LC 224 + 1 x LL 5.3 + 1 x LL 6.3	400.5	4497.1	-4267.6	-4441.4	2570.9	-3007.1	-3165.9	-589.5	857.2	-770.1	677.0	-685.0
228	LC 224 + 1 x LL 5.4 + 1 x LL 6.4	860.1	3105.9	-3252.8	-3274.0	1482.1	-2158.3	-2155.2	-360.6	616.9	-531.2	450.8	-450.5
229	LC 224 + 1 x LL 5.5 + 1 x LL 6.5	492.0	4817.1	-4673.2	-4827.8	2817.8	-3415.4	-3522.3	-695.1	1036.6	-892.4	849.6	-808.0

	II. Wind load leading - 28.5 m/sec	Partial safety factor		DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Wind-1 , Live load -0.75,Shrinkage & creep -1									
	Except Live load												
230	1 DL+ 1 SIDL+1 DS+1 WL 28.5 m/sec+Diff. shrinkage	761.8	3306.5	-3436.0	-3605.4	1589.7	-2257.7	-2410.8	-405.5	667.1	-585.7	488.3	-499.3
	Including live load												
231	LC 230 + 0.75 x LL 5.1 + 0.75 x LL 6.1	964.6	3701.8	-3724.1	-4116.8	1884.6	-1824.6	-2098.5	-375.1	705.4	-547.5	431.3	-452.5
232	LC 230 + 0.75 x LL 5.2 + 0.75 x LL 6.2	885.5	3386.3	-3217.5	-3849.6	1506.7	-2015.7	-2238.3	-394.1	652.7	-570.4	466.5	-482.0
233	LC 230 + 0.75 x LL 5.3 + 0.75 x LL 6.3	417.2	4349.9	-4197.0	-4480.9	2406.3	-2894.3	-3168.9	-577.1	847.4	-764.8	658.0	-675.2
234	LC 230 + 0.75 x LL 5.4 + 0.75 x LL 6.4	761.8	3306.5	-3436.0	-3605.4	1589.7	-2257.7	-2410.8	-405.5	667.1	-585.7	488.3	-499.3
235	LC 230 + 0.75 x LL 5.5 + 0.75 x LL 6.5	485.7	4589.9	-4501.2	-4770.7	2591.5	-3200.6	-3436.1	-656.3	981.9	-856.6	787.5	-767.5
	II.A. Wind load leading 29 m/sec												
236	1 DL+ 1 SIDL+1 DS+1 WL - 29 m/sec+Diff. shrinkage+ creep	782.2	3300.9	-3441.3	-3580.9	1586.2	-2267.1	-2387.4	-402.8	666.4	-582.9	488.0	-496.7
	III. Temperature load leading	Partial safety factor		DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75,Shrinkage & creep -1									
	Temperature rise Case												
	Except Live load												
237	1 DL+ 1 SIDL+1 DS+ 1 Temp. rise +Diff. shrinkage + creep	548.0	3057.7	-3079.4	-3334.7	1468.3	-2129.7	-2130.6	-379.8	601.0	-534.7	447.8	-447.7
	Including live load												
238	LC 237 + 0.75 x LL 5.1 + 0.75 x LL 6.1	750.8	3453.0	-3367.5	-3846.1	1763.2	-1696.6	-1818.3	-349.4	639.2	-496.6	390.7	-400.8
239	LC 237 + 0.75 x LL 5.2 + 0.75 x LL 6.2	671.6	3137.6	-2860.9	-3578.9	1385.3	-1887.7	-1958.0	-368.4	586.6	-519.4	425.9	-430.3
240	LC 237 + 0.75 x LL 5.3 + 0.75 x LL 6.3	203.3	4101.1	-3840.5	-4210.2	2284.9	-2766.3	-2888.6	-551.5	781.2	-713.9	617.4	-623.6
241	LC 237 + 0.75 x LL 5.4 + 0.75 x LL 6.4	548.0	3057.7	-3079.4	-3334.7	1468.3	-2129.7	-2130.6	-379.8	601.0	-534.7	447.8	-447.7
242	LC 237 + 0.75 x LL 5.5 + 0.75 x LL 6.5	271.9	4341.1	-4144.7	-4500.0	2470.1	-3072.6	-3155.9	-630.7	915.8	-805.6	746.9	-715.8
	Temperature Fall Case												
	Except Live load												
243	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall +Diff. shrinkage + creep	1172.2	3154.1	-3426.3	-3213.4	1495.9	-2186.8	-2179.9	-341.4	632.7	-527.7	453.8	-453.2
	Including live load												
244	LC 243 + 0.75 x LL 5.1 + 0.75 x LL 6.1	1375.0	3549.4	-3714.3	-3724.8	1790.8	-1753.7	-1867.6	-311.0	671.0	-489.6	396.8	-406.4
245	LC 243 + 0.75 x LL 5.2 + 0.75 x LL 6.2	1295.8	3233.9	-3207.7	-3457.6	1412.9	-1944.9	-2007.3	-330.0	618.3	-512.4	432.0	-435.9
246	LC 243 + 0.75 x LL 5.3 + 0.75 x LL 6.3	827.5	4197.4	-4187.3	-4088.9	2312.5	-2823.5	-2937.9	-513.1	813.0	-706.9	623.5	-629.1
247	LC 243 + 0.75 x LL 5.4 + 0.75 x LL 6.4	1172.2	3154.1	-3426.3	-3213.4	1495.9	-2186.8	-2179.9	-341.4	632.7	-527.7	453.8	-453.2
248	LC 243 + 0.75 x LL 5.5 + 0.75 x LL 6.5	896.1	4437.5	-4491.5	-4378.7	2497.7	-3129.7	-3205.2	-592.3	947.5	-798.6	753.0	-721.4

	Positive Temperature Gradient Case												
	Except Live load												
249	1 DL+ 1 SIDL+1 DS + 1 Positive Gradient+Diff. shrinkage + creep	1356.5	3284.3	-3371.4	-3342.4	1456.1	-2115.5	-2109.6	-338.9	637.0	-533.0	445.7	-445.1
	Including live load												
250	LC 249 + 0.75 x LL 5.1 + 0.75 x LL 6.1	1559.3	3679.6	-3659.5	-3853.8	1751.0	-1682.4	-1797.3	-308.5	675.2	-494.8	388.7	-398.3
251	LC 249 + 0.75 x LL 5.2 + 0.75 x LL 6.2	1480.1	3364.1	-3152.9	-3586.6	1373.2	-1873.5	-1937.0	-327.5	622.6	-517.6	423.9	-427.8
252	LC 249 + 0.75 x LL 5.3 + 0.75 x LL 6.3	1011.8	4327.7	-4132.4	-4218.0	2272.7	-2752.1	-2867.6	-510.5	817.2	-712.1	615.4	-621.0
253	LC 249 + 0.75 x LL 5.4 + 0.75 x LL 6.4	1356.5	3284.3	-3371.4	-3342.4	1456.1	-2115.5	-2109.6	-338.9	637.0	-533.0	445.7	-445.1
254	LC 249 + 0.75 x LL 5.5 + 0.75 x LL 6.5	1080.4	4567.7	-4436.6	-4507.7	2458.0	-3058.4	-3134.9	-589.7	951.8	-803.8	744.9	-713.2
	Reverse Temperature Gradient Case												
	Except Live load												
255	1 DL+ 1 SIDL+1 DS + 1 Reverse Gradient+Diff. shrinkage + creep	607.9	3024.2	-3189.6	-3254.5	1491.6	-2173.7	-2172.3	-372.7	607.2	-531.3	452.6	-452.5
	Including live load												
256	LC 255 + 0.75 x LL 5.1 + 0.75 x LL 6.1	810.7	3419.5	-3477.6	-3765.9	1786.5	-1740.6	-1860.0	-342.3	645.5	-493.1	395.6	-405.7
257	LC 255 + 0.75 x LL 5.2 + 0.75 x LL 6.2	731.5	3104.1	-2971.0	-3498.7	1408.7	-1931.7	-1999.7	-361.3	592.8	-515.9	430.8	-435.2
258	LC 255 + 0.75 x LL 5.3 + 0.75 x LL 6.3	263.2	4067.6	-3950.6	-4130.0	2308.2	-2810.3	-2930.3	-544.3	787.5	-710.4	622.3	-628.4
259	LC 255 + 0.75 x LL 5.4 + 0.75 x LL 6.4	607.9	3024.2	-3189.6	-3254.5	1491.6	-2173.7	-2172.3	-372.7	607.2	-531.3	452.6	-452.5
260	LC 255 + 0.75 x LL 5.5 + 0.75 x LL 6.5	331.8	4307.6	-4254.8	-4419.8	2493.4	-3116.6	-3197.6	-623.5	922.0	-802.2	751.8	-720.6
	Quasi permanent Combination	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5 ,Shrinkage & creep -1											
261	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinkage+ creep	704.0	3081.8	-3166.1	-3304.4	1475.2	-2144.0	-2142.9	-370.2	608.9	-533.0	449.3	-449.1
262	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkage+ creep	1016.1	3130.0	-3339.6	-3243.7	1489.0	-2172.5	-2167.6	-351.0	624.8	-529.5	452.3	-451.8
263	2 DL+ 1 SIDL+1 DS + 0.5 +ve Grad+ Diff. Shrinkage+ creep	1108.3	3195.1	-3312.1	-3308.2	1469.1	-2136.9	-2132.4	-349.7	626.9	-532.1	448.2	-447.8
264	3 DL+ 1 SIDL+1 DS + 0.5 Rev Grad+ Diff. Shrinkage+ creep	734.0	3065.1	-3221.2	-3264.3	1486.8	-2166.0	-2163.8	-366.6	612.1	-531.3	451.7	-451.5

Summary of load combinaton Serviceability Limit State for Girder G 3

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
Rare Combination												
I. Live load leading with Wind/Temp	1131	4937	-4783	-5027	2882	-3475	-3676	-722	1067	-925	872	-837
II. Wind load leading 28.5 m/sec	965	4590	-4501	-4771	2592	-3201	-3436	-656	982	-857	787	-767
II.B. Wind load leading 29 m/sec	782	3301	-3441	-3581	1586	-2267	-2387	-403	666	-583	488	-497
III. Temperature load leading	1559	4568	-4492	-4508	2498	-3130	-3205	-631	952	-806	753	-721
Design Forces	***1559***	***4937***	***-4783***	***-5027***	***2882***	***-3475***	***-3676***	***-722***	***1067***	***-925***	***872***	***-837***
Quasi permanent Combination	**1108**	**3195**	**-3340**	**-3308**	**1489**	**-2173**	**-2168**	**-370**	**627**	**-533**	**452**	**-452**

3.4 Summary of load combination of girders

3.4.1 *Ultimate Limit State*

Girder	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
G1	**Basic combination**												
	I. Live load leading	-1714	10593	-9281	-8899	8038	-7076	-7128	-1755	2148	-2038	1840	-1919
	II. Wind load leading-36m/sec	-1521	9842	-8633	-8431	7367	-6510	-6645	-1603	1993	-1878	1690	-1756
	II.A. Wind load leading-50m/sec	-713	6890	-6142	-6151	4906	-4418	-4555	-1000	1369	-1230	1107	-1116
	Seismic combination												
	Seismic longitudinal Case	-954	7059	-6074	-6258	5158	-4378	-4790	-1048	1380	-1271	1130	-1168
	Seismic Transverse Case	-757	7060	-6297	-6047	5153	-4599	-4589	-1036	1396	-1256	1145	-1154
	Design Forces for G1	***-1714***	***10593***	***-9281***	***-8899***	***8038***	***-7076***	***-7128***	***-1755***	***2148***	***-2038***	***1840***	***-1919***
G2	**Basic combination**												
	I. Live load leading	-1215	8893	-6479	-7055	6560	-4786	-5325	-1409	1695	-1641	1420	-1514
	II. Wind load leading-28.5m/sec	-928	8207	-5958	-6551	5961	-4287	-4827	-1236	1524	-1461	1254	-1335
	II.A. Wind load leading-29m/sec	267	5536	-3947	-4195	3774	-2491	-2675	-572	867	-757	635	-648
	Seismic combination												
	Seismic longitudinal Case	-203	5680	-3736	-4404	3999	-2375	-2984	-650	885	-821	667	-718
	Seismic Transverse Case	446	5700	-4047	-4132	3995	-2657	-2709	-623	908	-801	687	-699
	Design Forces for G2	***-1215***	***8893***	***-6479***	***-7055***	***6560***	***-4786***	***-5325***	***-1409***	***1695***	***-1641***	***1420***	***-1514***
G3	**Basic combination**												
	I. Live load leading	712	7988	-5987	-6363	5718	-4313	-4619	-1046	1469	-1270	1211	-1160
	II. Wind load leading-28.5m/sec	558	7509	-5600	-6018	5315	-3933	-4294	-956	1352	-1177	1094	-1064
	II.A. Wind load leading-29m/sec	278	5533	-3974	-4194	3773	-2501	-2687	-567	868	-757	635	-649
	Seismic combination												
	Seismic longitudinal Case	-93	5561	-3671	-4315	3888	-2311	-2891	-598	854	-772	639	-671
	Seismic Transverse Case	446	5584	-3969	-4046	3885	-2586	-2609	-571	878	-752	659	-651
	Design Forces for G3	***712***	***7988***	***-5987***	***-6363***	***5718***	***-4313***	***-4619***	***-1046***	***1469***	***-1270***	***1211***	***-1160***

3.4.2 *Serviceability Limit State*

Girder	Description	Bending moment (kN.m)							Shear force (kN)				
		End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
		Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
		Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
G1	**Rare Combination**												
	I. Live load leading	-488	6791	-7169	-6918	4498	-5448	-5486	-1224	1560	-1477	1326	-1378
	II. Wind load leading-28.5 m/sec	-348	6248	-6700	-6573	4016	-5040	-5134	-1114	1448	-1361	1217	-1261
	II.A. Wind load leading-29 m/sec	179	4323	-5076	-5085	2410	-3675	-3770	-721	1041	-938	837	-843
	III. Temperature load leading	810	6204	-6670	-6332	3903	-4940	-4913	-1076	1416	-1306	1175	-1211
	Design Forces for G1	***810***	***6791***	***-7169***	***-6918***	***4498***	***-5448***	***-5486***	***-1224***	***1560***	***-1477***	***1326***	***-1378***
	Quasi-permanent Combination	**520**	**4195**	**-4954**	**-4817**	**2298**	**-3557**	**-3557**	**-682**	**999**	**-884**	**795**	**-795**
G2	**Rare Combination**												
	I. Live load leading	1103	5543	-5168	-5545	3445	-3788	-4146	-965	1225	-1180	1011	-1074
	II. Wind load leading-28.5 m/sec	933	5046	-4791	-5176	3015	-3429	-3783	-840	1102	-1050	892	-944
	II.A. Wind load leading-29 m/sec	776	3304	-3480	-3639	1588	-2258	-2379	-407	673	-591	488	-496
	III. Temperature load leading	1539	5021	-4804	-4950	2920	-3368	-3562	-813	1078	-1002	858	-899
	Design Forces for G2	***1539***	***5543***	***-5168***	***-5545***	***3445***	***-3788***	***-4146***	***-965***	***1225***	***-1180***	***1011***	***-1074***
	Quasi-permanent Combination	**1110**	**3196**	**-3394**	**-3384**	**1490**	**-2170**	**-2166**	**-374**	**637**	**-543**	**453**	**-452**
G3	**Rare Combination**												
	I. Live load leading	1131	4937	-4783	-5027	2882	-3475	-3676	-722	1067	-925	872	-837
	II. Wind load leading-28.5 m/sec	965	4590	-4501	-4771	2592	-3201	-3436	-656	982	-857	787	-767
	II.A. Wind load leading-29 m/sec	782	3301	-3441	-3581	1586	-2267	-2387	-403	666	-583	488	-497
	III. Temperature load leading	1559	4568	-4492	-4508	2498	-3130	-3205	-631	952	-806	753	-721
	Design Forces for G3	***1559***	***4937***	***-4783***	***-5027***	***2882***	***-3475***	***-3676***	***-722***	***1067***	***-925***	***872***	***-837***
	Quasi-permanent Combination	**1108**	**3195**	**-3340**	**-3308**	**1489**	**-2173**	**-2168**	**-370**	**627**	**-533**	**452**	**-452**

From the above talbe it is observed that Girder 1 is governing

The summary of Load Combination for Girder 2 and Girder 3 are given Annexure - 1

Forces Considered for girder Design

Description	Bending moment (kN.m)							Shear force (kN)				
	End span girder			*Inner span girder*				*End span girder*		*Inner span girder*		
	Sect. 1	Sect. 2	Sect. 3	Sect. 4	Sect. 5	Sect. 6	Sect. 7	Sect. 1	Sect. 3	Sect. 4	Sect. 6	Sect. 7
	Hogging	Sagging	Hogging	Hogging	Sagging	Hogging	Hogging					
ULS	-1714	10593	-9281	-8899	8038	-7076	-7128	-1755	2148	-2038	1840	-1919
SLS Rare	1559	6791	-7169	-6918	4498	-5448	-5486	-1224	1560	-1477	1326	-1378
SLS Quasi	1110	4195	-4954	-4817	2298	-3557	-3557	-682	999	-884	795	-795

4 Design of Girder

From the construction methodology envisaged in the section 1.2, precast RCC girders are proposed. The girders are designed as for the continuous action under service condition. The girders are supported over temporary supports before casting the diaphragm. At this point of time, the girder will be simply supported over temporary supports and the sagging bending moment calculations are shown below.

With the c/c of supports as 30m and assuming girder is being supported at 1.0m away from c/l of supports.

4.1 Self-Weight of Girder

Bending moment due to self wt. of girder placed over temporary support

For End span

Distance between temporary support	=30.000-1.00-1.00	=	28.000m
Bending moment		=	1577.80kNm
	Say	=	1,577.80kNm

For Inner span

Distance between temporary support	=30.00-1.00-1.00	=	28.00m
Bending moment		=	1577.80kNm
	Say	=	1577.80kNm

Reactions due to self-weight of the precast girder

For End span

Length of precast girder	=(30.0-0.000-0.98-1.10/2)+0.23×2	=	28.930m
Total weight of precast girder		=	465.77kN
Reactions due to self-weight of precast girder		=	232.89kN
	Say	=	232.90kN

For Inner span

Length of precast girder	=(30.0-1.10/2-1.10/2)+0.23×2	=	29.36m
Total weight of precast girder		=	472.70kN
Reactions due to self-weight of precast girder		=	236.35kN
	Say	=	236.40kN

It is suggested that the strength of concrete in girder at the time of pouring green concrete for diaphragm and in situ slab on the end panel shall be 45 MPa or the age of the girder shall be 21 days after casting whichever is later.

4.2 Design for service condition

The summary of the loads and moments for the girders are taken from the STAAD output and presented below.

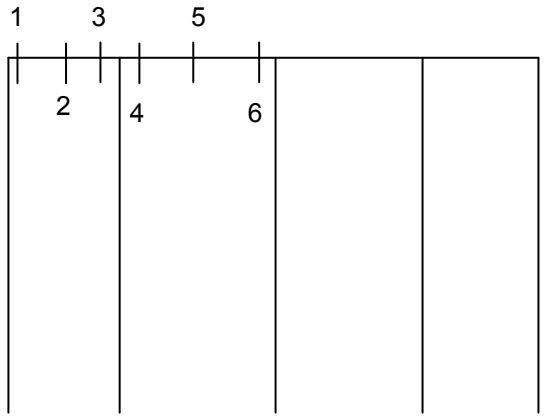


Figure 4-1 Schematic Sketch Showing Location of Sections for Moments and forces

Section	Distance
1	0.49m from end pier
2	15.0m from end pier
3	1.0m from inner pier
4	1.0m from inner pier
5	15.0m from inner pier
6	1.0m from inner pier

4.3 Design of RCC I Girder at Mid Span (Sagging)

4.3.1 Design parameters

c/c Distance Between End Diaphragm and Inner Diaphragm	l_0	=	29.66	m
c/c Distance Between Inner Diaphragms	l_0	=	30.00	m
Overall depth of girder (including deck slab)	D	=	2.230	m
Width of web	b_w	=	0.250	m
Thickness of deck slab	D_f	=	0.230	m
Width of Flange of Girder		=	3.500	m
Modulus of elasticity of steel	E_s		2.0E+05	N/mm^2
Modulus of elasticity of concrete	E_c		34000	N/mm^2
Modular Ratio (Long term)	m	=	11.76	
Grade of concrete	f_{ck}	=	M45	N/mm^2
Grade of steel reinforcement	f_y	=	Fe500	N/mm^2
Grade of steel considered for shear stirrups	f_{ywk}	=	Fe500	N/mm^2
Mean value of axial tensile strength of concrete	f_{ctm}	=	3.30	N/mm^2
			(IRC: 112-2011 Table 6.5)	

Permissible comp. stress in concrete (Rare Combinations)	0.48 x f_{ck}	=	21.6	N/mm^2
			(IRC: 112-2011 cl.no. 12.2.1)	
Permissible compressive stress in concrete (Quasi-permanent Combinations)	0.36 x f_{ck}	=	16.2	N/mm^2
			(IRC: 112-2011 cl.no. 12.2.1)	
Permissible Tensile stress in steel (Rare Combinations)	0.6 x f_y	=	300	N/mm^2
			(IRC: 112-2011 cl.no. 12.2.2)	

4.3.2 Design Forces and Moments in Longitudinal Girder G1 :

Description	BM (kN m)	
	Mid of End Span	Mid of intermediate Span
ULS- Basic combn.	10593	8038
SLS- Rare combn.	6791	4498
SLS- Quasi-permanent C	4195	2298

4.3.3 Check for stresses at various sections:

Description	Unit	Mid of End Span	Mid of intermediate Span
Width of the flange, b	mm	450	450
Width of the composite section (slab), b_f	mm	3500	3500
CG of section from Top,Y_t	mm	635	635
CG of section from Top of Flange,Y_{tf} (Composite)	mm	405	405
CG of section from bottom,Y_b	mm	1595	1595
Area of Steel Provided, A_{st}	mm^2	12566	10304
Effective Depth, d	mm	2118	2128
Lever arm, (d - 0.42 * X_u)	mm	2078	2095
Distance of N.A. from Compression fiber, X_u	mm	96	79
Distance of N.A. from tensile steel, (d - X_u)	mm	2022	2049
Distance of N.A. from Tension Fiber, (D - X_u)	mm	2134	2151

Properties of Gross Section	Unit	Mid of End Span	Mid of intermedia
Gross Area, A_{gr}	mm^2	1.42E+06	1.42E+06
Gross Moment of Inertia, I_{gr}	mm^4	7.56E+11	7.56E+11

Properties of Uncracked Transformed Section	Unit	Mid of End Span	Mid of intermedia to Span
CG of Uncracked section from Compression Fiber, Y_{tT}	mm	764	743
CG of Uncracked section from Top of Flange, Y_{tfT} (Composite	mm	534	513
CG of Uncracked section from bottom, Y_{bT}	mm	1466	1487
CG of Uncracked section from steel, Y_{sT}	mm	1354	1385
Uncracked Moment of Inertia, I_T	mm^4	1.03E+12	9.86E+11

4.3.4 Properties of Cracked Section

Calculation of C.G. of Cracked Transformed section from Top .Mid of intermediate Span Kd

Assume, C.G. lies within the slab

$b_f * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$

$3500 * Y^2_{tCr} / 2 = 11.76 * 10304 * (2128 - Kd)$

$1750\ Y^2_{tCr} + 1.21E+05\ Y_{tCr} - 2.58E+08 = 0$

$Y_{tCr} = 351$ mm

NA Lies in Web

Take, n = Depth of N.A. from bottom of slab

$b_f * D_f (Df / 2 + n) + b * n^2 / 2 = m * A_{st} * (d - (n + D_f))$

$3500 * 230 (230 / 2 + n) + 450 * n^2 / 2 = 11.76 * 10304 * (2128 - n - 230)$

$225\ n^2 + 926229\ n - 1.38E+08 = 0$

$n = 144$ mm

$Y_{tCr} = 374$ mm

NA Lies in Web

Assumption is Wrong

4.3.5 Calculation of C.G. of Cracked Transformed section from Top Mid of End Span Y_{tCr}

Assume, C.G. lies within the slab

$b_f * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$

$3500 * Y^2_{tCr} / 2 = 11.76 * 12566 * (2118 - YtCr)$

$1750\ Y^2_{tCr} + 1.48E+05\ Y_{tCr} - 3.13E+08 = 0$

$Y_{tCr} = 383$ mm

NA Lies in Web

Take, n = Depth of N.A. from bottom of slab

$b_f * D_f (Df / 2 + n) + b * n^2 / 2 = m * A_{st} * (d - (n + D_f))$

$3500 * 230 (230 / 2 + n) + 450 * n^2 / 2 = 11.76 * 12566 * (2118 - n - 230)$

$225\ n^2 + 952840\ n - 1.9E+08 = 0$

$n = 187$ mm

$Y_{tCr} = 417$ mm

NA Lies in Web

Properties of Cracked Transformed Section	Unit	Mid of End Span	Mid of intermediate Span
CG of Cracked section from Top, Y_{tCr}	mm	417	374
CG of Cracked section from Top of Flange, Y_{tfCr} (Composite)	mm	187	144
CG of Cracked section from bottom, Y_{bCr}	mm	1813	1856
CG of Cracked section from steel, Y_{sCr}	mm	1701	1755
Cracked Moment of Inertia, I_{cr}	mm^4	5.06E+11	4.31E+11

Stresses under Rare Combination	Unit	Mid of End Span	Mid of intermedia
Cracking Moment, M_{cr}	kN m	1169	1160
State of Section		Cracked	Cracked
Tensile stress in concrete at bottom fibre, fct	Mpa	9.69	6.79
Tensile stress in concrete at bottom fibre due to Differential sl	Mpa	0.45	0.45
Tensile stress in concrete at bottom fibre due to Temp.gradie	Mpa	0.92	0.92
Total tensile stress	Mpa	11.06	8.16
State of Section		Cracked	Cracked
Compressive stress in concrete, fc	Mpa	5.61	3.90
Compressive stress in concrete due to Differential shrinkage,	Mpa	-0.12	-0.12
Comp. stress in conc. at bott. fibre due to Temp.gradient, fct	Mpa	0.21	0.21
Total compressive stress	Mpa	5.70	3.99
Compressive stress check		SAFE	SAFE
Stress at top of the flange of girder	Mpa	2.5	1.5
Tensile stress in concrete at steel level, fct_{steel}	Mpa	22.84	18.31
Tensile stress in steel, fst	Mpa	268.66	215.41
Tensile steel Stress Check		SAFE	SAFE

Stresses under Quasi-permanent Combination	Unit	Mid of End Span	Mid of intermedia
Cracking Moment, M_{cr}	kN m	1169	1160
State of Section		Cracked	Cracked
Compressive stress in concrete, fc	Mpa	3.46	1.99
Compressive stress in concrete due to Differential shrinkage,	Mpa	-0.12	-0.12
Compressive stress in concrete at bottom fibre due to Temp.g	Mpa	0.11	0.11
Total compressive stress	Mpa	3.45	1.98
Compressive stress check		Linear Creep	Linear Creep
Tensile stress in concrete at steel level, fct_{steel}	Mpa	14.11	9.36
Tensile stress in steel, fst	Mpa	165.97	110.06

4.3.6 Design of Longitudinal Girder at Mid of Intermediate Span (Section 5 - Fig. 4.1)

4.3.6.1 Details of Reinforcement:

Layer No.	Dia of bar (mm)	No. of bars	Cover (mm)	Area (mm^2)	Area x cover
1	40	5	72	6283	452389
2	32	5	148	4021	595143
3	25	0	209	0	0
Total No.		10		10304	1047533

Area of tensile reinforcement provided		A_{st} prov	=	10304	mm^2
C.G of the steel from bottom of the girder	=1047533/10304	d'	=	102	mm
Effective depth of the girder	=2.230×1000-102	d	=	2128	mm
Effective width of the flange		b_f	=	3500	mm
Depth of the Flange		D_f	=	230	mm
Design Moment		M_u	=	8037.6	kN-m

Assume Depth of the N.A, $x_u = D_f$ and Calculate M_{ur1}

$M_{ur1} = 0.36 \times f_{ck} \times b_f \times D_f \times (d-0.42 \times D_f)$ $\quad M_{ur1}$ = = 26496 KN-m

N.A. lies in the slab

A_{st} reqd $= 0.5 \times f_{ck} / f_y \, (1 - \text{sqrt}(1 - 4.6 \times M_u/f_{ck} \times b_f \times d^2)) \times b_f \times d$

A_{st} reqd = 8801 mm^2

SAFE

4.3.6.2 **Check for longitudinal steel:**

Minimum steel:

$A_{S.min}$ = $0.26 \times f_{ctm} \times b_t \times d / f_{yk}$ (Refer IRC:112-2011, Cl 16.5.1.1, Eq 16.1)

But not less than,
$0.0013 \times b_t \times d$

where,

f_{ctm} = Mean value of axial tensile strength of concrete (Refer IRC:112-2011, Table-6.5)

b_t = Mean width of the tension zone (web width)

f_{yk} = Characteristic yield strength of the reinforcement

f_{ctm}	=	3.3	N / mm^2
b_t	=	250	mm
$A_{S.min}$	=	913	mm^2

SAFE

Maximum steel:

Tensile steel provided shall not be greater than 0.025 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

where, A_c = Cross-sectional area of concrete

A_c	=	1420000	mm^2
0.025 x A_c	=	35500	mm^2

SAFE

Also,

Total tension and compression reinforcement shall not exceed 0.04 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

Area of the compression steel = 17 Nos 25 dia = 8346 mm^2

Total tension and compression reinforcement = 18650 mm^2

0.04 x A_c = 56800 mm^2

SAFE

4.3.6.3 **Minimum Reinforcement for Crack control**

$$A_{s\,min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ (Refer IRC:112-2011, Cl 12.3.3)

Where,

$A_{s\,min}$ = Minimum area of reinforcing steel within the tensile zone

A_{ct} = Area of concrete within tensile zone

σ_s = Maximum stress permitted in the reinforcement immediately after formation of the crack

$f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}

k = Coefficient which allows for the effect of non-uniform self equilibrium stresses

k_c = Coefficient which takes account of stress distribution within the section just prior to cracking

$k_c = 0.4 \times [\ 1 - \sigma_c / (\ k_1 \times (\ h/h^*\ ) \times f_{ct,eff}\ )]$

A_{ct}	=	537736.22	mm^2
σ_s	=	160	N / mm^2
		(Refer IRC:112-2011, Table 12.2)	
$f_{ct,eff}$	=	3.30	N / mm^2
k	=	0.65	
σ_c	=	0	N / mm^2 For RCC
k_c	=	0.4	
$A_{s\ min}$	=	2884	mm^2
		SAFE	

4.3.6.4 Calculation of Crack Width at Mid-Span

$W_k = S_{r\ max}\ (\ \varepsilon_{sm} - \varepsilon_{cm}\ )$ (Refer IRC:112-2011, Cl 12.3.4)

Where,

W_k = Crack width

$S_{r\ max}$ = Maximum crack spacing (Refer Eq. 12.8, 12.11 or 12.12)

$S_{r\ max} = 3.4c + (\ 0.425 * k_1 * k_2 * \phi / \rho_{p,eff}\ )$

c = Clear cover to lonfitudnal reinforcement

c	=	40	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (\ k_t * f_{ct,eff} / \rho_{p,eff}\ )\ (\ 1 + \alpha_e * \rho_{p,eff}\ )}{E_s} >= 0.6\ \sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

$\alpha_e = E_s / E_{cm}$

$\rho_{p,eff} = A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)

= D - x / 3

= D / 2

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	254.15	mm
$A_{c,eff}$	=	63537	mm^2
$\rho_{p,eff}$	=	0.162	
k_t	=	0.5	
σ_{sc}	=	110.06	N / mm^2
$f_{ct,eff}$	=	3.30	N / mm^2
α_e	=	11.76	
$\varepsilon_{sm} - \varepsilon_{cm}$	=	0.0004	
$S_{r\ max}$	=	177.9	
W_k	=	0.0716	mm
		SAFE	

4.3.7 Design of Longitudinal Girder at Mid of End Span (Section 2 - Fig 4.1)

4.3.7.1 Details of Reinforcement:

Layer	Dia of bar	No. of	Cover (mm)	Area	Area x
1	**40**	**5**	**72**	6283	452389
2	**40**	**5**	152	6283	955044
3	**32**	**0**	228	0	0
4	**32**	**0**	292	0	0
5		**0**	340	0	0
Total No.		**10**		**12566**	**1407434**

Area of tensile reinforcement provided		A_{st} prov	=	12566	mm^2
C.G of the steel from bottom of girder	=1407434/12566	d'	=	112	mm
Effective depth of the girder	=2.230×1000-112	d	=	2118	mm
Effective width of the flange		b_f	=	3500	mm
Depth of the Flange		D_f	=	230	mm
Design Moment		M_u	=	10593	kN-m

Assume Depth of the N.A, $x_u = D_f$ and Calculate M_{ur1}

$Mur1 = 0.36 \times f_{ck} \times b_f \times D_f \times (d-0.42 \times D_f)$ = 26361 KN-m

N.A. lies in the slab

A_{st} reqd $= 0.5 \times f_{ck} / f_y \left(1 - \sqrt{1 - 4.6 \times M_u / f_{ck} \times b_f \times d^2}\right) \times b_f \times d$

A_{st} reqd = 11709 mm^2

SAFE

4.3.7.2 Check for longitudinal steel:

Minimum steel:

$A_{S.min}$ = $0.26 \times f_{ctm} \times b_t \times d / f_{yk}$ (Refer IRC:112-2011, Cl 16.5.1.1, Eq 16.1)

But not less than,
$0.0013 \times b_t \times d$

where, f_{ctm} = Mean value of axial tensile strength of concrete (Refer IRC:112-2011, Table-6.5)

b_t = Mean width of the tension zone (web width)

f_{yk} = Characteristic yield strength of the reinforcement

f_{ctm}	=	3.3	N / mm^2
b_t	=	250	mm
$A_{S.min}$	=	909	mm^2

SAFE

Maximum steel:

Tensile steel provided shall not be greater than 0.025 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

where, A_c = Cross-sectional area of concrete

A_c	=	1420000	mm^2
$0.025 \times A_c$	=	35500	mm^2

SAFE

Also, Total tension and compression reinforcement shall not exceed 0.04 x Ac

(Refer IRC:112-2011, Cl 16.5.1.1)

Area of the compression steel	=	17 Nos	16 dia	=	3418 mm^2
Total tension and compression reinforcement				=	15985 mm^2
			$0.04 \times A_c$	=	56800 mm^2

SAFE

4.3.7.3 Minimum Reinforcement for Crack control

$$A_{s\,min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ (Refer IRC:112-2011, Cl 12.3.3)

Where,
- $A_{s\,min}$ = Minimum area of reinforcing steel within the tensile zone
- A_{ct} = Area of concrete within tensile zone
- σ_s = Maximum stress permitted in the reinforcement immediately after formation of the crack
- $f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}
- k = Coefficient which allows for the effect of non-uniform self equilibrium stresses
- k_c = Coefficient which takes account of stress distribution within the section just prior to cracking
  $k_c = 0.4 \times [\,1 - \sigma_c / (\,k_1 \times (\,h/h^*\,) \times f_{ct,eff}\,)]$

A_{ct}	=	533397.83	mm^2
σ_s	=	160	N / mm^2
		(Refer IRC:112-2011, Table 12.2)	
$f_{ct,eff}$	=	3.30	N / mm^2
k	=	0.65	
σ_c	=	0	N / mm^2 For RCC
k_c	=	0.4	

$A_{s\,min}$	=	2860	mm^2
		SAFE	

4.3.7.4 Calculation of Crack Width at Mid-Span

$$W_k = S_{r\,max}\,(\,\varepsilon_{sm} - \varepsilon_{cm}\,)$$ (Refer IRC:112-2011, Cl 12.3.4)

Where,
- W_k = Crack width
- $S_{r\,max}$ = Maximum crack spacing (Refer Eq. 12.8, 12.11 or 12.12)
- $S_{r\,max} = 3.4c + (\,0.425 * k_1 * k_2 * \phi / \rho_{p,eff}\,)$
- c = Clear cover to lonfitudnal reinforcement

c	=	40	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

- ε_{sm} = Mean strain in the reinforcement
- ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (\,k_t * f_{ct,eff} / \rho_{p,eff}\,)\,(\,1 + \alpha_e * \rho_{p,eff}\,)}{E_s} >= 0.6\,\sigma_{sc} / E_s$

Where,
- σ_{sc} = Stress in the tension reinforcement assuming a cracked section
- α_e = E_s / E_{cm}
- $\rho_{p,eff}$ = $A_s / A_{c,eff}$
- $A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$
  - $h_{c,eff}$ is the lesser of = $2.5\,(\,D - d\,)$
  - = $D - x / 3$
  - = $D / 2$
- k_t = Factor dependent on duration of load

$h_{c,eff}$	=	280.00	mm
$A_{c,eff}$	=	70000	mm^2
$\rho_{p,eff}$ =	=	0.180	
k_t	=	0.5	
σ_{sc}	=	165.97	N / mm^2
$f_{ct,eff}$	=	3.30	N / mm^2
α_e	=	11.76	

$\varepsilon_{sm} - \varepsilon_{cm}$ = 0.0007

$S_{r\,max}$ = 173.9

W_k = 0.1194 mm

SAFE

4.3.8 **Check for Deflection**

Max Deflection Due to Live Load = 13.3 mm For 70R Most Ecc - Node 164-LC 212

Max Deflection Dead load = 23.896 mm

Max Deflection SIDL = 6.82 mm

Max Allowable Deflection as per Cl. 12.4.1 IRC 112-2011 for Vehicular Traffic = Span / 800

37.50 mm

Ok

4.4 Design of RCC I Girder at Supports (Hogging)

4.4.1 Design parameters

c/c Distance Between End Diaphragm and Inner Diaphragm	l_0	=	29.66	m
c/c Distance Between Inner Diaphragms	l_0	=	30.00	m
Overall depth of girder (including deck slab)	D	=	2.230	m
Depth of flange	D_{f1}	=	0.250	m
Thickness of deck slab	D_f	=	0.230	m
Width of Flange of end Girder-G1		=	3.500	m
Width of Flange of Inner Girder-G2		=	3.000	m
Modulus of elasticity of steel	E_s		2.0E+05	N/mm^2
Modulus of elasticity of concrete	E_c		34000	N/mm^2
Modular Ratio (Long term)	m	=	11.76	
Grade of concrete	f_{ck}	=	M45	N/mm^2
Grade of steel reinforcement	f_y	=	Fe500	N/mm^2
Grade of steel considered for shear stirrups	f_{ywk}	=	Fe500	N/mm^2
Mean value of axial tensile strength of concrete	f_{ctm}	=	3.20	N/mm^2
		(IRC: 112-2011 Table 6.5)		
Permissible comp. stress in concrete (Rare Combinations)	0.48 x f_{ck}	=	21.6	N/mm^2
		(IRC: 112-2011 cl.no. 12.2.1)		
Permissible compressive stress in concrete (Quasi-permanent Combinations)	0.36 x f_{ck}	=	16.2	N/mm^2
		(IRC: 112-2011 cl.no. 12.2.1)		
Permissible Tensile stress in steel (Rare Combinations)	0.6 x f_y	=	300	N/mm^2
		(IRC: 112-2011 cl.no. 12.2.2)		

4.4.2 Design Forces and Moments in Longitudinal Girder G1 :

Descreption	BM (kN m)		SF (kN)		
	End Support	Intermediate Support	End Support	Intermediate Support	
				Near End Span	Near Mid Span
ULS- Basic combn.	1714	9281	1755	2148	2038
SLS- Rare combn.	1559	7169	1224	1560	1477
SLS- Quasi-permanent Com	1110	4954	682	999	884

4.4.3 Check for stresses at various sections:

Description	Unit	End Support	Intermediate Support
Width of compression flange, b	mm	550	550
Width of the composite section (slab), b_f	mm	550	550
CG of section from Top,Y_t	mm	1595	1595
CG of section from Top of Flange,Y_{tf} (Composite)	mm	1595	1595
CG of section from bottom,Y_b	mm	635	635
Area of Steel Provided, A_{st}	mm^2	3418	11763
Effective Depth, d	mm	2170	2167
Lever arm, (d - 0.42 * X_u)	mm	2100	1831
Distance of N.A. from Compression fiber, X_u	mm	167	798
Distance of N.A. from tensile steel, (d - X_u)	mm	2003	1368
Distance of N.A. from Tension Fiber, (D - X_u)	mm	2063	1432

Properties of Gross Section	Unit	End Support	Intermediate Support
Gross Area, A_{gr}	mm^2	1.42E+06	1.42E+06
Gross Moment of Inertia, I_{gr}	mm^4	7.56E+11	7.56E+11

Properties of Uncracked Transformed Section	Unit	End Support	Intermediate Support
CG of Uncracked section from Compression Fiber, Y_{tT}	mm	1609	1642
CG of Uncracked section from Top of Flange, Y_{tfT} (Composite	mm	1609	1642
CG of Uncracked section from bottom, Y_{bT}	mm	621	588
CG of Uncracked section from steel, Y_{sT}	mm	561	525
Uncracked Moment of Inertia, I_T	mm^4	7.68E+11	7.94E+11

4.4.4 Properties of Cracked Section

Calculation of C.G. of Cracked Transformed section from Top Intermediate Support Y_{tCr}

Assume, C.G. lies within the slab

$b_f * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$

$550 * Y^2_{tCr} / 2 = 11.76 * 11763 * (2167 - YtCr)$

$275\ Y^2_{tCr} + 1.38E+05\ Y_{tCr} - 3.00E+08 = 0$

$Y_{tCr} = 822$ mm

N.A. lies within the Web

Take, n = Depth of N.A. from bottom of slab

$b_f * D_f (Df / 2 + n) + b * n^2 / 2 = m * A_{st} * (d - (n + D_f))$

$550 * 250 (250 / 2 + n) + 250.000 * n^2 / 2 = 11.76 * 11763 * (2167 - n - 230)$

$125\ n^2 + 275887\ n - 2.48E+08 = 0$

$n = 686$ mm

$Y_{tCr} = 916$ mm

4.4.5 Calculation of C.G. of Cracked Transformed section from Top End Support Y_{tCr}

Assume, C.G. lies within the slab

$b_f * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$

$550 * Y^2_{tCr} / 2 = 11.76 * 3418 * (2170 - YtCr)$

$275\ Y^2_{tCr} + 4.02E+04\ Y_{tCr} - 8.73E+07 = 0$

$Y_{tCr} = 495$ mm

N.A. lies within the Web

Take, n = Depth of N.A. from bottom of slab

$b_f * D_f (Df / 2 + n) + b * n^2 / 2 = m * A_{st} * (d - (n + D_f))$

$550 * 250 (250 / 2 + n) + 250.000 * n^2 / 2 = 11.76 * 3418 * (2170 - n - 250)$

$125\ n^2 + 177712\ n - 61395281 = 0$

$n = 287$ mm

$Y_{tCr} = 517$ mm

Properties of Cracked Transformed Section	Unit	End Support	Intermediate Support
CG of Cracked section from Top, Y_{tCr}	mm	517	916
CG of Cracked section from Top of Flange, Y_{tfCr} (Composite)	mm	517	916
CG of Cracked section from bottom, Y_{bCr}	mm	1713	1314
CG of Cracked section from steel, Y_{sCr}	mm	1653	1251
Cracked Moment of Inertia, I_{cr}	mm^4	1.35E+11	3.57E+11

Stresses under Rare Combination	Unit	End Support	Intermediate Support
Cracking Moment, M_{cr}	kN m	1173	1690
State of Section		Cracked	Cracked
Tensile stress in concrete at bottom fibre, fct	Mpa	1.26	5.31
Tensile stress in concrete at bottom fibre due to Differential s	Mpa	0.44	0.44
Tensile stress in concrete at bottom fibre due to Temp.gradie	Mpa	0.90	0.90
Total tensile stress	Mpa	2.60	6.65
State of Section		Uncracked	Cracked
Compressive stress in concrete, fc	Mpa	3.27	18.37
Compressive stress in concrete due to Differential shrinkage	Mpa	-0.15	-0.12
Comp. stress in conc. at bott. fibre due to Temp.gradient, fct	Mpa	1.69	1.69
Total compressive stress	Mpa	4.81	19.95
Compressive stress check		SAFE	SAFE
Stress at top of the flange of girder	Mpa	3.3	18.4
Tensile stress in concrete at steel level, fct_{steel}	Mpa	1.14	25.09
Tensile stress in steel, fst	Mpa	13.39	295.15
Tensile steel Stress Check		SAFE	SAFE

Stresses under Quasi-permanent Combination	Unit	End Support	Intermediate Support
Cracking Moment, M_{cr}	kN m	1173	1690
State of Section		Uncracked	Cracked
Compressive stress in concrete, fc	Mpa	2.33	12.70
Compressive stress in concrete due to Differential shrinkage	Mpa	-0.15	-0.12
Compressive stress in concrete at bottom fibre due to Temp	Mpa	0.84	0.84
Total compressive stress	Mpa	3.02	13.43
Compressive stress check		Linear Creep	Linear Creep
Tensile stress in concrete at steel level, fct_{steel}	Mpa	0.81	17.34
Tensile stress in steel, fst	Mpa	9.53	203.98

4.4.6 Design of Longitudinal Girder at Intermediate Support (Section 4 - Fig 4.1)

4.4.6.1 Details of Reinforcement:

Layer No.	Dia of bar	No. of	Cover	Area	Area x
1	**25**	**17**	**65**	8345	538243
2	**16**	**17**	60	3418	205083
3	**20**	**0**	94	0	0
4	**25**	**0**	137	0	0
5	**25**	**0**	187	0	0
Total No.		**34**		**11763**	**743326**

Area of tensile reinforcement provided — A_{st} prov = 11763 mm^2

C.G of the steel from Top of girder =743326/11763 — d' = 63 mm

Effective depth of the girder	=2.230×1000-63	d	=	2167	mm
Effective width of the flange		b_f	=	550	mm
Width of Web		bw	=	250	
Depth of the Flange		D_f	=	250	mm
Design Moment		M_u	=	9281	kN-m

Assume Depth of the N.A, $x_u = D_f$ and Calculate M_{ur1}

Mur1 = 0.36 x f_{ck} x b_f x D_f x (d-0.42 x D_f) = 4593 KN-m

N.A. lies in Web

Assumind 3/7 Xu > Df

Mu = 0.36* fck * bw * Xu * (d-0.416Xu) + 0.447 fck * (bf - bw) * yf * (d-yf/2)

4050 Xu*(2154 - 0.416*Xu)+ 905.18 Xu + 980606.25 *(2154-(0.15Xu+0.65*Df)/2)

-1684.8 Xu^2 + 8775571 Xu + 2.045E+09

Mu = -135.776 Xu^2 -147091 Xu

1887795 Xu

9280769075 = -1820.58 Xu^2 + 1.1E+07 Xu + 2.045E+09

-1820.58 Xu^2 + 1.1E+07 Xu + -7.24E+09 = 0

Check 5.79E+13 **OK**

Xu = 798.397

3/7 Xu = 342.17 Ok

Assuming Df>3/7Xu

Mu = 0.36* fck * bf * Xu * (d-0.416Xu) + 0.447 fck * (bf - bw) * Df*(d-Df/2)

9280769075 = 4050 Xu*(1830 - 0.416*Xu)· 3.08E+09

0 = -1684.8 Xu^2 + 8775571 Xu + -6.20E+09

Check 3.52E+13 **OK**

Xu = 842.99

3/7 Xu = 361.282 Revise Xu

Xu = 842.9903

Area of Steel Required

0.87*fy*Ast = 0.36* fck * bw * Xu + 0.447 fck * (bf - bw) * Df

0.87*500*Ast = 4.74E+06

Ast = 10901.46 mm^2

Reinforcement Provided is Sufficient

4.4.6.2 Check for longitudinal steel:

Minimum steel:

$A_{S.min}$ = 0.26 x f_{ctm} x b_t x d /f_{yk} (Refer IRC:112-2011, Cl 16.5.1.1, Eq 16.1)

But not less than,
0.0013 x b_t x d

where,
f_{ctm} = Mean value of axial tensile strength of concrete (Refer IRC:112-2011, Table-6.5)
b_t = Mean width of the tension zone (web width)
f_{yk} = Characteristic yield strength of the reinforcement

f_{ctm}	=	3.2	N / mm^2
b_t	=	250	mm
$A_{S.min}$	=	901	mm^2

SAFE

Maximum steel:

Tensile steel provided shall not be greater than 0.025 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

where, A_c = Cross-sectional area of concrete

A_c = 1420000 mm^2

0.025 x A_c = 35500 mm^2

SAFE

Also, Total tension and compression reinforcement shall not exceed 0.04 x Ac

(Refer IRC:112-2011, Cl 16.5.1.1)

Area of the compression steel = 5 Nos 40 dia = 6284 mm^2

Total tension and compression reinforcement = 18047 mm^2

0.04 x A_c = 56800 mm^2

SAFE

4.4.6.3 Check for Shear at intermediate support

Design shear force,

V_{Ed} = 2148 kN

V_{ccd} = 0 kN For Uniform cross sectio

V_{td} = 0 kN For Uniform cross sectio

$V_{Rd\,s}$ = V_{NS} = 2148 kN

Maximum Allowabe Shear Force (for maximum shear force take Θ = 45 ^{0})

$V_{Rd.max}$ = $\alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ (Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)

where,

αcw = 1 (For RCC)

z = lever arm = 0.9d (For RCC)

v_1 is the strength reduction factor for concrete cracked in shear

v_1 = 0.60 for fck<=80Mpa

Θ = 45 (CotΘ = 1)

fcd is the design value of concrete compression strength =$\alpha_{cc} \times fck / \gamma_m$

α_{cc} = 0.67 (Refer IRC:112-2011, Pg.87)

γ_m = 1.50 (Partial factors for concrete for ULS)

$V_{Rd.max}$ = 2940 kN

Section is Safe

Allowable Shear Force without Shear Reinforcement

$V_{Rd\,c}$ = $(0.12 \times K (80 \times \rho_1 \times fck)^{0.33} + 0.15 \times \sigma_{cp}) b_w \times d$ (Refer IRC:112-2011, Cl 10.3.2(2))

But, $V_{Rd.c\,min}$ = $(v_{min} + 0.15 \times \sigma_{cp}) b_w \times d$

where,

K = 1+sqrt(200/d) <=2, where d is the depth in mm.

$V_{Rd\,c}$ = The design shear resistance of the member without shear reinforcement.

v_{min} = $0.031 \times K^{3/2} \times fck^{1/2}$

σ_{cp} = Concrete compressive stress at the centroidal axis due to axial loading or prestressing.

ρ_1 = Reinforcement ratio for longitudinal reinforcement , = $A_{st}/(b_w \times d)$ <=0.02

K = 1.3

ρ_1 = 0.0200

σ_{cp} = 0 For RCC

$V_{Rd\,c}$ = 348 kN

$V_{Rd\,c\,min}$ = 167.7 kN

shear reinforcement is required

Minimum Shear Force (for minimum shear force take Θ = 21.8 ^{0})

$V_{Rd.min}$ = $\alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ (Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)

where,
αcw = 1 (For RCC)
z = lever arm = 0.9d (For RCC)
v_1 is the strength reduction factor for concrete cracked in shear
v_1 = 0.60 for fck<=80Mpa
Θ = 21.8 (CotΘ = 2.5)
fcd is the design value of concrete compression strength = $\alpha_{cc} \times fck / \gamma_m$
α_{cc} = 0.67 (Refer IRC:112-2011, Pg.87)
γ_m = 1.50 (Partial factors for concrete for ULS)

$V_{Rd.min}$ = 2027 kN

Determine the value of 'Θ'

Design of Shear Reinforcement

$V_{Rd.s}$ = The design value of the shear force which can be sustained by yielding shear reinforcement.

$V_{Rd.s}$ = $(A_{sw}/s) * z * fywd * \cot\theta$ (Refer IRC:112-2011, Cl 10.3.3.2, Eq10.7)

where,
A_{sw} = The c/s area of the shear reinforcement
s = The spacing of the stirrups
f_{ywd} = The design yield strength of the shear reinforcement = $0.8 * f_{ywk}$

Provide 2L 12mm dia stirrups
A_{sw} = 226 mm^2
s = Spacing required = 205 mm
Spacing provided = 120 mm
SAFE

Hence provide 2L 12mm dia at 120mm c/c

Area of shear reinforcement provided = $A_{st, shear}$ = 1885 mm^2

Reinforcement ratio for shear reinforcement, σ_w = 0.0035

Check for minimum shear reinforcement:
Minimum shear reinforcement ratio, σ_{min} =
(0.072 x sqrt (fck)) / f_{yk} = $\frac{A_{sw}}{b_w \times s}$ (Refer IRC:112-2011, Cl 10.3.3.5)

where,
f_{yk} = The characteristic yield strength of steel
s = The spacing of the stirrups
A_{sw} = The c/s area of the shear reinforcement
σ_{min} = 0.0010
SAFE

4.4.6.4 Check for Interface Shear at intermediate Support

Let, find the interface shear stress per m length = *l* = 1000 mm

Interface Shear Stress
V_{Edi} = $\beta * V_{Ed} / z * b_i$ (Refer IRC:112-2011, Cl 10.3.4)
Where,
V_{Edi} = Design value of the shear stress in the interface
b = Ratio of the longitudinal force in new concrete area and the total longitudinal force either in compression or tension zone
V_{Ed} = Transverse shear force

z = Lever arm of composite section
b_i = Width of the interface

β	=	1	since, $X_u < D_f$
V_{Ed}	=	2148	kN
z	=	1368	mm
b_i	=	450	mm
V_{Edi}	=	3.488	N/mm^2

Resisting Capacity of the Section

V_{Rdi} = $\mu * \sigma_n + r * f_{yd} [\mu \sin\alpha + \cos\alpha]$ <= $0.5 * \nu * f_{cd}$

Where,
V_{Rdi} = Design shear resistance at the interface
σ_n = stress per unit area caused by the minimum external normal force across the interface that can act simultaneously with the shear force

< 0.6 fcd

f_{yd} = Design yeild strength of the reinforcement = $0.8 * f_{ywk}$
α = Angle of the reinforcement to the interface
r = A_s / A_j
A_s = Area of reinforcement crossing the interface
A_j = Area of the joint

Area of girder	=	A_G	=	615000	mm^2
Self weight of girder	=	W_G	=	15.4	kN
		μ	=	0.6	
		f_{cd}	=	20.1	N/mm^2
		σ_n	=	4.738	N/mm^2
		f_{yd}	=	435	N/mm^2
		α	=	90	

Provide 2L 12mm @ 120 mm

A_s	=	1885	mm^2
$A_{s\,min}$	=	675	mm^2
			SAFE
A_j	=	450000	mm^2
ρ	=	0.00419	
ν	=	0.60	for fck<=80Mpa
V_{Rdi}	=	3.9363	N/mm^2
			SAFE

4.4.6.5 Minimum Reinforcement for Crack control

$$A_{s\,min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ (Refer IRC:112-2011, Cl 12.3.3)

Where,
$A_{s\,min}$ = Minimum area of reinforcing steel within the tensile zone
A_{ct} = Area of concrete within tensile zone
σ_s = Maximum stress permitted in the reinforcement immediately after formation of the crack
$f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}
k = Coefficient which allows for the effect of non-uniform self equilibrium stresses
k_c = Coefficient which takes account of stress distribution within the section just prior to cracking
$k_c = 0.4 \times [1 - \sigma_c / (k_1 \times (h/h^*) \times f_{ct,eff})]$

A_{ct}	=	557300.4	mm^2
σ_s	=	160	N / mm^2

(Refer IRC:112-2011, Table 12.2)

$f_{ct,eff}$	=	3.20	N / mm^2	
k	=	0.65		
σ_c	=	0	N / mm^2	For RCC
k_c	=	0.4		
$A_{s\ min}$	=	2898	mm^2	

SAFE

4.4.6.6 Calculation of Crack Width at Intermediate Support

$W_k = S_{r\ max} (\varepsilon_{sm} - \varepsilon_{cm})$ (Refer IRC:112-2011, Cl 12.3.4)

Where,

W_k = Crack width

$S_{r\ max}$ = Maximum crack spacing (Refer Eq. 12.8, 12.11 or 12.12)

$S_{r\ max} = 3.4c + (0.425 * k_1 * k_2 * \phi / \rho_{p,eff})$

c = Clear cover to lonfitudnal reinforcement

c	=	40	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\ \sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

$\alpha_e = E_s / E_{cm}$

$\rho_{p,eff} = A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)

= D - x / 3

= D / 2

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	157.98	mm
$A_{c,eff}$	=	552933	mm^2
$\rho_{p,eff}$ =	=	0.021	
k_t	=	0.5	
σ_{sc}	=	203.98	N / mm^2
$f_{ct,eff}$	=	3.20	N / mm^2
α_e	=	11.76	
$\varepsilon_{sm} - \varepsilon_{cm}$	=	0.0006	
$S_{r\ max}$	=	335.8	
W_k	=	0.2055	mm

SAFE

4.4.7 Design of Longitudinal Girder at End Support (Section 1 -Fig 4.1)

4.4.7.1 Details of Reinforcement:

Layer No.	Dia of bar	No. of	Cover	Area	Area x
1	**16**	**17**	**60**	3418	205083
2	**12**	**0**	58	0	0
3	**12**	**0**	82	0	0
4		**0**	100	0	0

5		**0**	100	0	0
Total No.		**17**		**3418**	**205083**

Area of tensile reinforcement provided — A_{st} prov = 3418 mm^2
C.G of the steel from bottom of girder =205083/3418 — d' = 60 mm
Effective depth of the girder =2.230×1000-60 — d = 2170 mm
Effective width of the flange — b_f = 550 mm
Depth of the Flange — D_f = 250 mm
Design Moment — M_u = 1714 kN-m

Assume Depth of the N.A, $x_u = D_f$ and Calculate M_{ur1}

Mur1 = 0.36 x f_{ck} x b_f x D_f x (d-0.42 x D_f) = 4600 KN-m

N.A. lies in the slab

Xu = 167 mm

A_{st} reqd = 0.5 x f_{ck} / f_y (1 - sqrt(1 - 4.6 x M_u/f_{ck} x b_f x d^2) x b_f x d

A_{st} reqd = 1849 mm^2

SAFE

4.4.7.2 Check for longitudinal steel:

Minimum steel:

$A_{S.min}$ = 0.26 x f_{ctm} x b_t x d /f_{yk} (Refer IRC:112-2011, Cl 16.5.1.1, Eq 16.1)

But not less than,
0.0013 x b_t x d

where, f_{ctm} = Mean value of axial tensile strength of concrete (Refer IRC:112-2011, Table-6.5)
b_t = Mean width of the tension zone (web width)
f_{yk} = Characteristic yield strength of the reinforcement

f_{ctm} = 3.2 N / mm^2
b_t = 250 mm
$A_{S.min}$ = 903 mm^2

SAFE

4.4.7.3 Maximum steel:

Tensile steel provided shall not be greater than 0.025 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

where, A_c = Cross-sectional area of concrete

A_c = 1420000 mm^2
0.025 x A_c = 35500 mm^2

SAFE

Also, Total tension and compression reinforcement shall not exceed 0.04 x Ac
(Refer IRC:112-2011, Cl 16.5.1.1)

Area of the compression steel = 5 Nos 40 dia = 6284 mm^2

Total tension and compression reinforcement = 9702 mm^2

0.04 x A_c = 56800 mm^2

SAFE

4.4.7.4 Check for shear at End Support

Design shear force, V_{Ed} = 1755 kN
V_{ccd} = 0 kN For Uniform cross sectio
V_{td} = 0 kN For Uniform cross sectio
$V_{Rd\,s}$ = V_{NS} = 1755 kN

Maximum Allowabe Shear Force (for maximum shear force take Θ = 45 ^{0})

$V_{Rd.max}$ = $\alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ (Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)

where,

αcw =	1	(For RCC)
z = lever arm =	0.9d	(For RCC)

v_1 is the strength reduction factor for concrete cracked in shear

v_1 =	0.60	for fck<=80Mpa
Θ =	45	(CotΘ = 1)

fcd is the design value of concrete compression strength =$\alpha_{cc} \times fck / \gamma_m$

α_{cc} =	0.67	(Refer IRC:112-2011, Pg.87)
γ_m =	1.50	(Partial factors for concrete for ULS)

$V_{Rd.max}$ = 2944 kN

Section is Safe

Allowable Shear Force without Shear Reinforcement

$V_{Rd\,c}$ = $(0.12 \times K (80 \times \rho_1 \times fck)^{0.33} + 0.15 \times \sigma_{cp}) b_w \times d$ (Refer IRC:112-2011, Cl 10.3.2(2))

But, $V_{Rd.c\,min}$ = $(v_{min} + 0.15 \times \sigma_{cp}) b_w \times d$

where,

K = 1+sqrt(200/d) <=2, where d is the depth in mm.

$V_{Rd\,c}$ = The design shear resistance of the member without shear reinforcement.

v_{min} = $0.031 \times K^{3/2} \times fck^{1/2}$

σ_{cp} = Concrete compressive stress at the centroidal axis due to axial loading or prestressing.

ρ_1 = Reinforcement ratio for longitudinal reinforcement , = $A_{st}/(b_w \times d)$ <=0.02

K	=	1.3	
ρ_1	=	0.0063	
σ_{cp}	=	0	For RCC

$V_{Rd\,c}$	=	238 kN
$V_{Rd\,c\,min}$	=	167.9 kN

shear reinforcement is required

Minimum Shear Force (for minimum shear force take Θ = 21.8 ^{0})

$V_{Rd.min}$ = $\alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ (Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)

where,

αcw =	1	(For RCC)
z = lever arm =	0.9d	(For RCC)

v_1 is the strength reduction factor for concrete cracked in shear

v_1 =	0.60	for fck<=80Mpa
Θ =	21.8	(CotΘ = 2.5)

fcd is the design value of concrete compression strength =$\alpha_{cc} \times fck / \gamma_m$

α_{cc} =	0.67	(Refer IRC:112-2011, Pg.87)
γ_m =	1.50	(Partial factors for concrete for ULS)

$V_{Rd.min}$ = 2030 kN

Take CotΘ = 2.5 and find Shear Reinforcemer

Design of Shear Reinforcement

$V_{Rd.s}$ = The design value of the shear force which can be sustained by yielding shear reinforcement.

$V_{Rd.s}$ = $(A_{sw}/s) * z * fywd * \cot\theta$ (Refer IRC:112-2011, Cl 10.3.3.2, Eq10.7)

where, A_{sw} = The c/s area of the shear reinforcement

s = The spacing of the stirrups
f_{ywd} = The design yield strength of the shear reinforcement = $0.8f_{ywk}$

Provide 2L 12mm dia stirrups

A_{sw} = 226 mm^2

s = Spacing required = 252 mm

Spacing provided = 200 mm

SAFE

Hence provide 2L 12mm dia at 200mm c/c

Area of shear reinforcement provided = $A_{st,\ shear}$ = 1131 mm^2

Reinforcement ratio for shear reinforcement, σ_w = 0.0021

Check for minimum shear reinforcement:

Minimum shear reinforcement ratio, σ_{min} =

$$(0.072 \times \sqrt{f_{ck}}) / f_{yk} = \frac{A_{sw}}{b_w \times s}$$ (Refer IRC:112-2011, Cl 10.3.3.5)

where, f_{yk} = The characteristic yield strength of steel

s = The spacing of the stirrups

A_{sw} = The c/s area of the shear reinforcement

σ_{min} = 0.0010

SAFE

4.4.7.5 Check for Interface Shear at end Support

Let, find the interface shear stress per m length = l = 1000 mm

Interface Shear Stress

V_{Edi} = $\beta * V_{Ed} / z * b_i$ (Refer IRC:112-2011, Cl 10.3.4)

Where, V_{Edi} = Design value of the shear stress in the interface

b = Ratio of the longitudinal force in new concrete area and the total longitudinal force either in compression or tension zone

V_{Ed} = Transverse shear force

z = Lever arm of composite section

b_i = Width of the interface

β = 1 since, $X_u < D_f$

V_{Ed} = 2148 kN

z = 2003 mm

b_i = 450 mm

V_{Edi} = 2.383 N/mm^2

Resisting Capacity of the Section

V_{Rdi} = $\mu * \sigma_n + r * f_{yd} [\ \mu \sin\alpha + \cos\alpha\ ]$ <= $0.5 * v * f_{cd}$

Where, V_{Rdi} = Design shear resistance at the interface

σ_n = stress per unit area caused by the minimum external normal force across the interface that can act simultaneously with the shear force

< 0.6 fcd

f_{yd} = Design yeild strength of the reinforcement = $0.8 * f_{ywk}$

α = Angle of the reinforcement to the interface

r = A_s / A_j

A_s = Area of reinforcement crossing the interface

A_j = Area of the joint

Area of girder = A_G = 615000 mm^2

Self weight of girder = W_G = 15.4 kN

μ	=	0.6	
f_{cd}	=	20.1	N/mm^2
σ_n	=	4.738	N/mm^2
f_{yd}	=	400	N/mm^2
α	=	90	

Provide 2L 12mm @ 200 mm

A_s	=	1131	mm^2
$A_{s\,min}$	=	675	mm^2
			SAFE
A_j	=	450000	mm^2
ρ	=	0.00251	
v	=	0.60	for fck<=80Mpa
V_{Rdi}	=	3.4462	N/mm^2
			SAFE

4.4.7.6 Minimum Reinforcement for Crack control

$$A_{s\,min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ (Refer IRC:112-2011, Cl 12.3.3)

Where,
- $A_{s\,min}$ = Minimum area of reinforcing steel within the tensile zone
- A_{ct} = Area of concrete within tensile zone
- σ_s = Maximum stress permitted in the reinforcement immediately after formation of the crack
- $f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}
- k = Coefficient which allows for the effect of non-uniform self equilibrium stresses
- k_c = Coefficient which takes account of stress distribution within the section just prior to cracking

$k_c = 0.4 \times [\,1 - \sigma_c / (\,k_1 \times (\,h/h^*\,) \times f_{ct,eff}\,)]$

A_{ct}	=	515781.34	mm^2
σ_s	=	160	N / mm^2
		(Refer IRC:112-2011, Table 12.2)	
$f_{ct,eff}$	=	3.20	N / mm^2
k	=	0.65	
σ_c	=	0	N / mm^2 For RCC
k_c	=	0.4	
$A_{s\,min}$	=	2682	mm^2
			SAFE

4.4.7.7 Calculation of Crack Width at End Support

$$W_k = S_{r\,max}\,(\,\varepsilon_{sm} - \varepsilon_{cm}\,)$$ (Refer IRC:112-2011, Cl 12.3.4)

Where,
- W_k = Crack width
- $S_{r\,max}$ = Maximum crack spacing (Refer Eq. 12.8, 12.11 or 12.12)
- $S_{r\,max}$ = $3.4c + (\,0.425 * k_1 * k_2 * \phi / \rho_{p,eff}\,)$
- c = Clear cover to lonfitudnal reinforcement

c	=	40	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

- ε_{sm} = Mean strain in the reinforcement
- ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s} >= 0.6\ \sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = $2.5 (D - d)$

= $D - x / 3$

= $D / 2$

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	150.00	mm
$A_{c,eff}$	=	450000	mm^2
$\rho_{p,eff}$ =	=	0.008	
k_t	=	0.5	
σ_{sc}	=	9.53	N / mm^2
$f_{ct,eff}$	=	3.20	N / mm^2
α_e	=	11.76	
$\varepsilon_{sm} - \varepsilon_{cm}$	=	2.86E-05	
$S_{r\,max}$	=	494.1	
W_k	=	0.0141	mm

SAFE

4.4.8 Design of Shear Connectors at Intermediate Support

Properties of Composite Section

Moment of Inertia of Composite Section	=	0.794	m^4
Distance of Neutral axis from Top Compression fac	=	0.798	m
Area of Concrete under Compression	=	0.439118	m^2
Distance of Centroid of concrete area under compression from top compression face	=	1.642	m
Shear Due to SIDL	=	335.895	kN
Shear Due to LL	=	555	kN
Total Vertical Shear =335.895×1.75+1.5×555	=	1419.676	kN

Design Longitudinal Shear V*Ac*Y/I

661.924 kN

Dia of Shear Connector = 12L mm 2L Legged

Area of Connector = 226.195 mm^2

Permissible Shear Stress = 435 Mpa

Shear Capacity of Connecto 98.3947

Spacing Required = 148.649

Spacing provided = 120mm Ok

Provide 12 mm 2 Legged bars @ 120 mm

4.4.9 Design of Shear Connectors at End Support

Properties of Composite Section

Moment of Inertia of Composite Section	=	0.768	m^4
Distance of Neutral axis from Top Compression fac	=	0.167	m
Area of Concrete under Compression	=	0.091781	m^2
Distance of Centroid of concrete area under compi	=	1.609	m

Shear Due to SIDL			=	268.07	kN	
Shear Due to LL			=	515.47	kN	
Total Vertical Shear	=268.07×1.75+1.5×515.47		=	1242.33	kN	
Design Longitudinal Shear	V*Ac*Y/I					
	214.158	kN				
Dia of Shear Connector =	12mm	mm	2L	Legged		
Area of Connector =	226.195	mm^2				
Permissible Shear Stress =	435	Mpa				
Shear Capacity of Connecto	98.3947					
Spacing Required =	459.45					
Spacing provided =	200mm	Ok				
Provide	12	mm	2	Legged bars	@	200 mm

4.4.10 Design Check for capacity of Lifting Hooks

Span of Girder	=	28.46	m
Cross sectional area of Girder	=	0.615	m^2
Weight of RC Girder	=	591	kN
Load on lifting hooks (One side)	=	295	kN
Embedded length of bars	=	1000	mm
Diameter of Bar	=	18	mm
Surface area of bar	=	56549	mm^2
No of Legs (One side)	=	4	
Total surface area for developing bond stress	=	226195	mm^2
Allowable bond stress	=	1.7	N/mm^2
		(Refer IS: 456 Clause 26.2.1.1)	
Allowable Load capacity	=	385	kN
		SAFE	

Check for Tensile Stress in Strand

Area of Strands	=	200	mm^2
Load on Lifting Hooks	=	295.36144	kN
Tensile Stress in Strands	=	1476.8072	N/mm^2
Permissible Stress in Strand	=	1618.2	N/mm^2
		SAFE	

5 Analysis and Design of Diaphragm

The design bending moments and shear forces are taken from the STAAD analysis of grillage model and the summary of results for critical load cases are presented in subsequent sections.

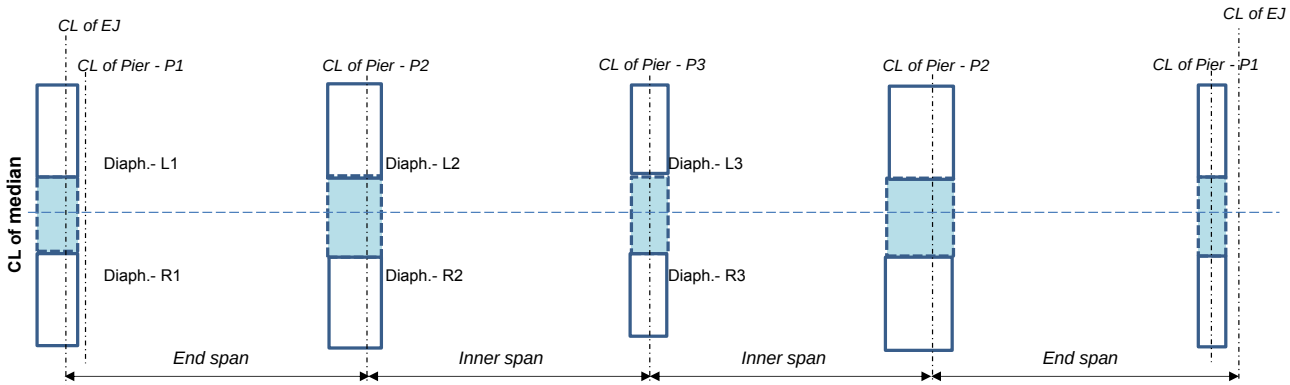
5.1 Staad Results and load combination for Diaphragm

Span of the diaphragm		=	4.780 m	
Impact factor for live load	For Class A		1.417	As per Cl: 208.2 of IRC 6-2017
	For 70R wheeled		1.25	As per Cl: 208.3 of IRC 6-2017

Equivalent Bending moment due to torsion $M_t = \frac{T_u\ (1+D/b)}{1.7}$

Equivalent Shear due to torsion $V_e = V_u + 1.6\ T_u / b$

T_u	=	Torsional Moment
V_u	=	Shear force
D	=	Overall Depth of the Beam
	=	2.255 m
b	=	Breadth of diaphragm
End diaphragm	=	0.830 m
Inner diaphragm	=	2.000 m



Typical Span arrangement showing Diaphragm

5.1.1 Summary of forces at face of the pier from staad

Load Case - LC	Description	Bending moment (kN.m)						Torsional moment (kN.m)						Shear force (kN)					
		Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3
1	Dead load - DL																		
1.1	DL of Girder reaction	-564	-1545	-1318	-564	-1545	-1317	182	-89	-1	-414	157	-1	188	515	439	-378	-1012	-878
1.2	DL of Diaphragm	-319	-576	-577	-319	-576	-577	0	0	0	-1	0	0	195	352	352	-195	-352	-352
1.3	DL of Deck slab	-710	-2004	-1683	-710	-2005	-1683	99	-49	-1	-200	81	-2	237	668	561	-450	-1252	-1059
	Total Dead load	-1593	-4125	-3577	-1593	-4127	-3577	281	-138	-2	-615	237	-3	620	1535	1352	-1024	-2617	-2290
2	Super Imposed Dead load - SIDL																		
2.1	Crash barrier - CB	-632	-1568	-1456	-633	-1570	-1458	522	-83	0	-24	22	0	208	517	480	-119	-340	-281
2.2	Wearing Coat - WC	-172	-494	-410	-176	-503	-418	8	-10	0	-56	22	0	57	165	137	-120	-339	-283
3	Differential Settlement - DS	-47	-152	-205	-47	-152	-205	27	-26	-13	-89	51	-30	16	51	68	-33	-101	-136
4	Live load (without impact)	**Max BM** & Corresponding Torsion						**Max Torsion** & Corresponding BM						**Max SF** & Corresponding Torsion					
4.1	LL- 70 R _ Most ecc	**-1406**	**-1642**	**-1510**	**86**	**68**	**111**	**618**	**-1431**	**1238**	**670**	**-1643**	**1510**	**521**	**609**	**567**	**55**	**-93**	**144**
		305	-213	47	661	136	-179	-869	-1255	-1130	84	-16	24	305	53	47	338	-554	298
4.2	LL- Class A _ Most ecc	**-1035**	**-1561**	**-1501**	**29**	**33**	**49**	**703**	**-1446**	**-1284**	**339**	**-992**	**-855**	**345**	**520**	**499**	**27**	**22**	**42**
		644	-227	-72	311	114	-101	-855	-1128	-1018	28	-20	0	644	-146	-72	302	363	123
4.1a	LL- 1_Class A for 70 R	**-1143**	**-1988**	**-1841**	**169**	**163**	**299**	**727**	**1818**	**1832**	**549**	**-1480**	**-1350**	**396**	**661**	**613**	**-180**	**-287**	**-234**
		159	-115	-9	545	549	108	-842	-1226	-1125	166	-38	82	104	-6	-9	370	-553	188
4.3	LL-2_70R	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.4	LL-4 Class A	**-1088**	**-1668**	**-1547**	**-244**	**-547**	**-467**	**294**	**-748**	**-619**	**77**	**-503**	**-453**	**379**	**602**	**562**	**-368**	**-622**	**-547**
		251	-293	-147	-23	-183	40	-775	-1239	-1039	54	-393	-242	251	-293	-147	-20	-111	-74
5	Live load (without impact)	**Max BM** + Eq. Torsional moment						**Max Eq. Torsional moment** + Cor. BM						**Max SF** + Eq. Torsional SF					
5.1	LL - 70 R _ Most ecc	-2073	-1909	-1569	1530	238	335	-2220	-3045	-2679	1548	-2073	1914	1109	652	604	706	-536	382
5.2	LL - Class A _ Most ecc	-2443	-1846	-1590	709	175	175	-2392	-2937	-2625	768	-1261	-1069	1586	636	556	608	312	140
5.1a	LL - 1_Class A for 70 R	-1491	-2132	-1852	1361	851	434	-2431	-3501	-3418	1366	-1891	1772	596	666	620	-893	-729	-385
5.3	LL - 70R+2 Class A																		
5.4	LL - 2_70R																		
5.5	LL - 4 Class A	-1637	-2035	-1731	-295	-775	-517	-1417	-2174	-1813	222	-1023	-808	863	837	679	-408	-710	-606
6	Live load (with impact)	**Max BM** + Eq. Torsional moment						**Max Eq. Torsional moment** + Cor. BM						**Max SF** + Eq. Torsional SF					
6.1	LL - 70 R _ Most ecc	-2592	-2386	-1961	1913	297	418	-2775	-3807	-3349	1935	-2591	2392	1386	815	755	883	-670	478
6.2	LL - Class A _ Most ecc	-3463	-2616	-2254	1005	249	248	-3391	-4164	-3720	1089	-1788	-1516	2248	902	789	862	442	199
6.1a	LL - 1_Class A for 70 R	-1902	-2720	-2363	1736	1085	554	-3101	-4467	-4361	1743	-2412	2260	761	850	790	-1139	-930	-491
6.3	LL - 70R+2 Class A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4	LL - 2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	LL - 4 Class A	-2321	-2885	-2453	-418	-1099	-733	-2009	-3082	-2570	314	-1450	-1146	1224	1186	963	-578	-1007	-859
7	Braking force																		
7.1	LL - 70 R _ Most ecc	-10	1	0	-10	1	0	60	125	130	-190	-305	-303	3	0	0	-12	2	0
7.2	LL - Class A _ Most ecc	-5	1	0	-5	1	0	33	69	72	-105	-169	-168	2	0	0	-6	1	0
7.3	LL - 1_Class A for 70 R	-12	1	0	-12	1	0	72	151	158	-229	-369	-366	4	0	0	-14	2	0
7.4	LL - 2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	LL - 4 Class A	-7	1	0	-7	1	0	46	95	99	-145	-233	-231	2	0	0	-9	1	0
8	Wind load WL																		
8.1	Wind load downwards 28.5 m/sec	-150	-373	-311	-135	-381	-322	95	165	126	-163	-212	-294	50	124	104	-91	-235	-200
8.2	Wind load downwards 29 m/sec	-139	-355	-296	-128	-361	-304	73	123	100	-137	-172	-232	46	118	99	-87	-225	-191
9	Temperature																		
9.1	Temperature Rise	-20	25	14	-20	25	14	151	164	3	-472	-418	-8	7	-8	-5	-26	21	11
9.2	Temperature Fall	20	-25	-14	20	-25	-14	-151	-164	-3	472	418	8	-7	8	5	26	-21	-11

10	Differential shrinkage	77	-92	39	76	-104	37	5	-46	4	-5	105	3	-26	31	-13	50	-56	24
11	Seismic force																		
11.1	Long.Seismic DL+SIDL	-22	0	0	-22	0	0	125	289	301	-398	-702	-699	7	0	0	-25	2	0
11.2	Trans. Seismic DL+SIDL	3	-1	-2	-3	1	2	-10	-20	0	-12	-25	0	-1	0	1	-1	1	1
11.3	Trans. Seismic 70 R_Most ecc	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0
11.4	Trans. Seismic Class A_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.5	Trans. Seismic 70R+2 CLASS A	0	0	0	0	0	0	0	-1	0	0	-1	0	0	0	0	0	0	0
11.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.7	Trans. Seismic 4 Class A	0	0	0	0	0	0	0	-1	0	0	-1	0	0	0	0	0	0	0
12	Temperature Gradient																		
12.1	Positive Gradient	81	-91	35	80	-99	33	56	-68	3	46	137	3	-27	30	-12	48	-55	22
12.2	Reverse Gradient	-31	38	-14	-31	43	-13	25	36	-2	-53	-90	-2	10	-13	5	-22	24	-8

Load Case - LC	Description	Eq. Bending moment (kN.m)						Eq. Shear force (kN)					
		Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3
20	Dead load - DL												
20.1	DL of Girder reaction	-962	-1656	-1319	-1470	-1742	-1319	539	586	440	-1177	-1138	-879
20.2	DL of Diaphragm	-319	-576	-577	-321	-577	-577	195	352	352	-196	-352	-352
20.3	DL of Deck slab	-927	-2066	-1685	-1147	-2106	-1685	427	707	562	-836	-1317	-1061
	Total Dead load	-2208	-4298	-3580	-2937	-4425	-3581	1161	1645	1354	-2209	-2807	-2292
21	Super Imposed Dead load - SIDL												
21.1	Crash barrier - CB	-1773	-1671	-1456	-686	-1597	-1458	1214	584	480	-165	-358	-281
21.2	Wearing Coat - WC	-191	-507	-410	-299	-531	-418	74	173	137	-228	-356	-283
22	Differential Settlement - DS	-107	-184	-222	-241	-216	-242	69	71	79	-204	-143	-160
23	Live load - with impact												
23.1	LL - 70 R _ Most ecc	-2775	-3807	-3349	1935	-2591	2392	1386	815	755	883	-670	478
23.2	LL - Class A _ Most ecc	-3463	-4164	-3720	1089	-1788	-1516	2248	902	789	862	442	199
23.3	LL - 1_Class A for 70 R	-3101	-4467	-4361	1743	-2412	2260	761	850	790	-1139	-930	-491
23.4	LL - 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
23.5	LL - 4 Class A	-2321	-3082	-2570	-418	-1450	-1146	1224	1186	963	-578	-1007	-859
24	Braking force												
24.1	LL - 70 R _ Most ecc	-141	-155	-163	-425	-381	-380	119	-100	-104	-378	246	-243
24.2	LL - Class A _ Most ecc	-78	-86	-91	-236	-212	-211	66	-56	-58	-210	137	-135
24.3	LL - 1_Class A for 70 R	-170	190	-197	-513	463	-458	143	-121	-126	-456	297	-293
24.4	LL - 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
24.5	LL - 4 Class A	-107	-118	-124	-324	-290	-289	90	-76	-80	-288	188	-185
25	Wind load WL												
25.1	Wind load downwards 28.5 m/sec	-359	-580	-468	-491	-647	-690	234	256	204	-406	-405	-436
25.2	Wind load downwards 29 m/sec	-299	-510	-420	-427	-576	-595	188	217	178	-350	-362	-377
26	Temperature												
26.1	Temperature Rise	-351	231	18	-1053	548	24	298	-140	-7	-937	355	17
26.2	Temperature Fall	351	-231	-18	1053	-548	-24	-298	140	7	937	-355	-17
27	Differential shrinkage	89	-150	45	87	-236	42	-36	67	-17	59	-140	27
28	Seismic force												
28.1	Long.Seismic DL+SIDL	-295	-362	-376	-892	-878	-874	248	-231	-240	-792	564	-559
28.2	Trans. Seismic DL+SIDL	24	-26	-2	-29	33	2	-20	-15	1	-24	-20	1
28.3	Trans. Seismic 70 R_Most ecc	0	-1	0	-1	-1	0	0	0	0	-1	0	0
28.4	Trans. Seismic Class A_Most ecc	0	0	0	0	0	0	0	0	0	0	0	0
28.5	Trans. Seismic 70R+2 CLASS A	-1	-1	0	-1	-1	0	-1	-1	0	-1	-1	0
28.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0
28.7	Trans. Seismic 4 Class A	-1	-1	0	-1	-1	0	-1	-1	0	-1	-1	0

29	Temperature Gradient												
29.1	Positive Gradient	203	-175	39	180	-271	37	-135	84	-14	137	-165	24
29.2	Reverse Gradient	-85	83	-16	-147	156	-15	58	-41	6	-125	96	-10

5.1.1.1 Load Combination Ultimate Limit State As per Table B.2 IRC 6 :2017

Load Case - LC	Description	Eq. Bending moment (kN.m)						Eq. Shear force (kN)					
		Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3
	Basic combination												
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9											
	Except Live load												
100	1.35 DL+ 1.75 SIDL+0.9 WL 28.5m/sec	-6030	-9467	-7938	-5856	-9640	-8156	3546	3542	2900	-3970	-5260	-4361
	Including live load												
101	LC 100 + 1.5 x LL 23.1 + 1.5 x LL 24.1	-10403	-15410	-13206	-3591	-14098	-5137	5803	4614	3876	-3211	-5896	-4008
102	LC 100 + 1.5 x LL 23.2 + 1.5 x LL 24.2	-11342	-15842	-13654	-4577	-12640	-10745	7017	4811	3996	-2991	-4391	-4265
103	LC 100 + 1.5 x LL 23.3 + 1.5 x LL 24.3	-10937	-15882	-14775	-4011	-12564	-5453	4902	4636	3896	-6362	-6209	-5537
104	LC 100 + 1.5 x LL 23.4 + 1.5 x LL 24.4	-6030	-9467	-7938	-5856	-9640	-8156	3546	3542	2900	-3970	-5260	-4361
105	LC 100 + 1.5 x LL 23.5 + 1.5 x LL 24.5	-9672	-14267	-11979	-6968	-12251	-10308	5517	5206	4225	-5268	-6489	-5927
	II.Wind load leading 36m/sec	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15											
	Except Live load												
106	1.35 DL+ 1.75 SIDL+1.5 WL 36m/sec	-6245	-9815	-8219	-6151	-10029	-8570	3686	3696	3022	-4213	-5503	-4623
	Including live load												
107	LC 106 + 1.15 x LL 23.1 + 1.15 x LL 24.1	-9598	-14371	-12258	-4414	-13446	-6255	5417	4517	3771	-3632	-5991	-4352
108	LC 106 + 1.15 x LL 23.2 + 1.15 x LL 24.2	-10318	-14702	-12602	-5170	-12328	-10555	6347	4669	3862	-3463	-4837	-4549
109	LC 106 + 1.15 x LL 23.3 + 1.15 x LL 24.3	-10007	-14733	-13461	-4737	-12270	-6497	4726	4534	3786	-6048	-6230	-5524
110	LC 106 + 1.15 x LL 23.4 + 1.15 x LL 24.4	-6245	-9815	-8219	-6151	-10029	-8570	3686	3696	3022	-4213	-5503	-4623
111	LC 106 + 1.15 x LL 23.5 + 1.15 x LL 24.5	-9037	-13495	-11317	-7003	-12030	-10220	5197	4972	4038	-5208	-6445	-5823
	II.A. Wind load leading 29m/sec												
112	1.35 DL+ 1.75 SIDL+1.5 WL 50m/sec	-6156	-9710	-8147	-6055	-9923	-8427	3617	3637	2983	-4130	-5439	-4535
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5											
	Seismic longitudinal Case												
	Except Live load												
113	1.35 DL+ 1.75 SIDL+1.5 Long.Seismic	-6150	-9488	-8080	-6751	-10375	-8846	3708	2965	2355	-4793	-4050	-4808
	Including live load												
114	LC 113 + 0.2 x LL 23.1 + 0.2 x LL 24.1	-6733	-10280	-8783	-6449	-10970	-8443	4009	3108	2485	-4692	-4135	-4761
115	LC 113 + 0.2 x LL 23.2 + 0.2 x LL 24.2	-6858	-10338	-8843	-6581	-10775	-9191	4171	3134	2501	-4663	-3934	-4795
116	LC 113 + 0.2 x LL 23.3 + 0.2 x LL 24.3	-6804	-10343	-8992	-6505	-10765	-8486	3889	3111	2488	-5112	-4176	-4964
117	LC 113 + 0.2 x LL 23.4 + 0.2 x LL 24.4	-6150	-9488	-8080	-6751	-10375	-8846	3708	2965	2355	-4793	-4050	-4808
118	LC 113 + 0.2 x LL 23.5 + 0.2 x LL 24.5	-6636	-10128	-8619	-6900	-10723	-9133	3971	3187	2532	-4966	-4214	-5016
	Seismic Transverse Case												
	Except Live load												
119	1.35 DL+ 1.75 SIDL+1.5 Trans.Seismic	-5671	-8985	-7520	-5457	-9008	-7531	3306	3289	2717	-3640	-4925	-3968
	Including live load												
120	LC 119+ 0.2 x LL23.1+ 0.2 x LL24.1+ 1.5xLL28.3	-6255	-9778	-8222	-5156	-9604	-7128	3606	3431	2847	-3540	-5010	-3921
121	LC 119+ 0.2 x LL23.2+ 0.2 x LL24.2+ 1.5xLL28.4	-6380	-9835	-8282	-5287	-9409	-7876	3768	3457	2863	-3510	-4809	-3955
122	LC 119+ 0.2 x LL23.3+ 0.2 x LL24.3+ 1.5xLL28.5	-6327	-9842	-8431	-5212	-9400	-7170	3485	3433	2850	-3961	-5052	-4124
123	LC 119+ 0.2 x LL23.4+ 0.2 x LL24.4+ 1.5xLL28.6	-5671	-8985	-7520	-5457	-9008	-7531	3306	3289	2717	-3640	-4925	-3968
124	LC 119+ 0.2 x LL23.5+ 0.2 x LL24.5+ 1.5xLL28.7	-6158	-9627	-8058	-5607	-9358	-7818	3567	3509	2893	-3815	-5090	-4176

Summary of load combination - Ultimate Limit State

Description	Eq. Bending moment (kN.m)						Eq. Shear force (kN)					
	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3
Basic combination												
I. Live load leading	-11342	-15882	-14775	-6968	-14098	-10745	7017	5206	4225	-6362	-6489	-5927
II. Wind load leading 36m/sec	-10318	-14733	-13461	-7003	-13446	-10555	6347	4972	4038	-6048	-6445	-5823
II.A. Wind load leading 50m/sec	-6156	-9710	-8147	-6055	-9923	-8427	3617	3637	2983	-4130	-5439	-4535
Seismic combination												
Seismic longitudinal Case	-6858	-10343	-8992	-6900	-10970	-9191	4171	3187	2532	-5112	-4214	-5016
Seismic Transverse Case	-6380	-9842	-8431	-5607	-9604	-7876	3768	3509	2893	-3961	-5090	-4176
Design Forces	**-11342**	**-15882**	**-14775**	**-7003**	**-14098**	**-10745**	**7017**	**5206**	**4225**	**-6362**	**-6489**	**-5927**

5.1.1.2 Load Combination - Serviceability Limit State As per Table B.3 IRC 6 :2017

Load Case - LC	Description	Eq. Bending moment (kN.m)						Eq. Shear force (kN)					
		Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3
	Rare Combination												
	I. Live load leading with Wind	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage 1											
	Except Live load												
200	1 DL+ 1 SIDL+1 DS +0.6 WL 28.5m/sec.+Diff. shrin	-4443	-7259	-5986	-4431	-7498	-6155	2637	2729	2183	-3037	-4117	-3307
	Including live load												
201	LC 200 + 1 x LL 23.1 + 1 x LL 24.1	-7358	-11220	-9498	-2921	-10471	-4143	4142	3443	2834	-2531	-4542	-3072
202	LC 200 + 1 x LL 23.2 + 1 x LL 24.2	-7984	-11508	-9797	-3578	-9498	-7882	4951	3575	2914	-2384	-3538	-3243
203	LC 200 + 1 x LL 23.3 + 1 x LL 24.3	-7714	-11535	-10544	-3201	-9448	-4353	3541	3458	2848	-4632	-4750	-4091
204	LC 200 + 1 x LL 23.4 + 1 x LL 24.4	-4443	-7259	-5986	-4431	-7498	-6155	2637	2729	2183	-3037	-4117	-3307
205	LC 200 + 1 x LL 23.5 + 1 x LL 24.5	-6871	-10459	-8680	-5172	-9239	-7590	3951	3838	3067	-3902	-4937	-4350
	IA. Live load leading with Temp Rise	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Temp-0.6, Shrinkage 1											
	Except Live load												
206	1 DL+ 1 SIDL+1 DS +0.6 Temp Rise.+Diff. shrinkage	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
	Including live load												
207	LC 206 + 1 x LL 23.1 + 1 x LL 24.1	-7143	-10873	-9217	-2626	-10082	-3729	4001	3289	2712	-2288	-4299	-2810
208	LC 206 + 1 x LL 23.2 + 1 x LL 24.2	-7769	-11161	-9516	-3283	-9110	-7467	4810	3421	2791	-2141	-3295	-2981
209	LC 206 + 1 x LL 23.3 + 1 x LL 24.3	-7499	-11187	-10263	-2906	-9059	-3939	3400	3304	2725	-4389	-4507	-3829
210	LC 206 + 1 x LL 23.4 + 1 x LL 24.4	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
211	LC 206 + 1 x LL 23.5 + 1 x LL 24.5	-6656	-10111	-8399	-4878	-8850	-7176	3810	3684	2944	-3659	-4694	-4089
	IB. Live load leading with Temp Fall												
	Except Live load												
212	1 DL+ 1 SIDL+1 DS +0.6 Temp Fall.+Diff. shrinkage	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
	Including live load												
213	LC 212 + 1 x LL 23.1 + 1 x LL 24.1	-7143	-10873	-9217	-2626	-10082	-3729	4001	3289	2712	-2288	-4299	-2810
214	LC 212 + 1 x LL 23.2 + 1 x LL 24.2	-7769	-11161	-9516	-3283	-9110	-7467	4810	3421	2791	-2141	-3295	-2981
215	LC 212 + 1 x LL 23.3 + 1 x LL 24.3	-7499	-11187	-10263	-2906	-9059	-3939	3400	3304	2725	-4389	-4507	-3829
216	LC 212 + 1 x LL 23.4 + 1 x LL 24.4	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
217	LC 212 + 1 x LL 23.5 + 1 x LL 24.5	-6656	-10111	-8399	-4878	-8850	-7176	3810	3684	2944	-3659	-4694	-4089
	IC. Live load leading with Positive Gradient												
	Except Live load												
218	1 DL+ 1 SIDL+1 DS +0.6 Pos.temp. gradient+Diff. sh	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
	Including live load												
219	LC 218 + 1 x LL 23.1 + 1 x LL 24.1	-7143	-10873	-9217	-2626	-10082	-3729	4001	3289	2712	-2288	-4299	-2810
220	LC 218 + 1 x LL 23.2 + 1 x LL 24.2	-7769	-11161	-9516	-3283	-9110	-7467	4810	3421	2791	-2141	-3295	-2981
221	LC 218 + 1 x LL 23.3 + 1 x LL 24.3	-7499	-11187	-10263	-2906	-9059	-3939	3400	3304	2725	-4389	-4507	-3829
222	LC 218 + 1 x LL 23.4 + 1 x LL 24.4	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046

223	LC 218 + 1 x LL 23.5 + 1 x LL 24.5	-6656	-10111	-8399	-4878	-8850	-7176	3810	3684	2944	-3659	-4694	-4089
	ID. Live load leading with Reverse Gradient												
	Except Live load												
224	1 DL+ 1 SIDL+1 DS +0.6 Rev.temp. gradient+Diff. sl	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
	Including live load												
225	LC 224 + 1 x LL 23.1 + 1 x LL 24.1	-7143	-10873	-9217	-2626	-10082	-3729	4001	3289	2712	-2288	-4299	-2810
226	LC 224 + 1 x LL 23.2 + 1 x LL 24.2	-7769	-11161	-9516	-3283	-9110	-7467	4810	3421	2791	-2141	-3295	-2981
227	LC 224 + 1 x LL 23.3 + 1 x LL 24.3	-7499	-11187	-10263	-2906	-9059	-3939	3400	3304	2725	-4389	-4507	-3829
228	LC 224 + 1 x LL 23.4 + 1 x LL 24.4	-4228	-6911	-5705	-4136	-7110	-5741	2496	2575	2061	-2793	-3874	-3046
229	LC 224 + 1 x LL 23.5 + 1 x LL 24.5	-6656	-10111	-8399	-4878	-8850	-7176	3810	3684	2944	-3659	-4694	-4089
	II. Wind load leading - 28.5 m/sec	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Wind-1 , Live load -0.75											
	Except Live load												
230	1 DL+ 1 SIDL+1 DS+1 WL 28.5 m/sec+Diff. shrinka	-4586	-7490	-6173	-4627	-7757	-6431	2730	2831	2265	-3199	-4279	-3481
	Including live load												
231	LC 230 + 0.75 x LL 23.1 + 0.75 x LL 24.1	-6773	-10462	-8808	-3495	-9986	-4922	3859	3367	2753	-2820	-4597	-3305
232	LC 230 + 0.75 x LL 23.2 + 0.75 x LL 24.2	-7242	-10678	-9032	-3988	-9257	-7726	4466	3466	2813	-2710	-3845	-3433
233	LC 230 + 0.75 x LL 23.3 + 0.75 x LL 24.3	-7040	-10698	-9592	-3705	-9219	-5080	3408	3378	2763	-4395	-4754	-4069
234	LC 230 + 0.75 x LL 23.4 + 0.75 x LL 24.4	-4586	-7490	-6173	-4627	-7757	-6431	2730	2831	2265	-3199	-4279	-3481
235	LC 230 + 0.75 x LL 23.5 + 0.75 x LL 24.5	-6407	-9890	-8194	-5184	-9062	-7508	3716	3663	2928	-3848	-4894	-4264
	II.A. Wind load leading 29 m/sec												
236	1 DL+ 1 SIDL+1 DS+1 WL - 29 m/sec+Diff. shrinkag	-4527	-7421	-6125	-4563	-7687	-6336	2684	2792	2239	-3143	-4237	-3423
	III. Temperature load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75											
	Temperature rise Case												
	Except Live load												
237	1 DL+ 1 SIDL+1 DS+ 1 Temp. rise +Diff. shrinkage	-4578	-6680	-5687	-5189	-6563	-5717	2794	2435	2053	-3730	-3519	-3029
	Including live load												
238	LC 237 + 0.75 x LL 23.1 + 0.75 x LL 24.1	-6765	-9652	-8321	-4057	-8792	-4208	3923	2971	2542	-3351	-3838	-2853
239	LC 237 + 0.75 x LL 23.2 + 0.75 x LL 24.2	-7234	-9867	-8545	-4550	-8062	-7012	4530	3069	2601	-3241	-3085	-2981
240	LC 237 + 0.75 x LL 23.3 + 0.75 x LL 24.3	-7032	-9887	-9105	-4267	-8024	-4366	3472	2982	2552	-4926	-3994	-3617
241	LC 237 + 0.75 x LL 23.4 + 0.75 x LL 24.4	-4578	-6680	-5687	-5189	-6563	-5717	2794	2435	2053	-3730	-3519	-3029
242	LC 237 + 0.75 x LL 23.5 + 0.75 x LL 24.5	-6399	-9080	-7707	-5745	-7868	-6794	3780	3267	2716	-4379	-4134	-3812
	Temperature Fall Case												
	Except Live load												
243	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall+Diff. shrinkage	-3877	-7141	-5723	-3083	-7658	-5765	2198	2715	2068	-1857	-4229	-3062
	Including live load												
244	LC 243 + 0.75 x LL 23.1 + 0.75 x LL 24.1	-6064	-10113	-8357	-1951	-9887	-4255	3327	3250	2556	-1478	-4547	-2886
245	LC 243 + 0.75 x LL 23.2 + 0.75 x LL 24.2	-6533	-10329	-8581	-2443	-9157	-7059	3934	3349	2616	-1367	-3795	-3014
246	LC 243 + 0.75 x LL 23.3 + 0.75 x LL 24.3	-6330	-10349	-9142	-2161	-9120	-4413	2876	3261	2566	-3053	-4704	-3650
247	LC 243 + 0.75 x LL 23.4 + 0.75 x LL 24.4	-3877	-7141	-5723	-3083	-7658	-5765	2198	2715	2068	-1857	-4229	-3062
248	LC 243 + 0.75 x LL 23.5 + 0.75 x LL 24.5	-5698	-9542	-7744	-3639	-8963	-6841	3184	3547	2731	-2506	-4844	-3845
	Positive Temperature Gradient Case												
	Except Live load												
249	1 DL+ 1 SIDL+1 DS + 1 Positive Gradient+Diff. shrin	-4025	-7086	-5666	-3956	-7382	-5704	2362	2659	2046	-2656	-4039	-3022
	Including live load												
250	LC 249 + 0.75 x LL 23.1 + 0.75 x LL 24.1	-6211	-10057	-8300	-2823	-9611	-4195	3490	3195	2535	-2277	-4357	-2845
251	LC 249 + 0.75 x LL 23.2 + 0.75 x LL 24.2	-6681	-10273	-8524	-3316	-8881	-6999	4097	3294	2594	-2167	-3605	-2973
252	LC 249 + 0.75 x LL 23.3 + 0.75 x LL 24.3	-6478	-10293	-9084	-3033	-8843	-4352	3040	3206	2545	-3853	-4514	-3609
253	LC 249 + 0.75 x LL 23.4 + 0.75 x LL 24.4	-4025	-7086	-5666	-3956	-7382	-5704	2362	2659	2046	-2656	-4039	-3022
254	LC 249 + 0.75 x LL 23.5 + 0.75 x LL 24.5	-5846	-9486	-7686	-4512	-8687	-6780	3347	3491	2709	-3305	-4654	-3804

	Reverse Temperature Gradient Case												
	Except Live load												
255	1 DL+ 1 SIDL+1 DS + 1 Reverse Gradient+Diff. shrin	-4313	-6828	-5721	-4283	-6954	-5756	2554	2534	2067	-2918	-3778	-3055
	Including live load												
256	LC 255 + 0.75 x LL 23.1 + 0.75 x LL 24.1	-6500	-9799	-8355	-3151	-9184	-4247	3683	3069	2555	-2539	-4097	-2879
257	LC 255 + 0.75 x LL 23.2 + 0.75 x LL 24.2	-6969	-10015	-8579	-3644	-8454	-7051	4290	3168	2615	-2429	-3344	-3007
258	LC 255 + 0.75 x LL 23.3 + 0.75 x LL 24.3	-6766	-10035	-9139	-3361	-8416	-4405	3232	3080	2565	-4115	-4253	-3643
259	LC 255 + 0.75 x LL 23.4 + 0.75 x LL 24.4	-4313	-6828	-5721	-4283	-6954	-5756	2554	2534	2067	-2918	-3778	-3055
260	LC 255 + 0.75 x LL 23.5 + 0.75 x LL 24.5	-6134	-9228	-7741	-4839	-8260	-6832	3540	3366	2729	-3567	-4393	-3838
	Quasi permanent Combination	Partial safety factors:-				DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5							
261	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinka	-4403	-6795	-5696	-4663	-6836	-5729	2645	2505	2057	-3262	-3697	-3037
262	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkag	-4053	-7026	-5714	-3610	-7384	-5753	2347	2645	2064	-2325	-4052	-3054
263	2 DL+ 1 SIDL+1 DS + 0.5 +ve Grad+ Diff. Shrinkage	-4126	-6998	-5685	-4046	-7246	-5723	2429	2617	2053	-2725	-3957	-3034
264	3 DL+ 1 SIDL+1 DS + 0.5 Rev Grad+ Diff. Shrinkag	-4270	-6869	-5713	-4210	-7032	-5749	2525	2554	2064	-2856	-3826	-3050

Summary of load combinaton - Serviceability Limit State

Description	Eq. Bending moment (kN.m)						Eq. Shear force (kN)					
	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3	Diaph L1	Diaph L2	Diaph L3	Diaph R1	Diaph R2	Diaph R3
Rare Combination												
I. Live load leading with Wind/Temp	-7984	-11535	-10544	-5172	-10471	-7882	4951	3838	3067	-4632	-4937	-4350
II. Wind load leading 28.5 m/sec	-7242	-10698	-9592	-5184	-9986	-7726	4466	3663	2928	-4395	-4894	-4264
II.A. Wind load leading 29 m/sec	-4527	-7421	-6125	-4563	-7687	-6336	2684	2792	2239	-3143	-4237	-3423
III. Temperature load leading	-7234	-10349	-9142	-5745	-9887	-7059	4530	3547	2731	-4926	-4844	-3845
Design Forces	***-7984***	***-11535***	***-10544***	***-5745***	***-10471***	***-7882***	***4951***	***3838***	***3067***	***-4926***	***-4937***	***-4350***
Quasi permanent Combination	**-4403**	**-7026**	**-5714**	**-4663**	**-7384**	**-5753**	**2645**	**2645**	**2064**	**-3262**	**-4052**	**-3054**

5.2 Design of Intermediate Diaphragm

Bending Moment and Shear Force Values for Intermediate Diaphragm is taken Load combination summary

Ultimate Limit State (Basic Combination)

Note:- For Design, Combination of D.L+S.I.D.L + Maximum of Vehicular Load is Considered

Maximum Hogging Moment (-ve)			=	15882	kN m
Max Shear Force			=	6489	kN

Serviceability Limit State (Load Combinations - Rare)

Maximum Hogging Moment (-ve)			=	11535	

Serviceability Limit State (Load Combinations - Quasi Permanent)

Maximum Hogging Moment (-ve)			=	7384	kN m

5.2.1 Design data ;

Width of Diaphragm			=	2	m
C/C of Girder			=	3	m
Depth of Diaphragm	=2.15+0.15		=	2.3	m
Web Thickness of the Main Girder			=	0.25	m
Thickness of deck slab			=	0.23	m
Grade of concrete		f_{ck}	=	45	N/mm^2
Grade of Steel		f_y	=	Fe 500	N/mm^2
Grade of Steel for stirrups		f_{ywk}	=	Fe 500	N/mm^2
Modulus of elasticity of steel		E_s	=	200000	N/mm^2
Modulus of elasticity of concrete		E_c	=	34000	N/mm^2
Modular Ratio (Long term)		m	=	11.76	
Clear Cover		c	=	45	mm
Effective Span;		*l*	=	4.78	m
Overall Depth including haunch	=2.3+0.23+0.3	D	=	2.830	m

5.2.2 Reinforcement at the Top:

Details of Reinforcement:

Layer No.	Dia of bar (mm)	No. of bars	Cover (mm)	Area (mm^2)	Area x cover
1	**25**	**12**	**70**	5890	409389
2	**25**	**12**	120	5890	703913
3	**25**	**12**	170	5890	998437
Total No.		**36**		**17671**	**2111739**

Mu = 0.36fck*b*Xu*(d-0.416Xu)

32400.00 Xu*(2710.5 -0.416Xu)

1.59E+10 = 8.78E+07 Xu - 1.35E+04 Xu^2

1.35E+04 Xu^2 -8.78E+07 Xu + 1.59E+10 = 0

Check 6.86E+15 Ok

Xu = 186.16

Ast Req = 13866.0

Area of tensile reinforcement provided		A_{st} prov =	17671	mm^2	Ok
C.G of the steel from Top of girder	= 2111739/17671 = d'		=	120	mm
Effective depth of beam provided;		d_{prov}	=	2711	mm
Depth of Neutral Axis		Xu	=	237	mm
Ultimate Moment Resistance =	0.87*fy*Ast*z		=	20077	KNm

Ok

Xu Max /d = 0.617
Xu Max = 1671.67

Section is under Reinforced.
Assumption is Correct.
Hence Ok.

5.2.3 Check for longitudinal steel:

Minimum steel:

$A_{S.min}$ = $0.26 \times f_{ctm} \times b_t \times d / f_{yk}$ (Refer IRC:112-2011, Cl 16.5.1.1, Eq 16.1)
But not less than,
$0.0013 \times b_t \times d$

where, f_{ctm} = Mean value of axial tensile strength of concrete (Refer IRC:112-2011, Table-6.5)
b_t = Mean width of the tension zone (web width)
f_{yk} = Characteristic yield strength of the reinforcement

f_{ctm}	=	3.3	N / mm^2 (Refer IRC:112-2011, Table-6.5)
b_t	=	2000	mm
$A_{S.min}$	=	9302	mm^2

SAFE

Maximum steel:

Tensile steel provided shall not be greater than 0.025 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

where, A_c = Cross-sectional area of concrete

A_c	=	5660000	mm^2
$0.025 \times A_c$	=	141500	mm^2

SAFE

Also, Total tension and compression reinforcement shall not exceed 0.04 x Ac
(Refer IRC:112-2011, Cl 16.5.1.1)

Area of the compression steel	=	12 Nos	20 dia	=	3770 mm^2
Total tension and compression reinforcement				=	21442 mm^2
			$0.04 \times A_c$	=	226400 mm^2

SAFE

5.2.4 Check for Shear:

(In continuous deep beam we cannot depend on arch action as in simple deep beams. Hence, the design for shear is based as in ordinary normal beams.

Design shear force,

	V_{Ed}	=	6489 kN	
	V_{ccd}	=	0 kN	For Uniform cross section
	V_{td}	=	0 kN	For Uniform cross section
$V_{Rd\,s}$ =	V_{NS}	=	6489 kN	

Maximum Allowabe Shear Force (for maximum shear force take Θ = 45 ^{0})

$V_{Rd.max} = \alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ **(Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)**

where,

αcw =	1	(For RCC)
z = lever arm = 0.9d=	2.44	m
v_1 =	0.60	for fck<=80Mpa

v_1 is the strength reduction factor for concrete cracked in shear

Θ =	45	(CotΘ = 1)
f_{cd} =	the design value of concrete compression strength = $\alpha_{cc} \times fck / \gamma_m$	kN

α_{cc} = 0.67 **(Refer IRC:112-2011, Pg.87)**

γ_m = 1.50 (Partial factors for concrete for ULS)

$V_{Rd.max}$ = 29420

Section is Safe

Allowable Shear Force without Shear Reinforcement

$V_{Rd\,c}$ = (0.12 x K (80 x ρ_1 x fck)^0.33 + 0.15 x σ_{cp}) b_w x d **(Refer IRC:112-2011, Cl 10.3.2(2))**

But,

$V_{Rd.c\ min}$ = (v_{min} + 0.15 x σ_{cp}) b_w x d

where,

K = 1+sqrt(200/d) <=2, where d is the depth in mm.

$V_{Rd\,c}$ = The design shear resistance of the member without shear reinforcement.

v_{min} = 0.031 x K^3/2 x fck^1/2

σ_{cp} = Concrete compressive stress at centroidal axis due to axial loading or prestressing.<=0.02

ρ_1 = Reinforcement ratio for longitudinal reinforcement , = $A_{st}/(b_w$ x d)

K	=	1.3	
ρ_1	=	0.0033	
σ_{cp}	=	0	For RCC
$V_{Rd\,c}$	=	1864	kN
$V_{Rd\,c\,min}$	=	1617	kN

Shear Reinforcement is Required.

Minimum Shear Force (for minimum shear force take Θ = 21.8 ^{0})

$V_{Rd.min}$ = α_{cw} x b_w x z x v_1 x (f_{cd}/(cotΘ+tanΘ)) **(Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)**

where,

αcw = 1 (For RCC)

z = lever arm = 0.9d= 2.44 m

v_1 = 0.60 for fck<=80Mpa

v_1 is the strength reduction factor for concrete cracked in shear

Θ = 21.8 (CotΘ = 2.5)

f_{cd} = the design value of concrete compression strength =α_{cc} x fck /γ_m

α_{cc} = 0.67 **(Refer IRC:112-2011, Pg.87)**

γ_m = 1.50 (Partial factors for concrete for ULS)

$V_{Rd.min}$ = 20288 kN

Take CotΘ = 2.5 and find Shear Reinforcement

Design of Shear Reinforcement

$V_{Rd.s}$ = The design value of the shear force which can be sustained by the yielding shear reinforcement.

$V_{Rd.s}$ = (A_{sw}/s) * z * fywd * cotθ **(Refer IRC:112-2011, Cl 10.3.3.2, Eq10.7)**

where,

A_{sw} = The c/s area of the shear reinforcement

s = The spacing of the stirrups

f_{ywd} = The design yield strength of the shear reinforcement = 0.8f_{ywk}

Provide 6L 12mm dia stirrups

			A_{sw}	=	679	mm^2	
	s =	Spacing required		=	222	mm	
		Spacing provided		=	125	mm	
	Hence provide	6L	12mm	dia at	125mm	c/c	SAFE

Area of shear reinforcement provided = $A_{st,\ shear}$ = 5429 mm^2

Reinforcement ratio for shear reinforcement, σ_w = 0.0010

Check for minimum shear reinforcement:

Minimum shear reinforcement ratio;

σ_{min} = (0.072 x sqrt(fck)) / f_{yk} = $\frac{A_{sw}}{b_w \times s}$ **(Refer IRC:112-2011, cl.no. 10.3.3.5)**

where,
f_{yk} = The characteristic yield strength of steel
s = The spacing of the stirrups
A_{sw} = The c/s area of the shear reinforcement

σ_{min} = 0.0010 SAFE

5.2.5 Check for Minimum Reinforcement for Crack control

$$A_{s\ min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ **(Refer IRC:112-2011, Cl 12.3.3)**

Where,
$A_{s\ min}$ = Minimum area of reinforcing steel within the tensile zone
A_{ct} = Area of concrete within tensile zone
σ_s = Maximum stress permitted in the

$f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}
k = Coefficient which allows for the effect of non-uniform self equilibrium stresses
k_c = Coefficient which takes account stress distribution within the section just prior to cracking

$k_c = 0.4 \times [\ 1 - \sigma_c / (\ k_1 \times (\ h/h^*\ ) \times f_{ct,eff}\ )]$

A_{ct}	=	5660000	mm^2	
σ_s	=	435	N / mm^2	**(Refer IRC:112-2011, Table 12.2)**
$f_{ct,eff}$	=	3.30	N / mm^2	**(Refer IRC:112-2011, Tab. 6.5)**
k	=	0.65		(for web with h > 800mm)
σ_c	=	0	N / mm^2	For RCC
k_c	=	0.4		
$A_{s\ min}$	=	11164	mm^2	Safe

Calculation of C.G of cracked transformed section at Support (for hogging)

Equating the moments of areas about the centroidal axis

b	$* Y_t^2 / 2$	=	m	$* A_{st} *$	$(d - Y_t)$			
1000	Y_t^2 +	2.08E+05	Y_t +	-5.64E+08	=	0		
Check				2.30E+12	Ok			

	Y_t	=	654	mm
Distance of C.G. from Reinforcing steel;	Y_s	=	2057	mm
Inertia of section ;	I_{cr}	=	1.07E+12	mm^4
Section modulus;	Z_t	=	1.63E+09	mm^3

5.2.6 Calculation of Crack Width at Support

W_k = $S_{r\,max}$ (ε_{sm} - ε_{cm}) **(Refer IRC:112-2011, Cl 12.3.4)**

Where,

W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing **(Refer Eq. 12.8, 12.11 or 12.12)**

$S_{r\,max}$ = 3.4c + (0.425 * k_1 * k_2 * ϕ / $\rho_{p,eff}$)

c = Clear cover to lonfitudnal reinforcement

c	=	45	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\,\sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = b_w * $h_{c,eff}$

$h_{c,eff}$ is the lesser of	=	2.5 (D - d)
	=	D - x / 3
	=	D / 2

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	299	mm
$A_{c,eff}$	=	597500	mm^2
$\rho_{p,eff}$ =	=	0.030	
k_t	=	0.5	
σ_{sc}	=	167.64	N / mm^2
$f_{ct,eff}$	=	3.30	N / mm^2
α_e	=	11.76	
$\varepsilon_{sm} - \varepsilon_{cm}$	=	5.03E-04	
$S_{r\,max}$	=	296.7	
W_k	=	0.1492	mm

SAFE

5.2.7 Check for Stresses under Rare Combination

Case 1 : Uncracked Phase

Transformed Sectional properties						
Area of Tension Steel		=	17671	mm²		
Area of Transformed Section		=	5850228	mm²		
At x Yt =	8008900000 +		515613144			
		Yt =	1457.12493	mm		
Dist of NA to Extreme Compression Fibre		=	1457.1	mm		
Dist of NA to Extreme Tension Fibre		=	1372.9	mm		
Dist of NA to Reinforcing Steel		=	1253.4	mm		
Transformed Section Moment of Inertia =			4.0864E+12	mm^4		
Cracking Moment =			8413.31	KNm		
Max Compressive Stress in Concrete =			4.1	Mpa	Ok	

Case 2 : Cracked Phase

Calculation of CG of Cracked Section

b*Yct^2/2 = m*Ast*(d-Yct)

550	Yct^2	=	207899.514	*(2710.5-Yct)			
550	Yct^2	=	563511632	-207899.51	Yct		
550	Yct^2	+	207899.514	Yct +	-563511632	=	0
Check					1.2829E+12	Ok	
				Yct =	840.703038	mm	
CG of Cracked Section from Extreme Tension Fibre				=	1989.3		
CG of Cracked Section from Steel				=	1869.8		
Cracked Moment of Inertia				=	1.123E+12		
Max Compressive Stress				=	8.64	Ok	
Tensile Stress of Concrete at Steel				=	19.21		
Tensile Stress in Steel				=	226.0	Ok	

5.3 Design of End Diaphragm

Bending Moment and Shear Force Values for End Diaphragm From Load combination summary

Ultimate Limit State (Basic Combination)

Note:- For Design, Combination of D.L+S.I.D.L + Maximum of Vehicular Load is Considered

Maximum Hogging Moment (-ve)	=	11342	kN m
Max Shear Force	=	7017	kN

Serviceability Limit State (Load Combinations - Rare)

Maximum Hogging Moment (-ve)	=	7984	kNm

Serviceability Limit State (Load Combinations - Quasi Permanent)

MaximumHogging Moment (-ve)	=	4663	kN m

5.3.1 Design data ;

Width of Diaphragm			=	0.83	m
C/C of Girder			=	3	m
Depth of Diaphragm	=2.15+0.15		=	2.3	m
Web Thick of the Main Girder			=	0.25	m
Thickness of deck slab			=	0.23	m
Grade of concrete		f_{ck}	=	45	N/mm^2
Grade of Steel		f_y	=	Fe 500	N/mm^2
Grade of Steel for stirrups		f_{ywk}	=	Fe 500	N/mm^2
Modulus of elasticity of steel		E_s	=	200000	N/mm^2
Modulus of elasticity of concrete		E_c	=	34000	N/mm^2
Modular Ratio (Long term)		m	=	11.76	
Clear Cover		c	=	45	mm
Effective Span;		*l*	=	4.78	m
Overall Depth including haunch	=2.30+0.23+0.3	D	=	2.830	m

5.3.2 Reinforcement at the Top:

Details of Reinforcement:

Layer No.	Dia of bar (mm)	No. of bars	Cover (mm)	Area (mm^2)	Area x cover
1	**32**	**6**	**73**	4825	352261
2	**32**	**6**	137	4825	661092
3	**25**	**6**	198	2945	581686
Total No.		**18**		**12596**	**1595038**

Mu = 0.36fck*b*Xu*(d-0.416Xu)

13446 Xu*(2703.37 -0.416Xu)

1.13E+10 = 3.63E+07 Xu - 5.59E+03 Xu^2

5.59E+03 Xu^2 -3.6E+07 Xu + 1.13E+10 = 0

Check 1.07E+15 Ok

Xu = 328.64

Ast Req = 10158.32

Area of tensile reinforcement provi A_{st} prov = 12596 mm^2 Ok

C.G of the steel from Top of girder =1595038/12596 d' = 127 mm

Effective depth of beam provided; d_{prov} = 2703 mm

Depth of Neutral Axis Xu = 408 mm

Ultimate Moment Resistance = 0.87*fy*Ast*z = 13884 KNm

Ok

Xu Max /d = 0.617

Xu Max = 1667.3 Section is under Reinforced.
Assumption is Correct.
Hence Ok.

5.3.3 Check for longitudinal steel:

Minimum steel:

$A_{S.min}$ = $0.26 \times f_{ctm} \times b_t \times d / f_{yk}$ (Refer IRC:112-2011, Cl 16.5.1.1, Eq 16.1)
But not less than,
$0.0013 \times b_t \times d$

where, f_{ctm} = Mean value of axial tensile strength of concrete (Refer IRC:112-2011, Table-6.5)
b_t = Mean width of the tension zone (web width)
f_{yk} = Characteristic yield strength of the reinforcement

f_{ctm}	=	3.3	N / mm^2 (Refer IRC:112-2011, Table-6.5)
b_t	=	830	mm
$A_{S.min}$	=	3850	mm^2

SAFE

Maximum steel:

Tensile steel provided shall not be greater than 0.025 x Ac (Refer IRC:112-2011, Cl 16.5.1.1)

where, A_c = Cross-sectional area of concrete

A_c	=	2348900	mm^2
$0.025 \times A_c$	=	58723	mm^2

SAFE

Also, Total tension and compression reinforcement shall not exceed 0.04 x Ac
(Refer IRC:112-2011, Cl 16.5.1.1)

Area of the compression steel	=	6 Nos	20 dia	=	1885 mm^2
Total tension and compression reinforcement				=	14481 mm^2
			$0.04 \times A_c$	=	93956 mm^2

SAFE

5.3.4 Check for Shear:

(In continuous deep beam we cannot depend on arch action as in simple deep beams. Hence, the design for shear is based as in ordinary normal beams.

Design shear force,

	V_{Ed}	=	7017 kN	
	V_{ccd}	=	0 kN	For Uniform cross section
	V_{td}	=	0 kN	For Uniform cross section
$V_{Rd\,s}$ =	V_{NS}	=	7017 kN	

Maximum Allowabe Shear Force (for maximum shear force take Θ = 45 ^{0})

$V_{Rd.max} = \alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ **(Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)**

where,

αcw =	1	(For RCC)
z = lever arm = 0.9d=	2.43	m
v_1 =	0.60	for fck<=80Mpa
		v_1 is the strength reduction factor for concrete cracked in shear
Θ =	45	(CotΘ = 1)
f_{cd} =		the design value of concrete compression strength =$\alpha_{cc} \times fck / \gamma_m$ kN
α_{cc} =	0.67	**(Refer IRC:112-2011, Pg.87)**
γ_m =	1.50	(Partial factors for concrete for ULS)

$V_{Rd.max}$ = 12177

Section is Safe

Allowable Shear Force without Shear Reinforcement

$V_{Rd\,c} = (0.12 \times K (80 \times \rho_1 \times fck)^{0.33} + 0.15 \times \sigma_{cp}) b_w \times d$ **(Refer IRC:112-2011, Cl 10.3.2(2))**

But,

$V_{Rd.c\ min}$ = $(v_{min} + 0.15 \times \sigma_{cp})\ b_w \times d$

where,

K = 1+sqrt(200/d) <=2, where d is the depth in mm.

$V_{Rd\ c}$ = The design shear resistance of the member without shear reinforcement.

v_{min} = $0.031 \times K^{3/2} \times fck^{1/2}$

σ_{cp} = Concrete compressive stress at centroidal axis due to axial loading or prestressing.

ρ_1 = Reinforcement ratio for longitudinal reinforcement , = $A_{st}/(b_w \times d)$ <=0.02

K	=	1.3	
ρ_1	=	0.0056	
σ_{cp}	=	0	For RCC
$V_{Rd\ c}$	=	924	kN
$V_{Rd\ c\ min}$	=	669	kN

Shear Reinforcement is Required.

Minimum Shear Force (for minimum shear force take Θ = 21.8 ^{0})

$V_{Rd.min} = \alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta + \tan\Theta))$ **(Refer IRC:112-2011, Cl 10.3.3.2, Eq10.8)**

where,

αcw = 1 (For RCC)

z = lever arm = 0.9d = 2.43 m

v_1 = 0.60 for fck<=80Mpa

v_1 is the strength reduction factor for concrete cracked in shear

Θ = 21.8 (CotΘ = 2.5)

f_{cd} = the design value of concrete compression strength = $\alpha_{cc} \times fck / \gamma_m$

α_{cc} = 0.67 **(Refer IRC:112-2011, Pg.87)**

γ_m = 1.50 (Partial factors for concrete for ULS)

$V_{Rd.min}$	=	8398	kN

Take CotΘ = 2.5 and find Shear Reinforcement

Design of Shear Reinforcement

$V_{Rd.s}$ = The design value of the shear force which can be sustained by the yielding shear reinforcement.

$V_{Rd.s} = (A_{sw}/s) * z * fywd * \cot\theta$ **(Refer IRC:112-2011, Cl 10.3.3.2, Eq10.7)**

where,

A_{sw} = The c/s area of the shear reinforcement

s = The spacing of the stirrups

f_{ywd} = The design yield strength of the shear reinforcement = $0.8 f_{ywk}$

Provide 6L 12mm dia stirrups

	A_{sw}	=	679	mm^2
s =	Spacing required	=	205	mm
	Spacing provided	=	125	mm

Hence provide 6L 10mm dia at 125mm c/c SAFE

Area of shear reinforcement provided = $A_{st,\ shear}$ = 5429 mm^2

Reinforcement ratio for shear reinforcement, σ_w = 0.0024

Check for minimum shear reinforcement:

Minimum shear reinforcement ratio;

σ_{min} = (0.072 x sqrt(fck)) / f_{yk} = $\frac{A_{sw}}{b_w \times s}$ **(Refer IRC:112-2011, cl.no. 10.3.3.5)**

where, f_{yk} = The characteristic yield strength of steel
s = The spacing of the stirrups
A_{sw} = The c/s area of the shear reinforcement

σ_{min} = 0.0010

SAFE

5.3.5 Check for Minimum Reinforcement for Crack control

$$A_{s\,min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ **(Refer IRC:112-2011, Cl 12.3.3)**

Where,

$A_{s\,min}$ = Minimum area of reinforcing steel within the tensile zone
A_{ct} = Area of concrete within tensile zone
σ_s = Maximum stress

$f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}
k = Coefficient which allows for the effect of non-uniform self equilibrium stresses
k_c = Coefficient which takes account stress distribution within the section just prior to cracking

$k_c = 0.4 \times [\,1 - \sigma_c / (\,k_1 \times (\,h/h^*\,) \times f_{ct,eff}\,)]$

A_{ct}	=	2348900	mm^2	
σ_s	=	435	N/mm^2	**(Refer IRC:112-2011, Table 12.2)**
$f_{ct,eff}$	=	3.30	N/mm^2	**(Refer IRC:112-2011, Tab. 6.5)**
k	=	0.65		(for web with h > 800mm)
σ_c	=	0	N/mm^2	For RCC
k_c	=	0.4		
$A_{s\,min}$	=	4633	mm^2	Safe

Calculation of C.G of cracked transformed section at Support (for hogging)

Equating the moments of areas about the centroidal axis

b * Y_t^2 / 2 = m * A_{st} * (d - Y_t)

415 Y_t^2 + 1.48E+05 Y_t + -4.01E+08 = 0

Check 6.87E+11 Ok

	Y_t	=	820	mm
Distance of C.G. from Reinforcing steel;	Y_s	=	1883	mm
Inertia of section ;	I_{cr}	=	6.78E+11	mm^4
Section modulus;	Z_t	=	8.27E+08	mm^3

5.3.6 Calculation of Crack Width at Support

W_k = $S_{r\,max}$ (ε_{sm} - ε_{cm}) **(Refer IRC:112-2011, Cl 12.3.4)**

Where,

W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing **(Refer Eq. 12.8, 12.11 or 12.12)**

$S_{r\,max}$ = 3.4c + (0.425 * k_1 * k_2 * ϕ / $\rho_{p,eff}$)

c = Clear cover to lonfitudnal reinforcement

c	=	45	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\,\sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = b_w * $h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)
= D - x / 3
= D / 2

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	317	mm
$A_{c,eff}$	=	262754	mm^2
$\rho_{p,eff}$ =	=	0.048	
k_t	=	0.5	
σ_{sc}	=	152.33	N / mm^2
$f_{ct,eff}$	=	3.30	N / mm^2
α_e	=	11.76	
$\varepsilon_{sm} - \varepsilon_{cm}$	=	4.92E-04	
$S_{r\,max}$	=	266.5	
W_k	=	0.1312	mm

SAFE

5.3.7 Check for Stresses Under Rare Combination

Case 1 : Uncracked Phase

Transformed Sectional properties				
Area of Tension Steel	=	12596	mm²	
Area of Transformed Section	=	2903133.5	mm²	
At x Yt = 3.324E+09 + 1.5E+09				
Yt =		1660.961385	mm	
Dist of NA to Extreme Compression Fibre	=	1661.0	mm	
Dist of NA to Extreme Tension Fibre	=	1169.0	mm	
Dist of NA to Reinforcing Steel	=	1042.4	mm	
Transformed Section Moment of Inertia =		2.31202E+12	mm^4	
Cracking Moment =		4175.93	KNm	
Max Compressive Stress in Concrete =		5.74	Mpa	Ok

Case 2 : Cracked Phase

Calculation of CG of Cracked Section

b*Yct^2/2 = m*Ast*(d-Yct)

550 Yct^2 = 148190.8 *(2703-Yct)

550 Yct^2 = 4.01E+08 -148191 Yct

550 Yct^2 + 148190.8 Yct + -400614740.2 = 0

Check 9.033E+11 Ok

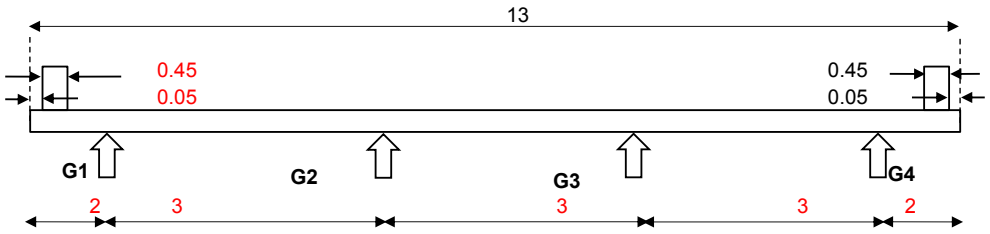
Yct = 729.31 mm

CG of Cracked Section from Extreme Tension Fibre	=	2100.7	mm	
CG of Cracked Section from Steel	=	1974.1	mm	
Cracked Moment of Inertia	=	6.848E+11	mm^4	
Max Compressive Stress	=	8.50		Ok
Tensile Stress of Concrete at Steel	=	23.015	Mpa	
Tensile Stress in Steel	=	270.8		Ok

6 Design of Deck Slab

6.1 Deck slab details

Thickness of deck slab (Mid Span)	D_f	=	230	mm
Thickness of deck slab (Support)	D_f	=	230	mm
Thickness of wearing coat	t	=	75	mm
Design width of slab slab considered	w	=	1	m
Total width of deck slab		=	13	m
Total one side carriageway width	B	=	13.00	m
Density of concrete		=	25	kN/m^3
Density of wearing coat		=	22	kN/m^3
Grade of Concrete	f_{ck}	=	M 35	N/mm^2
Grade of steel reinforcement	f_y	=	Fe 500	N/mm^2



Typical cross section of superstructure

The transverse analysis of the superstructure has been done using unit strip method. The live load distribution is considered using effective width concept given in IRC 112-2011-Annexure B-3. The deck modelling is done in STAAD Pro assuming rigid supports over each longitudinal girder.

6.2 Load calculation for analysis

6.2.1 Dead load

Self weight of deck slab

Width of deck slab considered for design		=	1.00	m
Thickness of deck slab		=	0.23	m
Cross sectional area of deck slab		=	0.23	m^2
Load per meter run		=	5.75	kN/m
	Say	=	***5.80***	***kN/m***

6.2.2 Superimposed dead load

Due to crash barrier

Area of end crash barrier		=	0.36	m^2
Length of crash barrier considered		=	1.00	m
Total weight of crash barrier in 1m length		=	9.00	kN
Service load for 1m length (assumed)		=	1.10	kN
Total weight due to end crash barrier		=	***10.10***	***kN***

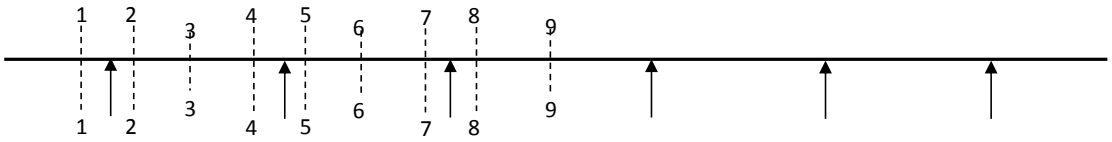
Due to Median

Area of crash barrier at median location (Including Kerb)	=0.35+0.105×2		0.56	m^2
Length of crash barrier considered at median location		=	1.00	m
Total weight of crash barrier at median location in 1m length		=	14.00	kN
Service load for 1m length (assumed)		=	2.00	kN
Total weight due to end crash barrier		=	***16.00***	***kN***

Due to Wearing coat

Thickness of wearing coat		=	0.075	m
Cross sectional area of wearing coat in 1m length		=	0.075	m^2
Load per meter run		=	1.65	kN/m
	Say	=	***1.70***	***kN/m***

6.3 Staad Results and load combination for deck slab design



Critical sections for Bending Moments

6.3.1 *Summary of forces from staad*

Bending moment in kN.m

Sections	1-Hogg.	2-Hogg.	3-Sagg.	4-Hogg.	5-Hogg.	6-Sagg.	7-Hogg.	8-Hogg.	9-Sagg.
Dead load	-9.14	-9.14	-0.73	-1.76	-1.10	3.61	-1.10	-1.76	-0.73
SIDL-C/B	-17.93	-18.39	-8.10	2.19	4.00	4.00	4.00	2.19	-8.10
SIDL-W/C	-1.38	-1.32	0.38	-0.68	-0.62	0.76	-0.62	-0.68	0.38
LL- 70 R_L	-7.70	14.72	33.91	-23.53	-25.66	26.73	-23.81	-23.29	33.39
LL- 70 R_M	-7.70	13.70	41.60	-21.15	-27.55	33.87	-26.55	-21.11	39.34
LL- 70 R_N	-4.10	14.80	42.92	-22.13	-28.83	34.85	-26.35	-22.08	40.13
LL- Class A	-51.24	-49.36	25.74	-21.24	-19.21	32.88	-19.15	-22.02	25.88
Governing Live Load Forces	-51.24	-49.36	42.92	-23.53	-28.83	34.85	-26.55	-23.29	40.13

Partial Safety Factor As per Table B.2 and B.3 of IRC 6-2017

Ultimate Limit State (Basic Combination)

Load case	Partial Safety Factor
Dead load	1.35
SIDL- C/B	1.35
SIDL-W/C	1.75
Live load	1.5

Serviceability Limit State (Quasi Permanent)

Load case	Partial Safety Factor
Dead load	1
SIDL- C/B	1
SIDL-W/C	1.2

Serviceability Limit State (Rare Combination)

Load case	Partial Safety Factor
Dead load	1
SIDL- C/B	1
SIDL-W/C	1.2
Live load	1

6.3.2 ULS-Factored Bending moment (kN.m)

Sections	1-Hogg.	2-Hogg.	3-Sagg.	4-Hogg.	5-Hogg.	6-Sagg.	7-Hogg.	8-Hogg.	9-Sagg.
Dead load	-12.33	-12.34	-0.99	-2.37	-1.49	4.87	-1.49	-2.37	-0.99
SIDL-C/B	-24.20	-24.82	-10.94	2.95	5.40	5.40	5.40	2.95	-10.94
SIDL-W/C	-2.42	-2.32	0.67	-1.18	-1.08	1.34	-1.08	-1.18	0.67
Live load	-76.86	-74.03	64.38	-35.30	-43.24	52.28	-39.82	-34.93	60.20
Total :- DL+SIDL+LL	*-115.82*	*-113.51*	*53.13*	*-35.89*	*-40.41*	*63.89*	*-36.99*	*-35.53*	*48.94*
Design moments	**115.9**	**113.6**	**53.2**	**35.9**	**40.5**	**63.9**	**37**	**35.6**	**49**

ULS -Design moments

Moment @ Mid Span sagging (+ ve) = 63.90 kN m
Moment @ Support hogging (- ve) = 40.50 kN m
Moment at the Cantiliver hogging (- ve) = 115.90 kN m

6.3.3 SLS-Factored Bending moment (kN.m) - Rare Combination

Sections	1-Hogg.	2-Hogg.	3-Sagg.	4-Hogg.	5-Hogg.	6-Sagg.	7-Hogg.	8-Hogg.	9-Sagg.
Dead load	-9.14	-9.14	-0.73	-1.76	-1.10	3.61	-1.10	-1.76	-0.73
SIDL-C/B	-17.93	-18.39	-8.10	2.19	4.00	4.00	4.00	2.19	-8.10
SIDL-W/C	-1.66	-1.59	0.46	-0.81	-0.74	0.92	-0.74	-0.81	0.46
LL	-51.24	-49.36	42.92	-23.53	-28.83	34.85	-26.55	-23.29	40.13
Total :- DL+SIDL+LL	*-79.96*	*-78.47*	*34.55*	*-23.91*	*-26.67*	*43.38*	*-24.39*	*-23.67*	*31.76*
Design moments	**80**	**78.5**	**34.6**	**24**	**26.7**	**43.4**	**24.4**	**23.7**	**31.8**

SLS -Design moments

Moment @ Mid Span sagging (+ ve) = 43.40 kN m
Moment @ Support hogging (- ve) = 26.70 kN m
Moment at the Cantiliver hogging (- ve) = 80.00 kN m

6.3.4 SLS-Factored Bending moment (kN.m) - Quasi Permanent

Sections	1-Hogg.	2-Hogg.	3-Sagg.	4-Hogg.	5-Hogg.	6-Sagg.	7-Hogg.	8-Hogg.	9-Sagg.
Dead load	-9.14	-9.14	-0.73	-1.76	-1.10	3.61	-1.10	-1.76	-0.73
SIDL-C/B	-17.93	-18.39	-8.10	2.19	4.00	4.00	4.00	2.19	-8.10
SIDL-W/C	-1.66	-1.59	0.46	-0.81	-0.74	0.92	-0.74	-0.81	0.46
Total :- DL+SIDL+LL	*-28.72*	*-29.11*	*-8.37*	*-0.38*	*2.16*	*8.53*	*2.16*	*-0.38*	*-8.37*
Design moments	**28.8**	**29.2**	**8.4**	**0.4**	**2.2**	**8.6**	**2.2**	**0.4**	**8.4**

SLS -Design moments

Moment @ Mid Span sagging (+ ve) = 8.60 kN m
Moment @ Support hogging (- ve) = 2.20 kN m
Moment at the Cantiliver hogging (- ve) = 29.20 kN m

6.4 Design of Deck Slab

Thickness of deck slab (Mid Span)		=	0.230	m
Thickness of deck slab (Support)		=	0.230	m
Adopt design width of slab	b	=	1000	mm
Clear Cover (Bottom)		=	40	mm
Clear Cover (Top)		=	40	mm
Moment @ Mid Span (+ ve)		=	63.90	kN m
Moment @ Support (-ve)		=	40.50	kN m
Moment @ the Cantiliver (-ve)		=	115.90	kN m
Grade of concrete	f_{ck}	=	M 45	
Grade of Steel	f_y	=	Fe 500	
Modulus of elasticity of steel	E_s	=	2.0E+05	N/mm^2
Modulus of elasticity of concrete	E_c	=	34000	N/mm^2
Modular Ratio (Long term)	m	=	11.76	

Check for effective Depth

Consider, section as a balanced section

Depth of N.A. ; $X_{u\,Bal}$ = 0.46 * d

M_u = 0.36 * f_{ck} * b * $X_{u\,Bal}$ * (d - 0.42 * $X_{u\,Bal}$)

Depth of slab available at mid span

d_{bal}	=	103.09	mm
D_{bal}	=	150	mm
		Safe	

Depth of slab at support

d_{bal}	=	138.84	mm
D_{bal}	=	185	mm
		Safe	

1] Main steel at Mid span

Design bending moment at mid span = 63.9 kNm

Effective depth of slab provided ; d_{prov} = 184 mm

Area of steel required at midspan

A_{st} reqd = 0.5 x f_{ck} / f_y (1 - sqrt(1 - 4.6 x M_u/f_{ck} x b x d^2) x b x d

A_{st} reqd = 842 mm^2

Hence, provide 12 mm dia at 120 mm Main Steel

A_{st} prov = 942 mm^2 SAFE

As min = 0.26 f_{ctm} x b_t x d /f_{yk} > 0.0013b_t d

f_{ctm} = 2.8

f_{yk} = 500

Hence $A_{s\,min}$ = 268 mm^2 SAFE

Distribution Steel at Mid span

$A_{st\,min}$ = 20 % * Ast

$A_{st\,min}$ = 188 mm^2

Hence, provide 8 mm dia at 200 mm c/c Distribution Steel

A_{st} prov = 251 mm^2 SAFE

2] Main steel at Support

Design bending moment at support = 40.50 kNm

Effective depth of slab provided d_{prov} = 184 mm

Area of steel required at midspan

A_{st} reqd = $0.5 \times f_{ck} / f_y (1 - \sqrt{(1 - 4.6 \times M_u / f_{ck} \times b \times d^2)}) \times b \times d$

A_{st} reqd = 522.8 mm^2

Hence, provide 12 mm dia at 200 mm c/c Main Steel

A_{st} prov = 565 mm^2 SAFE

$A_{st\ min} = 0.26\ f_{ctm} \times b_t \times d / f_{yk} > 0.0013 b_t d$

$A_{st\ min}$ = 268 mm^2 SAFE

Distribution Steel

$A_{st\ min}$ = 20 % * Ast

$A_{st\ min}$ = 113 mm^2

Hence, provide 10 mm dia at 200 mm c/c Distribution Steel

A_{st} prov = 393 mm^2 SAFE

3] Main steel at Cantiliver

Design bending moment at support = 115.90 kNm

Effective depth of slab provided d_{prov} = 184 mm

Area of steel required at midspan

A_{st} reqd = $0.5 \times f_{ck} / f_y (1 - \sqrt{(1 - 4.6 \times M_u / f_{ck} \times b \times d^2)}) \times b \times d$

A_{st} reqd = 1604 mm^2

Hence, provide 12 mm dia at 200 mm c/c Main Steel

& 20 mm dia at 200 mm c/c Main Steel

A_{st} prov = 2136 mm^2 SAFE

$A_{st\ min} = 0.26\ f_{ctm} \times b_t \times d / f_{yk} > 0.0013 b_t d$

$A_{st\ min}$ = 268 mm^2 SAFE

Distribution Steel

$A_{st\ min}$ = 20 % * Ast

$A_{st\ min}$ = 427 mm^2

Hence, provide 12 mm dia at 200 mm c/c Distribution Steel

A_{st} prov = 565 mm^2 SAFE

6.4.1 Calculation of Crack Width

Section	Units	Cant. Support	Mid Span	Support Mid Span
Depth of Slab	mm	230	230	230
Clear Cover to The R/F	mm	40	40	40
Width	mm	1000	1000	1000
Maximum Diameter of Bar	mm	12	12	12
CG of Section from Top	mm	115	115	115
CG of Section from Bottom	mm	115	115	115
Area of Steel Provided	mm^2	2136	942	565
Effective Depth, d	mm	184	184	184
Depth of NA		57.36	25.31	15.18
Xu = (0.87*fy*Ast)/(0.36*fck*b)				
fctm		3.28	3.28	3.28
Service Moment- Quasi Permanent	kNm	29	9	2
Service Moment - Rare Combination	kNm	80	43	27

Properties of Gross Section	Unit	Cant. Support	Mid Span	Support Mid Span
Gross Area, A_{gr}	mm^2	2.30E+05	2.30E+05	2.30E+05
Gross Moment of Inertia, I_{gr}	mm^4	1.01E+09	1.01E+09	1.01E+09

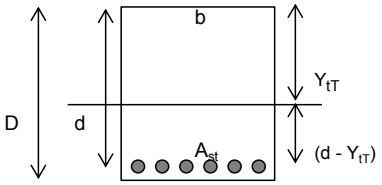
Properties of Uncracked Section

$$Y_{tT} = \frac{(b * D * D/2) + ((m - 1) * A_{st} * d)}{(b * D * D/2) + ((m - 1) * A_{st})}$$

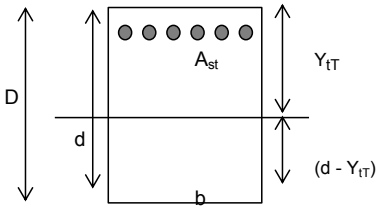
$$Y_{bT} = D - Y_{tT}$$

$$Y_{sT} = d - Y_{tT}$$

$$I_T = (b * D3/12 + b * D * (D/2 - Y_{tT})2) + ((m - 1) * A_{st} * (d - Y_{tT})2)$$



At Mid Span



At Support

Properties of Uncracked Transformed Section	Unit	Cant. Support	Mid Span	Support Mid Span
CG of Uncracked section from Top, Y_{tT}	mm	121.27	117.92	116.78
CG of Uncracked section from bottom, Y_{bT}	mm	108.73	112.08	113.22
CG of Uncracked section from steel, Y_{sT}	mm	62.73	66.08	67.22
Uncracked Moment of Inertia, I_T	mm^4	1.113E+09	1.06E+09	1.04E+09

Properties of Cracked Section

Calculation of C.G. of Cracked Transformed section from Top (Can. Support) Y_{tcr}

$$b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$$

$$1000 * Y^2_{tCr} / 2 = 11.76 * 2136 * (184 - Ytcr)$$

500 Y^2_{tCr} 2.51E+04 Y_{tCr} - 4.62E+06 = 0

Y_{tCr} = 74 mm

Calculation of C.G. of Cracked Transformed section at Midspan Y_{tcr}

b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})

1000 * Y^2_{tCr} / 2 = 11.76 * 942 * (184 - Ytcr)

500 Y^2_{tCr} 11087.97 Y_{tCr} - 2040187 = 0

Y_{tCr} = 54 mm

Calculation of C.G. of Cracked Transformed section at Midspan (Support) Y_{tcr}

b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})

1000 * Y^2_{tCr} / 2 = 11.76 * 565 * (184 - Ytcr)

500 Y^2_{tCr} 6652.784 Y_{tCr} - 1224112 = 0

Y_{tCr} = 43 mm

Properties of Cracked Transformed Section	Unit	Cant. Support	Mid Span	Support Mid Span
CG of Cracked section from Top, Y_{tCr}	mm	74	54	43
CG of Cracked section from bottom, Y_{bCr}	mm	156	176	187
CG of Cracked section from steel, Y_{sCr}	mm	110	130	141
Cracked Moment of Inertia, I_{cr}	mm^4	4.39E+08	2.40E+08	1.59E+08

Stresses under Rare Combination	Unit	Cant. Support	Mid Span	Support Mid Span
Cracking Moment, $M_{cr} = I_{gr} * f_{ctm} / Y_b$	kN m	28.89	28.89	28.89
State of Section		Cracked	Cracked	Uncracked
Comp stress in concrete, fc = $(M / I_T) * Y_{tT}$	Mpa	13.53	9.72	2.99
Compressive stress check		Linear Creep	Linear Creep	Linear Creep
Tensile stress in conc. at steel level, fct_{steel} = $(M / I_T) * Y_{st}$	Mpa	19.99	23.57	1.72
Tensile stress in steel, fst = m * fct_{steel}	Mpa	235.16	277.26	20.26

Stresses under Quasi Permanent	Unit	Cant. Support	Mid Span	Support Mid Span
Cracking Moment, $M_{cr} = I_{gr} * f_{ctm} / Y_b$	kN m	28.89	28.89	28.89
State of Section		Cracked	Uncracked	Uncracked
Comp stress in concrete, fc = $(M / I_T) * Y_{tT}$	Mpa	4.94	0.96	0.25
Compressive stress check		Linear Creep	Linear Creep	Linear Creep
Tensile stress in conc. at steel level, fct_{steel} = $(M / I_T) * Y_{st}$	Mpa	7.30	0.54	0.14
Tensile stress in steel, fst = m * fct_{steel}	Mpa	85.83	6.31	1.67

Stresses are within permissible limit

6.4.2 Check Minimum Reinforcement for Crack control

$$A_{s\,min} = \frac{k_c * k * f_{ct,eff} * A_{ct}}{\sigma_s}$$ (Refer IRC:112-2011, Cl 12.3.3)

Where,
- $A_{s\,min}$ = Minimum area of reinforcing steel within the tensile zone
- A_{ct} = Area of concrete within tensile zone
- σ_s = Maximum stress permitted in the reinforcement immediately after formation of the crack
- $f_{ct,eff}$ = Mean value of tensile strength of the concrete = f_{ctm}
- k = Coefficient which allows for the effect of non-uniform self equilibrium stresses
- k_c = Coefficient which takes account stress distribution within the section just prior to cracking

$k_c = 0.4 \times [\,1 - \sigma_c / (\,k_1 \times (\,h/h^*\,) \times f_{ct,eff}\,)]$

Cant. Support

A_{ct}	=	155732.02	mm^2	
σ_s	=	240	N / mm^2	(Refer IRC:112-2011, Table 12.2)
$f_{ct,eff}$	=	3.28	N / mm^2	(Refer IRC:112-2011, Tab. 6.5)
k	=	1		(for web with h <300mm)
σ_c	=	0	N / mm^2	For RCC
k_c	=	0.4		
$A_{s\,min}$	=	850	mm^2	SAFE

Mid Span

A_{ct}	=	112085	mm^2	
σ_s	=	240	N / mm^2	
$f_{ct,eff}$	=	3.28	N / mm^2	
k	=	1		(for web with h <300mm)
σ_c	=	0	N / mm^2	For RCC
k_c	=	0.4		
$A_{s\,min}$	=	612	mm^2	SAFE

Support Mid Span

A_{ct}	=	113220.9	mm^2	
σ_s	=	240	N / mm^2	
$f_{ct,eff}$	=	3.28	N / mm^2	
k	=	1		(for web with h <300mm)
σ_c	=	0	N / mm^2	For RCC
k_c	=	0.4		
$A_{s\,min}$	=	618	mm^2	Provide Minimum R/F for crack cor

9.2 Calculation of Crack Width at Mid-Span (for sagging)

$$W_k = S_{r\,max}\,(\,\varepsilon_{sm} - \varepsilon_{cm}\,)$$ (Refer IRC:112-2011, Cl 12.3.4)

Where,
- W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing (Refer IRC:112-2011, Eq. 12.8, 12.11 or 12.12)

$S_{r\,max}$ = $3.4c + (0.425 * k_1 * k_2 * \phi / \rho_{p,eff})$

c = Clear cover to lonfitudnal reinforcement

c	=	40	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s} \geq 0.6\,\sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = $2.5 (h - d)$
= $h - x / 3$
= $h / 2$

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	115	mm
$A_{c,eff}$	=	115000	mm^2
$\rho_{p,eff}$ =	=	0.008	
k_t	=	0.5	
σ_{sc}	=	6.31	N / mm^2
$f_{ct,eff}$	=	3.28	N / mm^2
α_e	=	11.76	
$\varepsilon_{sm} - \varepsilon_{cm}$	=	1.89E-05	
$S_{r\,max}$	=	384.9	
W_k	=	0.0073	mm SAFE

9.3 Calculation of Crack Width at support (for hogging)

W_k = $S_{r\,max} (\varepsilon_{sm} - \varepsilon_{cm})$ (Refer IRC:112-2011, Cl 12.3.4)

Where, W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing (Refer IRC:112-2011, Eq. 12.8, 12.11 or 12.12)

$S_{r\,max}$ = $3.4c + (0.425 * k_1 * k_2 * \phi / \rho_{p,eff})$

c = Clear cover to lonfitudnal reinforcement

c	=	40	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\ \sigma_{sc} / E_s$

Where,

σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (h - d)
= h - x / 3
= h / 2

k_t = Factor dependent on duration of load

$h_{c,eff}$	=	115 mm
$A_{c,eff}$	=	115000 mm^2
$\rho_{p,eff}$ =	=	0.005
k_t	=	0.5
σ_{sc}	=	1.67 N / mm^2
$f_{ct,eff}$	=	3.28 N / mm^2
α_e	=	11.76
$\varepsilon_{sm} - \varepsilon_{cm}$	=	5.01E-06
$S_{r\ max}$	=	550.9
W_k	=	0.0028 mm

SAFE

7 Analysis and Design of Pier

Impact factor for live load — For Class A 1.125 — For 70R wheeled 1.162 — Span = 30 m

7.1 *Staad Results and load combination at top of pier*

Summary of forces from staad at Top of Pier

Load Case - LC	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		Fx kN	Fy kN	Fz kN	My kNm	Mz kNm	Fx kN	Fy kN	Fz kN	My kNm	Mz kNm	Fx kN	Fy kN	Fz kN	My kNm	Mz kNm
		P-kN	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*	*P-kN*	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*	*P-kN*	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*
1	Dead load -DL															
1.1	DL of Girder	757	-114	0	0	-708	2040	44	0	-22	267	1757	0	0	-1	0
1.2	DL of Diaphragm	568	0	0	0	-1	1026	0	0	0	-1	1027	0	0	0	0
1.3	DL of Deck slab	901	-55	-1	-1	-342	2522	22	2	-23	138	2119	0	-1	-2	0
1.4	DL of Pier	55	0	0	0	0	65	0	0	0	0	65	0	0	0	0
	Total Dead load	2281	-170	-1	-2	-1051	5653	66	2	-45	404	4967	0	-1	-2	0
2	Super Imposed Dead load -SIDL															
2.1	Crash barrier -CB	240	-7	0	0	-42	687	6	0	0	37	569	0	0	0	0
2.2	Wearing Coat- WC	239	-15	0	6	-92	674	6	0	14	37	562	0	0	13	0
3	Differential Settlement -DS	66	-25	0	0	-151	203	16	0	0	86	272	-10	0	0	-48
4	Live load															
4.1	Live load - Without impact															
4.1.1	LL- 70 R _ Most ecc															
	Max P	789	-27	49	-2616	-168	967	11	189	-2869	72	823	-12	113	-2869	-73
	Max MT	734	-19	25	-2643	-116	861	20	112	-2940	120	690	0	40	-2918	1
	Max ML	498	-43	-7	-1719	-266	808	49	44	-2574	303	740	-42	39	-2465	-263
4.1.2	LL- Class A _ Most ecc															
	Max P	335	-16	10	-1567	-99	518	5	136	-2115	30	468	13	52	-2089	80
	Max MT	313	-12	-6	-1607	-75	504	10	64	-2235	58	397	0	5	-2211	-2
	Max ML	254	-18	-12	-1210	-109	393	23	67	-1521	141	282	15	20	-1269	95
4.1.3	LL- 1_Class A for 70 R															
	Max P	1089	-45	34	-2118	-286	1486	14	189	-2922	88	1278	-24	98	-2941	-147
	Max MT	1002	-45	-21	-2283	-282	1330	40	96	-3018	245	1086	17	14	-3009	99
	Max ML	794	-69	-3	-1868	-432	1115	75	89	-2058	461	1204	-59	50	-2684	-366
4.1.4	LL-2_70R															
	Max P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max ML	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.5	LL-3 Class A															
	Max P	1010	-62	8	-1201	-384	1556	16	104	-1619	96	1404	42	40	-1600	260
	Max MT	945	-51	-4	-1231	-314	1512	29	49	-1711	179	1194	-1	4	-1694	-5
	Max ML	795	-67	-7	-962	-413	1176	75	51	-1164	462	847	54	15	-972	325

4.2	Live load - With impact															
4.2.1	LL- 70 R _ Most ecc															
	Max P	916	-31	57	-3039	-195	1123	13	220	-3333	83	956	-14	131	-3333	-85
	Max MT	853	-22	28	-3070	-135	1000	23	130	-3415	139	801	0	46	-3389	1
	Max ML	578	-50	-8	-1997	-309	939	57	51	-2991	353	859	-49	46	-2863	-306
4.2.2	LL- Class A _ Most ecc															
	Max P	377	-18	12	-1763	-111	583	5	153	-2379	34	526	15	59	-2350	90
	Max MT	353	-14	-6	-1808	-85	567	11	72	-2514	65	446	0	6	-2487	-3
	Max ML	286	-20	-13	-1362	-122	443	26	75	-1711	159	317	17	23	-1428	107
4.2.3	LL-70R+1 Class A															
	Max P	1102	-46	35	-2145	-290	1505	14	191	-2959	89	1294	-24	99	-2978	-149
	Max MT	1014	-46	-21	-2311	-286	1347	41	98	-3056	248	1099	17	15	-3047	100
	Max ML	804	-70	-3	-1891	-437	1129	76	90	-2084	467	1219	-59	51	-2717	-371
4.2.4	LL-2_70R															
	Max P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max ML	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.2.5	LL-3 Class A															
	Max P	1136	-69	9	-1351	-432	1750	18	117	-1821	109	1580	47	45	-1800	293
	Max MT	1063	-57	-5	-1385	-353	1700	33	55	-1925	202	1343	-1	4	-1905	-6
	Max ML	894	-75	-8	-1082	-465	1323	85	58	-1309	519	952	61	17	-1094	365
4.3	Governing live load															
4.3.1	LL - Max P	1136	-69	9	-1351	-432	1750	18	117	-1821	109	1580	47	45	-1800	293
4.3.2	LL - Max MT	853	-22	28	-3070	-135	1000	23	130	-3415	139	801	0	46	-3389	1
4.3.3	LL - Max ML	894	-75	-8	-1082	-465	1323	85	58	-1309	519	1219	-59	51	-2717	-371
5	Braking force															
5.1	Braking force															
5.1.1	LL- 70 R _ Most ecc	23	-55	0	0	-224	-4	-97	0	0	-411	0	-96	0	0	-407
5.1.2	LL- Class A _ Most ecc	13	-31	0	0	-125	-2	-54	0	0	-228	0	-53	0	0	-226
5.1.3	LL-70R+1 Class A	28	-67	0	0	-271	-5	-117	0	0	-496	0	-116	0	0	-492
5.1.4	LL-2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.1.5	LL-3 Class A	18	-42	0	0	-171	-3	-74	0	0	-313	0	-73	0	0	-310
5.2	Governing braking force															
5.2.1	LL - Max P	18	-42	0	0	-171	-3	-74	0	0	-313	0	-73	0	0	-310
5.2.2	LL - Max MT	23	-55	0	0	-224	-4	-97	0	0	-411	0	-96	0	0	-407
5.2.3	LL - Max ML	18	-42	0	0	-171	-3	-74	0	0	-313	0	-116	0	0	-492
6	Wind load -WL															
6.1	Wind load downwards -28.5 m/sec	189	-60	-235	-385	-326	470	-96	-364	-600	-456	396	-100	-395	-624	-481
6.2	Wind load downwards -29 m/sec	177	-46	-176	-205	-267	450	-72	-277	-294	-358	379	-76	-300	-308	-382
7	Temperature															
7.1	Temperature Rise	52	-182	0	0	-750	-41	-157	0	0	-668	-21	-3	0	0	-12
7.2	Temperature Fall	-52	182	0	0	750	41	157	0	0	668	21	3	0	0	12

8	Temperature gradient															
8.1	Positive Temperature	-97	26	0	1	66	118	48	1	-3	221	-43	0	-1	1	1
8.2	Reverse Temperature	45	-24	0	-1	-82	-53	-32	0	1	-144	17	0	0	-1	-1
9	Differential shrinkage	-99	8	0	2	-15	124	36	1	-4	170	-49	0	-1	2	1
10	Seismic force															
10.1	Long.Seismic DL+SIDL	51	-148	0	0	-637	-5	-258	0	0	-1126	0	-257	0	0	-1121
10.2	Trans. Seismic DL+SIDL	0	0	-374	-393	0	0	0	-401	-436	0	0	0	-389	-426	0
10.3	Trans. Seismic 70 R_Most ecc	0	0	-9	-10	0	0	0	-10	-11	0	0	0	-10	-11	0
10.4	Trans. Seismic Class A_Most ecc	0	0	-5	-5	0	0	0	-6	-6	0	0	0	-5	-6	0
10.5	Trans. Seismic 70R+1 CLASS A	0	0	-14	-15	0	0	0	-15	-17	0	0	0	-15	-16	0
10.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.7	Trans. Seismic 3 Class A	0	0	-15	-16	0	0	0	-17	-18	0	0	0	-16	-18	0
	Governing Trans. Seismic Live load															
	Max P	0	0	-15	-16	0	0	0	-17	-18	0	0	0	-16	-18	0
	Max MT	0	0	-9	-10	0	0	0	-10	-11	0	0	0	-10	-11	0
	Max ML	0	0	-15	-16	0	0	0	-17	-18	0	0	0	-15	-16	0

Seismic Combinations:(As per IRC-6:2017- Cl.219.4)

Load Case	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
11	**Seismic - Longitudinal**															
11.1	(L+0.3T-0.3V) Max. P	-15	-148	-117	-123	-637	1	-258	-125	-136	-1126	0	-257	-121	-133	-1121
11.2	(L+0.3T+0.3V) Max. P	15	-148	-117	-123	-637	-1	-258	-125	-136	-1126	0	-257	-121	-133	-1121
11.3	(L+0.3T-0.3V) Max. M_T	-15	-148	-115	-121	-637	1	-258	-123	-134	-1126	0	-257	-120	-131	-1121
11.4	(L+0.3T+0.3V) Max. M_T	15	-148	-115	-121	-637	-1	-258	-123	-134	-1126	0	-257	-120	-131	-1121
11.5	(L+0.3T-0.3V) Max. M_L	-15	-148	-117	-123	-637	1	-258	-125	-136	-1126	0	-257	-121	-133	-1121
11.6	(L+0.3T+0.3V) Max. M_L	15	-148	-117	-123	-637	-1	-258	-125	-136	-1126	0	-257	-121	-133	-1121
12	**Seismic - Transverse**															
12.1	(0.3L+T-0.3V) Max. P	0	-44	-389	-410	-191	0	-77	-418	-454	-338	0	-77	-405	-443	-336
12.2	(0.3L+T+0.3V) Max. P	0	-44	-389	-410	-191	0	-77	-418	-454	-338	0	-77	-405	-443	-336
12.3	(0.3L+T-0.3V) Max. M_T	0	-44	-383	-403	-191	0	-77	-411	-447	-338	0	-77	-399	-436	-336
12.4	(0.3L+T+0.3V) Max. M_T	0	-44	-383	-403	-191	0	-77	-411	-447	-338	0	-77	-399	-436	-336
12.5	(0.3L+T-0.3V) Max. M_L	0	-44	-389	-410	-191	0	-77	-418	-454	-338	0	-77	-404	-442	-336
12.6	(0.3L+T+0.3V) Max. M_L	0	-44	-389	-410	-191	0	-77	-418	-454	-338	0	-77	-404	-442	-336

7.1.1 Load combination - Ultimate Limit State

Load Case	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
	Basic combination															
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9														
	Except Live load															
100	1.35 DL+ 1.35 C/B + 1.75 WC +0.9 WL-28.5m/sec	3981	-306	-159	-176	-1877	10143	42	-248	-300	337	8799	-69	-271	-257	-344
101	1.35 DL+ 1.35 C/B + 1.75 WC +0.9 WL-29m/sec	3992	-319	-212	-338	-1930	10160	22	-326	-576	249	8814	-90	-357	-541	-433

	Including live load															
102	LC 101 + 1.5 x LL 4.3.1 + 1.5 x LL 5.2.1	5723	-486	-198	-2364	-2834	12781	-63	-151	-3308	-57	11184	-129	-290	-3241	-459
103	LC 101 + 1.5 x LL 4.3.2 + 1.5 x LL 5.2.2	5306	-434	-169	-4944	-2469	11655	-89	-131	-5699	-158	10016	-234	-288	-5625	-1041
104	LC 101 + 1.5 x LL 4.3.3 + 1.5 x LL 5.2.3	5360	-494	-223	-1961	-2884	12140	38	-240	-2540	559	10642	-353	-281	-4617	-1727
	II.Wind load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15														
	Except Live load															
105	1.35 DL+ 1.35 C/B + 1.75 WC +1.5 WL-28.5m/sec	4088	-334	-264	-299	-2037	10413	-1	-414	-476	122	9026	-115	-450	-442	-573
106	1.35 DL+ 1.35 C/B + 1.75 WC +1.5 WL-3629m/sec	4105	-355	-353	-569	-2125	10442	-36	-545	-936	-24	9052	-149	-594	-916	-721
	Including live load															
107	LC 106 + 1.15 x LL 4.3.1 + 1.15 x LL 5.2.1	5432	-483	-342	-2122	-2819	12452	-100	-410	-3031	-259	10868	-180	-543	-2986	-741
108	LC 106 + 1.15 x LL 4.3.2 + 1.15 x LL 5.2.2	5113	-443	-320	-4100	-2539	11588	-121	-395	-4864	-337	9973	-260	-541	-4813	-1188
109	LC 106 + 1.15 x LL 4.3.3 + 1.15 x LL 5.2.3	5154	-489	-361	-1813	-2857	11960	-23	-478	-2442	213	10453	-352	-536	-4040	-1713
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5														
	Seismic Longitudinal Case (with -P)															
	Except Live load															
110	1.35 DL+ 1.35 C/B + 1.75 WC	3822	-265	-1	8	-1637	9738	108	2	-36	659	8458	0	-1	20	0
	Including live load															
111	LC 110 +0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.1	4030	-509	-174	-446	-2712	10089	-291	-163	-604	-1070	8774	-391	-174	-539	-1685
112	LC 110 +0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.3	3975	-502	-167	-787	-2664	9939	-294	-157	-920	-1084	8619	-405	-171	-854	-1763
113	LC 110 +0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.5	3982	-510	-177	-392	-2719	10004	-277	-175	-502	-988	8702	-421	-173	-722	-1854
	Seismic Longitudinal Case (with +P)															
	Except Live load															
114	1.35 DL+ 1.35 C/B + 1.75 WC	3822	-265	-1	8	-1637	9738	108	2	-36	659	8458	0	-1	20	0
	Including live load															
115	LC 114 +0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.2	4076	-509	-174	-446	-2712	10085	-291	-163	-604	-1070	8774	-391	-174	-539	-1685
116	LC 114 +0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.4	4020	-502	-167	-787	-2664	9935	-294	-157	-920	-1084	8619	-405	-171	-854	-1763
117	LC 114 +0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.6	4027	-510	-177	-392	-2719	9999	-277	-175	-502	-988	8702	-421	-173	-722	-1854
	Seismic Transverse Case (with -P)															
	Except Live load															
118	1.35 DL+ 1.35 C/B + 1.75 WC	3822	-265	-1	8	-1637	9738	108	2	-36	659	8458	0	-1	20	0
	Including live load															
119	LC 118+ 0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.1	4053	-354	-583	-876	-2044	10087	-20	-601	-1081	112	8774	-121	-599	-1004	-508
120	LC 118+ 0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.3	3997	-347	-570	-1210	-1995	9937	-23	-589	-1389	98	8619	-135	-589	-1312	-586
121	LC 118+ 0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.5	4004	-355	-586	-822	-2050	10001	-6	-613	-978	194	8702	-151	-597	-1186	-677
	Seismic Transverse Case (with +P)															
	Except Live load															
122	1.35 DL+ 1.35 C/B + 1.75 WC	3822	-265	-1	8	-1637	9738	108	2	-36	659	8458	0	-1	20	0
	Including live load															
123	LC 122+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.2	4053	-354	-583	-876	-2044	10087	-20	-601	-1081	112	8774	-121	-599	-1004	-508
124	LC 122+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.4	3997	-347	-570	-1210	-1995	9937	-23	-589	-1389	98	8619	-135	-589	-1312	-586
125	LC 122+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.6	4004	-355	-586	-822	-2050	10001	-6	-613	-978	194	8702	-151	-597	-1186	-677

Summary of load combination - Ultimate Limit State

Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
Basic combination															
I. Live load leading	5723	-494	-223	-4944	-2884	12781	-89	-326	-5699	559	11184	-353	-357	-5625	-1727
II. Wind load leading	5432	-489	-361	-4100	-2857	12452	-121	-545	-4864	-337	10868	-352	-594	-4813	-1713
Seismic combination															
Seismic Longitudinal Case	4076	-510	-177	-787	-2719	10089	-294	-175	-920	-1084	8774	-421	-174	-854	-1854
Seismic Transverse Case	4053	-355	-586	-1210	-2050	10087	108	-613	-1389	659	8774	-151	-599	-1312	-677
Design Forces	**5723**	**-510**	**-586**	**-4944**	**-2884**	**12781**	**-294**	**-613**	**-5699**	**-1084**	**11184**	**-421**	**-599**	**-5625**	**-1854**

7.1.2 load combination- Serviceability Limit State

Load Case -	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
	Rare Combination															
	I. Live load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage - 1														
	Except Live load															
200	1 DL+ 1 SIDL+1 DS +0.6 WL (29m/s)+Diff. shrinkage	2881	-239	-106	-116	-1530	7744	87	-164	-208	525	6662	-56	-181	-169	-277
201	1 DL+ 1 SIDL+1 DS +0.6 WL(28.5m/)+Diff. shrinkage	2888	-248	-141	-224	-1566	7756	74	-217	-392	467	6672	-70	-239	-359	-336
	Including live load															
202	LC 201 + 1 x LL 4.3.1 + 1 x LL 5.2.1	4042	-359	-132	-1575	-2168	9503	17	-100	-2213	262	8251	-96	-194	-2159	-353
203	LC 201 + 1 x LL 4.3.2 + 1 x LL 5.2.2	3765	-324	-113	-3294	-1925	8753	0	-86	-3807	195	7473	-166	-192	-3748	-741
204	LC 201 + 1 x LL 4.3.3 + 1 x LL 5.2.3	3800	-365	-149	-1305	-2202	9076	84	-159	-1701	673	7891	-245	-188	-3076	-1198
	II. Wind load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Live load -0.75, Wind-1 , Shrinkage - 1														
	Except Live load															
205	1 DL+ 1 SIDL+1 DS+1 WL -29 m/sec+Diff. shrinkage	2952	-258	-176	-198	-1637	7924	58	-275	-325	382	6813	-86	-301	-293	-429
206	1 DL+ 1 SIDL+1 DS+1 WL -28.5 m/sec+Diff. shrinkag	2964	-272	-235	-378	-1696	7944	35	-362	-632	284	6830	-109	-397	-608	-528
	Including live load															
207	LC 206 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	3829	-355	-228	-1391	-2148	9254	-7	-275	-1998	131	8015	-129	-363	-1958	-541
208	LC 206 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	3621	-329	-214	-2680	-1966	8691	-20	-265	-3193	81	7431	-181	-362	-3150	-832
209	LC 206 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	3648	-359	-241	-1189	-2173	8934	43	-319	-1614	439	7744	-241	-359	-2646	-1175
	III. Temperature load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75, Shrinkage - 1														
	Bridge Temperature															
	Temperature Rise Case															
	Except Live load															
210	1 DL+ 1 SIDL+1 DS+ 1 Temp. Rise +Diff. shrinkage	2827	-393	0	7	-2120	7433	-26	2	-31	73	6413	-13	-1	16	-59
	Including live load															
211	LC 210 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	3693	-477	6	-1006	-2572	8743	-68	89	-1397	-81	7598	-32	32	-1334	-72
212	LC 210 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	3485	-451	21	-2295	-2390	8180	-81	99	-2593	-131	7014	-85	33	-2526	-363
213	LC 210 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	3511	-481	-6	-804	-2597	8423	-18	45	-1013	228	7327	-144	36	-2022	-706
	Temperature Fall Case															
	Except Live load															
214	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall +Diff. shrinkage	2723	-30	-1	7	-620	7516	287	2	-31	1408	6456	-7	-1	16	-35

	Including live load															
215	LC 214 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	3588	-113	6	-1006	-1073	8826	245	90	-1397	1255	7640	-27	33	-1334	-49
216	LC 214 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	3380	-87	21	-2296	-890	8263	232	100	-2593	1204	7056	-79	34	-2526	-340
217	LC 214 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	3407	-118	-6	-804	-1097	8505	296	45	-1013	1563	7370	-139	37	-2022	-682
	Temperature Gradient															
	Positive Temperature															
	Except Live load															
218	1 DL+ 1 SIDL+1 DS+ 1 Positive temp. +Diff. shrinkag	2678	-186	-1	9	-1304	7592	179	3	-34	962	6391	-10	-2	17	-46
	Including live load															
219	LC 218 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	3544	-269	6	-1005	-1756	8903	137	90	-1400	809	7576	-29	32	-1333	-59
220	LC 218 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	3336	-243	21	-2294	-1574	8340	124	100	-2595	758	6992	-82	33	-2525	-351
221	LC 218 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	3362	-273	-6	-803	-1781	8582	187	46	-1016	1117	7305	-141	36	-2021	-693
	Reverse Temperature															
	Except Live load															
222	1 DL+ 1 SIDL+1 DS + 1 Reverse temp.+Diff. shrinka	2820	-236	-1	7	-1452	7422	99	1	-30	596	6451	-10	-1	15	-48
	Including live load															
223	LC 222 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	3685	-319	6	-1007	-1904	8732	57	89	-1396	443	7636	-30	33	-1335	-61
224	LC 222 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	3477	-293	21	-2296	-1722	8169	43	99	-2591	392	7052	-82	34	-2527	-352
225	LC 222 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	3504	-324	-6	-805	-1929	8411	107	45	-1012	751	7365	-142	37	-2023	-695
	Quasi-Permanent Combination	Partial safety factors:-			DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5, Shrinkage -1											
226	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinka	2801	-303	-1	7	-1745	7454	53	2	-31	406	6424	-11	-1	16	-53
227	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkag	2749	-121	-1	7	-995	7495	209	2	-31	1074	6445	-8	-1	16	-41
228	1 DL+ 1 SIDL+1 DS + 0.5 Positive temp.+ Diff. Shrin	2727	-199	-1	8	-1337	7533	155	2	-33	851	6413	-10	-2	16	-47
229	1 DL+ 1 SIDL+1 DS + 0.5 Reverse temp.l+ Diff. Shri	2798	-224	-1	7	-1411	7448	115	2	-31	668	6443	-10	-1	15	-48

Summary of load combinaton -Serviceability Limit State

Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
Rare Combination															
I. Live load leading	4042	-365	-149	-3294	-2202	9503	87	-217	-3807	673	8251	-245	-239	-3748	-1198
II. Wind load leading	3829	-359	-241	-2680	-2173	9254	58	-362	-3193	439	8015	-241	-397	-3150	-1175
III. Temperature load leading	3693	-481	21	-2296	-2597	8903	296	100	-2595	1563	7640	-144	37	-2527	-706
Design Forces	***4042***	***-481***	***-241***	***-3294***	***-2597***	***9503***	***296***	***-362***	***-3807***	***1563***	***8251***	***-245***	***-397***	***-3748***	***-1198***
Quasi-permanent Combination	**2801**	**-303**	**-1**	**8**	**-1745**	**7533**	**209**	**2**	**-33**	**1074**	**6445**	**-11**	**-2**	**16**	**-53**

7.2 *Staad Results and load combination at Bottom of pier*

Impact factor for live load	For Class A	1
	For 70R wheeled	1

Summary of forces from staad at Bottom of Pier

Load Case - LC	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		Fx kN	Fy kN	Fz kN	My kNm	Mz kNm	Fx kN	Fy kN	Fz kN	My kNm	Mz kNm	Fx kN	Fy kN	Fz kN	My kNm	Mz kNm
		P-kN	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*	*P-kN*	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*	*P-kN*	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*
1	Dead load -DL															
1.1	DL of Girder	-757	114	0	1	-405	-2040	-44	0	22	158	-1757	0	0	1	0
1.2	DL of Diaphragm	-568	0	0	0	-1	-1026	0	0	0	0	-1027	0	0	0	0
1.3	DL of Deck slab	-901	55	1	9	-198	-2522	-22	-2	8	81	-2119	0	1	9	0
1.4	DL of Pier	-551	0	0	0	0	-649	0	0	0	0	-649	0	0	0	0
	Total Dead load	-2777	170	1	9	-603	-6237	-66	-2	30	238	-5551	0	1	9	0
2	Super Imposed Dead load -SIDL															
2.1	Crash barrier -CB	-240	7	0	0	-24	-687	-6	0	0	21	-569	0	0	0	0
2.2	Wearing Coat- WC	-239	15	0	-8	-53	-674	-6	0	-12	21	-562	0	0	-14	0
3	Differential Settlement -DS	-66	25	0	0	-88	-203	-16	0	0	71	-272	-10	0	0	-49
4	Live load															
4.1	Live load - Without impact															
4.1.1	LL- 70 R _ Most ecc															
	Max P	-789	27	-49	2138	-93	-967	-11	-189	1028	39	-823	12	-113	1773	-42
	Max MT	-731	20	-7	2566	-69	-679	11	63	2651	-36	-690	-1	-40	2531	3
	Max ML	-480	43	11	1763	-150	-813	-49	-49	2134	177	-740	42	-39	2081	-150
4.1.2	LL- Class A _ Most ecc															
	Max P	-335	16	-10	1465	-57	-518	-5	-136	794	17	-468	-13	-52	1582	45
	Max MT	-304	12	22	1789	-45	-477	-3	8	2052	10	-397	1	-5	2161	-3
	Max ML	-254	18	12	1324	-63	-384	-23	-63	872	81	-264	-15	-13	1053	56
4.1.3	LL- 1_Class A for 70 R															
	Max P	-1089	45	-34	1785	-156	-1486	-14	-189	1082	49	-1278	24	-98	1986	-83
	Max MT	-1002	45	21	2484	-160	-1174	-1	12	2706	9	-1084	-20	-14	2870	77
	Max ML	-766	69	7	1871	-243	-1059	-75	-76	1202	273	-889	-57	-40	1435	209
4.1.4	LL-2_70R															
	Max P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max ML	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.5	LL-3 Class A															
	Max P	-1010	62	-8	1122	-216	-1556	-16	-104	608	57	-1404	-42	-40	1212	146
	Max MT	-916	51	16	1370	-180	-1423	-11	6	1572	42	-1194	3	-4	1655	-11
	Max ML	-795	67	7	1027	-235	-1147	-75	-48	668	272	-820	-54	-13	814	200

4.2	Live load - With impact															
4.2.1	LL- 70 R _ Most ecc															
	Max P	-789	27	-49	2138	-93	-967	-11	-189	1028	39	-823	12	-113	1773	-42
	Max MT	-731	20	-7	2566	-69	-679	11	63	2651	-36	-690	-1	-40	2531	3
	Max ML	-480	43	11	1763	-150	-813	-49	-49	2134	177	-740	42	-39	2081	-150
4.2.2	LL- Class A _ Most ecc															
	Max P	-335	16	-10	1465	-57	-518	-5	-136	794	17	-468	-13	-52	1582	45
	Max MT	-304	12	22	1789	-45	-477	-3	8	2052	10	-397	1	-5	2161	-3
	Max ML	-254	18	12	1324	-63	-384	-23	-63	872	81	-264	-15	-13	1053	56
4.2.3	LL-70R+1 Class A															
	Max P	-980	41	-31	1606	-141	-1338	-13	-170	974	44	-1150	21	-88	1787	-75
	Max MT	-902	41	19	2235	-144	-1057	-1	11	2435	8	-976	-18	-13	2583	69
	Max ML	-689	62	6	1683	-219	-953	-68	-69	1081	245	-800	-51	-36	1292	188
4.2.4	LL-2_70R															
	Max P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max ML	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.2.5	LL-3 Class A															
	Max P	-1010	62	-8	1122	-216	-1556	-16	-104	608	57	-1404	-42	-40	1212	146
	Max MT	-916	51	16	1370	-180	-1423	-11	6	1572	42	-1194	3	-4	1655	-11
	Max ML	-795	67	7	1027	-235	-1147	-75	-48	668	272	-820	-54	-13	814	200
4.3	Governing live load															
4.3.1	LL - Max P	-1010	62	-8	1122	-216	-1556	-16	-104	608	57	-1404	-42	-40	1212	146
4.3.2	LL - Max MT	-731	20	-7	2566	-69	-679	11	63	2651	-36	-976	-18	-13	2583	69
4.3.3	LL - Max ML	-795	67	7	1027	-235	-1147	-75	-48	668	272	-820	-54	-13	814	200
5	Braking force															
5.1	Braking force															
5.1.1	LL- 70 R _ Most ecc	-23	55	0	0	-312	4	97	0	0	-532	0	96	0	0	-530
5.1.2	LL- Class A _ Most ecc	-13	31	0	0	-173	2	54	0	0	-295	0	53	0	0	-294
5.1.3	LL-70R+1 Class A	-28	67	0	0	-376	5	117	0	0	-642	0	116	0	0	-640
5.1.4	LL-2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.1.5	LL-3 Class A	-18	42	0	0	-237	3	74	0	0	-405	0	73	0	0	-403
5.2	Governing braking force															
5.2.1	LL - Max P	-18	42	0	0	-237	3	74	0	0	-405	0	73	0	0	-403
5.2.2	LL - Max MT	-23	55	0	0	-312	4	97	0	0	-532	0	116	0	0	-640
5.2.3	LL - Max ML	-18	42	0	0	-237	3	74	0	0	-405	0	73	0	0	-403
6	Wind load -WL															
6.1	Wind load downwards -28.5 m/sec	-189	113	242	2705	-517	-470	149	373	4189	-734	-396	153	404	4517	-748
6.2	Wind load downwards -29 m/sec	-177	99	183	1954	-440	-450	126	286	3036	-607	-379	130	308	3268	-621
7	Temperature															
7.1	Temperature Rise	-52	182	0	-2	-1019	41	157	0	1	-857	21	3	0	2	-15
7.2	Temperature Fall	52	-182	0	2	1019	-41	-157	0	-1	857	-21	-3	0	-2	15

8	Temperature gradient															
8.1	Positive Temperature	97	-26	0	-1	185	-118	-48	-1	-3	248	43	0	1	5	1
8.2	Reverse Temperature	-45	24	0	0	-154	53	32	0	3	-170	-17	0	0	-3	-1
9	Differential shrinkage	99	-8	0	-1	88	-124	-36	-1	-2	178	49	0	1	4	1
10	Seismic force															
10.1	Long.Seismic DL+SIDL	-51	170	0	0	-912	5	284	0	0	-1513	0	283	0	0	-1510
10.2	Trans. Seismic DL+SIDL	0	0	414	4228	0	0	0	448	4567	0	0	0	436	4440	0
10.3	Trans. Seismic 70 R_Most ecc	0	0	9	100	0	0	0	10	107	0	0	0	10	104	0
10.4	Trans. Seismic Class A_Most ecc	0	0	5	55	0	0	0	6	60	0	0	0	5	58	0
10.5	Trans. Seismic 70R+1 CLASS A	0	0	14	155	0	0	0	15	167	0	0	0	15	162	0
10.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.7	Trans. Seismic 3 Class A	0	0	15	166	0	0	0	17	179	0	0	0	16	173	0

Governing Trans. Seismic Live load

Max P	0	0	15	166	0	0	0	17	179	0	0	0	16	173	0
Max MT	0	0	9	100	0	0	0	10	107	0	0	0	15	162	0
Max ML	0	0	15	166	0	0	0	17	179	0	0	0	16	173	0

Seismic Combinations:(As per IRC-6:2017- Cl.219.4)

Load Case	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
11	**Seismic - Longitudinal**															
11.1	(L+0.3T-0.3V) Max. P	15	170	129	1318	-912	-1	284	139	1424	-1513	0	283	136	1384	-1510
11.2	(L+0.3T+0.3V) Max. P	-15	170	129	1318	-912	1	284	139	1424	-1513	0	283	136	1384	-1510
11.3	(L+0.3T-0.3V) Max. M_T	15	170	127	1298	-912	-1	284	137	1402	-1513	0	283	135	1380	-1510
11.4	(L+0.3T+0.3V) Max. M_T	-15	170	127	1298	-912	1	284	137	1402	-1513	0	283	135	1380	-1510
11.5	(L+0.3T-0.3V) Max. M_L	15	170	129	1318	-912	-1	284	139	1424	-1513	0	283	136	1384	-1510
11.6	(L+0.3T+0.3V) Max. M_L	-15	170	129	1318	-912	1	284	139	1424	-1513	0	283	136	1384	-1510
12	**Seismic - Transverse**															
12.1	(0.3L+T-0.3V) Max. P	0	51	429	4394	-274	0	85	464	4746	-454	0	85	452	4613	-453
12.2	(0.3L+T+0.3V) Max. P	0	51	429	4394	-274	0	85	464	4746	-454	0	85	452	4613	-453
12.3	(0.3L+T-0.3V) Max. M_T	0	51	423	4328	-274	0	85	458	4675	-454	0	85	451	4602	-453
12.4	(0.3L+T+0.3V) Max. M_T	0	51	423	4328	-274	0	85	458	4675	-454	0	85	451	4602	-453
12.5	(0.3L+T-0.3V) Max. M_L	0	51	429	4394	-274	0	85	464	4746	-454	0	85	452	4613	-453
12.6	(0.3L+T+0.3V) Max. M_L	0	51	429	4394	-274	0	85	464	4746	-454	0	85	452	4613	-453

7.2.1 Load combination - Ultimate Limit State

Load Case -	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
	Basic combination															
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9														
	Except Live load															
100	1.35 DL+ 1.35 C/B + 1.75 WC +0.9 WL-28.5m/sec	-4652	354	166	1756	-1336	-10931	6	256	2751	-158	-9588	117	278	2930	-559
101	1.35 DL+ 1.35 C/B + 1.75 WC +0.9 WL-29m/sec	-4662	367	219	2432	-1406	-10949	26	334	3789	-272	-9603	138	365	4053	-674

	Including live load															
102	LC 101 + 1.5 x LL 4.3.1 + 1.5 x LL 5.2.1	-6204	522	206	4116	-2085	-13278	113	178	4701	-795	-11709	185	305	5871	-1060
103	LC 101 + 1.5 x LL 4.3.2 + 1.5 x LL 5.2.2	-5793	479	207	6281	-1977	-11961	188	429	7766	-1124	-11066	284	346	7927	-1529
104	LC 101 + 1.5 x LL 4.3.3 + 1.5 x LL 5.2.3	-5881	529	229	3974	-2114	-12665	24	262	4791	-472	-10833	167	346	5274	-979
	II.Wind load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15														
	Except Live load															
105	1.35 DL+ 1.35 C/B + 1.75 WC +1.5 WL-28.5m/sec	-4758	414	276	2929	-1600	-11201	81	427	4573	-522	-9815	195	464	4890	-932
106	1.35 DL+ 1.35 C/B + 1.75 WC +1.5 WL-29m/sec	-4775	434	364	4055	-1716	-11231	116	558	6302	-713	-9840	229	607	6763	-1122
	Including live load															
107	LC 106 + 1.15 x LL 4.3.1 + 1.15 x LL 5.2.1	-5957	554	354	5346	-2237	-13016	182	438	7002	-1113	-11455	266	561	8157	-1419
108	LC 106 + 1.15 x LL 4.3.2 + 1.15 x LL 5.2.2	-5643	521	355	7006	-2154	-12007	239	631	9351	-1365	-10962	342	593	9733	-1778
109	LC 106 + 1.15 x LL 4.3.3 + 1.15 x LL 5.2.3	-5710	559	372	5237	-2259	-12546	114	503	7070	-866	-10783	252	593	7699	-1356
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5														
	Seismic Longitudinal Case (with -P)															
	Except Live load															
110	1.35 DL+ 1.35 C/B + 1.75 WC	-4492	265	1	-2	-940	-10526	-108	-2	19	388	-9247	0	1	-12	0
	Including live load															
111	LC 110+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.1	-4675	541	192	2200	-2399	-10839	330	186	2276	-1951	-9528	431	196	2307	-2317
112	LC 110+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.3	-4620	535	190	2459	-2385	-10663	340	217	2653	-1995	-9442	444	201	2576	-2379
113	LC 110+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.5	-4632	542	195	2181	-2403	-10757	318	198	2288	-1908	-9411	429	202	2227	-2306
	Seismic Longitudinal Case (with +P)															
	Except Live load															
114	1.35 DL+ 1.35 C/B + 1.75 WC	-4492	265	1	-2	-940	-10526	-108	-2	19	388	-9247	0	1	-12	0
	Including live load															
115	LC 114+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.2	-4721	541	192	2200	-2399	-10834	330	186	2276	-1951	-9528	431	196	2307	-2317
116	LC 114+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.4	-4666	535	190	2459	-2385	-10659	340	217	2653	-1995	-9442	444	201	2576	-2379
117	LC 114+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.6	-4678	542	195	2181	-2403	-10753	318	198	2288	-1908	-9411	429	202	2227	-2306
	Seismic Transverse Case (with -P)															
	Except Live load															
118	1.35 DL+ 1.35 C/B + 1.75 WC	-4492	265	1	-2	-940	-10526	-108	-2	19	388	-9247	0	1	-12	0
	Including live load															
119	LC 118+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.1	-4698	362	643	6814	-1441	-10837	32	674	7260	-363	-9528	134	671	7150	-731
120	LC 118+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.3	-4643	356	634	7003	-1427	-10661	42	698	7562	-406	-9442	147	674	7407	-794
121	LC 118+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.5	-4655	363	646	6795	-1445	-10755	20	685	7272	-320	-9411	131	676	7071	-720
	Seismic Transverse Case (with +P)															
	Except Live load															
122	1.35 DL+ 1.35 C/B + 1.75 WC	-4492	265	1	-2	-940	-10526	-108	-2	19	388	-9247	0	1	-12	0
	Including live load															
123	LC 122+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.2	-4698	362	643	6814	-1441	-10837	32	674	7260	-363	-9528	134	671	7150	-731
124	LC 122+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.4	-4643	356	634	7003	-1427	-10661	42	698	7562	-406	-9442	147	674	7407	-794
125	LC 122+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.6	-4655	363	646	6795	-1445	-10755	20	685	7272	-320	-9411	131	676	7071	-720

Summary of load combination - Ultimate Limit State

Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
Basic combination															
I. Live load leading	-6204	529	229	6281	-2114	-13278	188	429	7766	-1124	-11709	284	365	7927	-1529
II. Wind load leading	-5957	559	372	7006	-2259	-13016	239	631	9351	-1365	-11455	342	607	9733	-1778
Seismic combination															
Seismic Longitudinal Case	-4721	542	195	2459	-2403	-10839	340	217	2653	-1995	-9528	444	202	2576	-2379
Seismic Transverse Case	-4698	363	646	7003	-1445	-10837	-108	698	7562	-406	-9528	147	676	7407	-794
Design Forces	**-6204**	**559**	**646**	**7006**	**-2403**	**-13278**	**340**	**698**	**9351**	**-1995**	**-11709**	**444**	**676**	**9733**	**-2379**

7.2.2 load combination- Serviceability Limit State

Load Case -	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
	Rare Combination															
	I. Live load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage - 1														
	Except Live load															
200	1 DL+ 1 SIDL+1 DS +0.6 WL (29m/s)+Diff. shrinkage	-3378	271	111	1171	-954	-8328	-55	170	1834	170	-7246	68	186	1957	-421
201	1 DL+ 1 SIDL+1 DS +0.6 WL(28.5m/)+Diff. shrinkage	-3385	280	146	1621	-1001	-8340	-42	222	2526	94	-7256	82	244	2706	-497
	Including live load															
202	LC 201 + 1 x LL 4.3.1 + 1 x LL 5.2.1	-4413	383	138	2744	-1454	-9893	16	118	3134	-255	-8660	113	204	3918	-755
203	LC 201 + 1 x LL 4.3.2 + 1 x LL 5.2.2	-4139	354	138	4187	-1382	-9015	66	285	5177	-474	-8231	179	231	5289	-1067
204	LC 201 + 1 x LL 4.3.3 + 1 x LL 5.2.3	-4198	388	153	2649	-1473	-9484	-43	174	3194	-40	-8076	101	231	3520	-700
	II. Wind load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Live load -0.75, Wind-1 , Shrinkage - 1														
	Except Live load															
205	1 DL+ 1 SIDL+1 DS+1 WL -29 m/sec+Diff. shrinkage	-3449	311	184	1952	-1130	-8508	-5	284	3049	-73	-7397	120	310	3264	-669
206	1 DL+ 1 SIDL+1 DS+1 WL -28.5 m/sec+Diff. shrinka	-3460	325	243	2703	-1208	-8528	18	371	4201	-200	-7414	143	406	4513	-796
	Including live load															
207	LC 206 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	-4231	403	237	3545	-1547	-9693	61	293	4658	-461	-8467	166	376	5422	-990
208	LC 206 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	-4026	381	237	4628	-1493	-9034	99	419	6190	-626	-8146	216	396	6450	-1224
209	LC 206 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	-4070	406	248	3474	-1562	-9386	17	335	4703	-300	-8029	157	396	5124	-949
	III. Temperature load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75, Shrinkage - 1														
	Bridge Temperature															
	Temperature Rise Case															
	Except Live load															
210	1 DL+ 1 SIDL+1 DS+ 1 Temp. Rise +Diff. shrinkage	-3324	393	0	-3	-1710	-8017	26	-2	14	-323	-6997	-7	1	-2	-64
	Including live load															
211	LC 210 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	-4095	471	-6	838	-2050	-9182	69	-80	471	-585	-8050	16	-28	907	-257
212	LC 210 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	-3889	450	-5	1921	-1996	-8523	106	46	2003	-749	-7729	66	-8	1935	-491
213	LC 210 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	-3933	475	5	767	-2064	-8875	25	-38	515	-423	-7612	7	-8	609	-216
	Temperature Fall Case															
	Except Live load															
214	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall +Diff. shrinkage	-3219	30	1	0	329	-8100	-287	-2	12	1391	-7040	-13	1	-5	-33

	Including live load														
215	LC 214 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	-3990	108	-5	842	-11	-9264	-244	-80	468	1129	-8093	11	-29	904	-226
216	LC 214 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	-3785	86	-5	1925	43	-8606	-207	45	2000	965	-7771	60	-9	1932	-460
217	LC 214 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	-3829	111	6	771	-25	-8957	-289	-38	513	1291	-7655	2	-9	605	-185
	Temperature Gradient															
	Positive Temperature															
	Except Live load															
218	1 DL+ 1 SIDL+1 DS+ 1 Positive temp. +Diff. shrinka	-3175	186	1	-3	-505	-8177	-179	-3	9	781	-6975	-10	2	1	-47
219	LC 218 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	-3946	263	-5	839	-845	-9341	-136	-80	466	520	-8028	13	-28	910	-241
220	LC 218 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	-3740	242	-5	1922	-791	-8683	-98	45	1998	356	-7707	63	-8	1938	-475
221	LC 218 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	-3784	267	6	768	-860	-9034	-180	-38	511	681	-7590	4	-8	612	-200
	Reverse Temperature															
	Except Live load															
222	1 DL+ 1 SIDL+1 DS + 1 Reverse temp.+Diff. shrinka	-3316	236	1	-1	-845	-8006	-99	-1	16	364	-7035	-10	1	-7	-49
	Including live load															
223	LC 222 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	-4087	314	-5	841	-1185	-9170	-55	-79	472	103	-8088	14	-29	902	-242
224	LC 222 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	-3882	292	-5	1924	-1131	-8512	-18	46	2004	-62	-7767	63	-9	1930	-476
225	LC 222 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	-3926	317	6	770	-1199	-8864	-100	-37	517	264	-7650	5	-9	604	-201
	Quasi-Permanent Combination	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5, Shrinkage -1														
226	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinka	-3298	303	1	-2	-1200	-8038	-53	-2	14	105	-7008	-9	1	-3	-56
227	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkag	-3246	121	1	-1	-181	-8079	-209	-2	12	962	-7029	-12	1	-4	-40
228	1 DL+ 1 SIDL+1 DS + 0.5 Positive temp.+ Diff. Shrir	-3223	199	1	-2	-598	-8117	-155	-2	11	658	-6997	-10	2	-1	-48
229	1 DL+ 1 SIDL+1 DS + 0.5 Reverse temp.l+ Diff. Shri	-3294	224	1	-1	-768	-8032	-115	-2	14	449	-7027	-10	1	-5	-48

Summary of load combinaton -Serviceability Limit State

Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
Rare Combination															
I. Live load leading	-4413	388	153	4187	-1473	-9893	66	285	5177	-474	-8660	179	244	5289	-1067
II. Wind load leading	-4231	406	248	4628	-1562	-9693	99	419	6190	-626	-8467	216	406	6450	-1224
III. Temperature load leading	-4095	475	6	1925	-2064	-9341	-289	-80	2004	1391	-8093	66	-29	1938	-491
Design Forces	***-4413***	***475***	***248***	***4628***	***-2064***	***-9893***	***-289***	***419***	***6190***	***1391***	***-8660***	***216***	***406***	***6450***	***-1224***
Quasi-permanent Combination	**-3298**	**303**	**1**	**-2**	**-1200**	**-8117**	**-209**	**-2**	**14**	**962**	**-7029**	**-12**	**2**	**-5**	**-56**

7.3 Design at Bottom of Pier

7.3.1 Design Parameters

Grade of concrete		f_{ck}	=	M35
Grade of reinforcement steel		f_{yk}	=	Fe500
Grade of steel for stirrups		f_{ywk}	=	Fe500
Tensile strength of concrete	Table 6.5 of IRC 112	f_{ctm}	=	2.8 MPa
Partial safety factor for concrete for Basic & Seismic comb.		γ_m	=	1.5
Partial safety factor for reinforcement		γ_s	=	1.15
Design compressive strength of concrete		f_{cd}	=	$\frac{\alpha}{\gamma m} * fck$
Factor	Cl 6.4.2.8 of IRC 112-2011	α	=	0.67
Design compressive strength of concrete		f_{cd}	=	15.6 MPa
Design tensile strength of reinforcement		f_{yd}	=	434.8 MPa
Design tensile strength of reinforcement stirrups		f_{ywd}	=	434.8 MPa
Secant modulus elasticity of Concrete		E_{cm}	=	32 GPa
Elastic modulus of Steel		E_s	=	200 GPa
Ultimate compressive strain in concrete	table 6.5 of IRC 112	εcu3	=	0.0035
Ultimate tensile strain in steel		εst	=	2.17.E-03
limiting neutral axis to depth ratio		$\frac{x_{u,max}}{d} = \frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{st}}$		
limiting neutral axis to depth ratio		$X_{u,max}$ / d	=	0.617

7.3.2 Design of pier at bottom

7.3.2.1 Check for Ultimate Limit State (ULS)

Description	units	End pier P1		Inner Pier P2 / P3		Remarks / Reference
		For MT	For ML	For MT	For ML	
Width(b)	mm	680	3000	800	3000	
Depth (D)	mm	3000	680	3000	800	
Clear cover (c)	mm	45	45	45	45	
Dia of bar	mm	40	32	40	20	
Dia of links if any	mm	16	16	16	16	
Effective depth (d)	mm	2919	603	2919	729	
a) **Check for flexure**						
Mu	kNm	**7006**	**2403**	**9733**	**2379**	Refer load comb.-ULS
Xu,max	mm	1801	372	1801	450	=+0.617×729
Factor η		1.0	1.0	1.0	1.0	Refer A2.9 of IRC 112-2011
Factor λ		0.8	0.8	0.8	0.8	
Depth required	mm	1332	371	1447	369	**dreqd < dprov**
						Depth is adquate
Mu,limit	kNm	33670	6339	39612	9265	
Netural axis Xu for Mu	$x = \frac{d - \sqrt{d^2 - \frac{2Mu}{\eta fcd * b}}}{\lambda}$					
X_u	mm	294.07	114.99	350.06	91.58	**Xu < Xu,max**
						Under reinforced
Ast required for Mu	$Ast = \frac{\eta fcd * \lambda * b * x}{fyd}$					
Ast required	mm^2	5752	9923	8056	7903	
Min Ast	mm^2	2448	2448	2880	2880	Cl 16.3.1 of IRC 112
Max Ast	mm^2	40800	40800	48000	48000	Cl 16.3.1of IRC 112

Ast Required	mm^2	5752	9923	8056	7903	
Dia of bar	mm	40	32	40	20	
No. of bars	mm	6	20	8	18	OK
Spacing of bar provide	mm	104	150	92	169	
Max spacing b/w bars	mm	200	200	200	200	Cl 16.3.1 of IRC 112
Ast provided	mm^2	7540	18598	10053	8168	**Ast pro > Ast reqd**
Note:Corner bars (2-no's) are considered for calculating moment capacity.						**OK**
Xu for Ast provided	mm	385.5	215.5	436.9	94.7	
Lever arm z	mm	2726	495	2701	682	
MuR for Ast pro	kNm	8937	4005	11804	2421	**MuR > Mu**
						OK
Horizontal reinforcement , Cl 16.3.2 of IRC 112 - 2011						
Ast, distribution	mm^2		1550		681	=0.25×18598/(3000/1000)
Diameter of bar	mm	16	16	16	16	
Spacing of bar (s_{pro})	mm	120	120	200	200	
Ast provided	mm^2	1608	1608	1005	1005	**Ast pro > Ast reqd**
						OK
Max spacing (s_{max})	mm	300	300	300	300	**Smax > Spro**
						OK

b.1) **Check for shear ,Cl 10.3 of IRC 112 - 2011**

Description	units	End Pier -HL	Inner Pier -HT	Remarks / Reference
Max Shear V_{Ed}	kN	559	698	
Shear resistance of concrete $VRd,c = [0.12K(80\rho 1.fck)^{0.33} + 0.15\sigma_{cp}]b_w.d$				
bw	mm	3000	800	
ρ1		0.010	0.0043	ρ1 ≤ 0.02
K		1.58	1.26	K ≤ 2
Axial force N_{ED}	kN	0	0	
C/S area Ac	mm^2	1809000	2335200	
Concrete comp. σcp	MPa	0.00	0.00	σcp < 0.2fcd
$V_{Rd,c}$	kN	1037	804	
$V_{Rd,c\ min}$	kN	656	607	
so ,$V_{Rd,c}$	kN	1037	804	**max of $V_{Rd,c}$ and $V_{Rd,c}$ min**
Shear R/F requirement		**Not required**	**Not required**	
		VRd,c > VEd		**Shear R/F not required**
Max shear capacity of concrete strut $V_{Rd,max} = \alpha_{cw} * b_w * z * v * \frac{fcd}{(cot\theta + tan\theta)}$				
Concrete comp. σcp	MPa	0.00	0.00	=+0×1000/1809000
Factor αcw		1.00	1.00	
lever arm z	mm	543	2627	z = 0.9 d
Strength reduction facor v		0.53	0.53	eq^{n} 10.6 of IRC 112
Inclination of Compression strut $\theta = \frac{\sin^{-1}(\frac{2V_{Ed}}{\alpha_{cw} * b_W * Z * V_1 * f_{cd}})}{2}$				
Inclination of Compression strut θ	degree	2.4	2.3	
Max θ	degree	45	45	Cl10.2.2.2 of IRC 112
Min θ	degree	21.8	21.8	
hence θ	degree	21.8	21.8	
$V_{Rd,max}$	kN	4671	6030	**VRd,max > VEd**
				Safe against brittle failure

Shear Reinforcement calculation				
Dia of links d	mm	10	16	
No of links		8	2	
Area of links	mm^2	628	402	=3.141/4×16^2×2
Spacing of links	mm	200	200	
Shear capcity of reinforcement				
$V_{Rd,s}$	kN	**1853**	**5742**	**VRd,s > VEd**
				OK
Shear R/F ratio ρ_w		0.0010	0.0025	
min ratio $\rho_{w,min}$		0.0009	0.0009	**ρw > ρw,min**
				OK

b.2)

Check for shear ,Cl 10.3 of IRC 112 - 2011				
Description	**units**	**End Pier -HT**	**Inner Pier -HL**	**Remarks / Reference**
Max Shear V_{Ed}	kN	**646**	**340**	
Shear resistance of concrete	$VRd,c = [0.12K(80\rho 1.fck)^{0.33} + 0.15\sigma_{cp}]b_w.d$ $VRd,c\,min = [0.031K^{3/2}fck^{0.5} + 0.15\sigma_{cp}]b_w.d$			
bw	mm	680	3000	
ρ1		0.004	0.0037	ρ1 ≤ 0.02
K		1.26	1.52	K ≤ 2
Axial force N_{ED}	kN	**0**	**0**	
C/S area Ac	mm^2	1984920	2187000	
Concrete comp. σcp	MPa	0.00	0.00	σcp < 0.2fcd
$V_{Rd,c}$	kN	656	868	
$V_{Rd,c\,min}$	kN	516	754	
so ,$V_{Rd,c}$	kN	656	868	**max of $V_{Rd,c}$ and $V_{Rd,c}$ min**
Shear R/F requirement		**Not required**	**Not required**	
		VRd,c > VEd		**Shear R/F not required**
Max shear capacity of concrete strut	$V_{Rd,max} = \alpha_{cw} * b_w * z * v * \frac{fcd}{(cot\theta + tan\theta)}$			
Concrete comp. σcp	MPa	0.00	0.00	=+0×1000/1984920
Factor αcw		1.00	1.00	
lever arm z	mm	2627	656	z = 0.9 d
Strength reduction facor v		0.53	0.53	eq^n 10.6 of IRC 112
Inclination of Compression strut	$\theta = \frac{\sin^{-1}(\frac{2V_{Ed}}{\alpha_{cw} * b_W * Z * V_1 * f_{cd}})}{2}$			
Inclination of Compression strut θ	degree	2.5	1.2	
Max θ	degree	45	45	Cl10.2.2.2 of IRC 112
Min θ	degree	21.8	21.8	
hence θ	degree	21.8	21.8	
$V_{Rd,max}$	kN	5126	5647	**VRd,max > VEd**
				Safe against brittle failure

Shear Reinforcement calculation				
Dia of links d	mm	16	10	
No of links		2	8	
Area of links	mm^2	402	628	=3.141/4×10^2×8
Spacing of links	mm	200	200	
Shear capcity of reinforcement				
$V_{Rd,s}$	kN	**5742**	**2241**	**VRd,s > VEd**

				OK
Max Spacing long. $s_{l.max}$	mm	2189	547	Cl 16.5.2 of IRC 112 (Vertical Stirrups α=90)
Shear R/F ratio ρ_w		0.0030	0.0010	
min ratio $\rho_{w,min}$		0.0009	0.0009	**ρw > ρw,min**
				OK

7.3.2.2 Check for Serviceability Limit State (SLS)

a) Check for stress limitation

Description	units	End pier P1		Inner Pier P2 / P3		Remarks / Reference
		For MT	For ML	For MT	For ML	
Max moment - Rare	kNm	**4628**	**2064**	**6450**	**1391**	From load combinations
Max moment - Quasi	kNm	**2**	**1200**	**14**	**962**	
Permissible stress limitation - Rare combination Cl 12.2 of IRC 112-2011						
Compressive stress in concrete σ_c	MPa	16.80	16.80	16.80	16.80	0.48 fck
Tensile stress in reinforcement σ_{st}	MPa	300	300	300	300	0.6 fyk
Permissible stress limitation - Ouasi permanent combination						
Compressive stress in concrete σ_c	MPa	12.60	12.60	12.60	12.60	0.36 fck
Tensile stress in reinforcement σ_{st}	MPa	300	300	300	300	0.6 fyk
Calculation of Stress in concrete and reinforcement						
Ecm	MPa	32000	32000	32000	32000	
Modular ratio m (Long term)		12.50	12.50	12.50	12.50	=200×1000/(32000×0.5)
Ast provided	mm^2	7540	18598	10053	8168	
Stress calculation for Rare combination						
Depth of neutral axis x	$x = \frac{-mAst + \sqrt{(mAst)^2 + 2mAst.bd}}{b}$					
Depth of neutral axis	mm	772	238	813	191	
Cracked moment of Inertia	$I_c = \frac{bx^3}{3} + mAst\,(d-x)^2$					
I_c	mm^4	5.4.E+11	4.4.E+10	7.0.E+11	3.7.E+10	
Stress in concrete and R/F	$\sigma_c = \frac{M * x}{I_c}$ $\sigma_s = m * \frac{M * (d-x)}{I_c}$					
σ_c - Rare comb	MPa	6.63	11.05	7.49	7.28	**σc < 0.48fck**
σ_{st} - Rare comb	MPa	230.59	211.93	242.30	255.93	**σst < 0.6fyk**
Stress calculation for Quasi permanent combination						
σ_c - Quasi comb	MPa	0.00	6.42	0.02	5.04	**σc < 0.36fck**
σ_{st} - Quasi comb	MPa	0.12	123.23	0.54	177.08	**σst < 0.6fyk**
			Stresses are within permissible limit			
Check for Crack width - Quasi permanent						
Permissible limit	mm	0.30	0.30	0.30	0.30	Moderate exposure
Effective ht hceff	mm	203	147	203	178	Cl 12.3.4 of IRC 112
Aceff	mm^2	137700	442118	162000	532500	
α_e		6.25	6.25	6.25	6.25	Ratio of Es/Ecm
Factor k_t		0.5	0.5	0.5	0.5	Cl 12.3.4 of IRC 112

Factor k_1		0.8	0.8	0.8	0.8	Cl 12.3.4 of IRC 112
Factor k_2		0.5	0.5	0.5	0.5	Cl 12.3.4 of IRC 112
Dia of bar 1	mm	40	32	40	20	
No of bar 1	nos	**6**	**20**	**8**	**18**	
Dia of bar 2	mm	0	0	0	0	
No of bar 2	nos	7	21	9	18	
Equivalent dia Φ	mm	40	32	40	20	Eq 12.9 of IRC 112
Factor $\rho_{p.eff}$		0.0548	0.0421	0.0621	0.0153	=+8168/532500
Max crack spacing	$s_{r.max} = 3.4c + \frac{0.425 k_1 k_2 \phi}{\rho_{p.eff}}$					
$S_{r,max}$	mm	277	282	263	375	
mean strain in concrete	$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_{st} - kt \frac{f_{ct,eff}}{\rho_{p.eff}} (1 + \alpha_e \rho_{p.eff})}{E_s} \geq 0.6 \frac{\sigma_{st}}{E_s}$					
ε_{sm}-ε_{cm}		0.00000	0.00041	0.00000	0.00053	
Crack width W_k	mm	0.000	0.115	0.000	0.199	**Wk < 0.3 mm**
				Crack width is with limit		

7.4 Design at Top of Pier

7.4.1 Design Parameters

Grade of concrete		f_{ck}	=	M35
Grade of reinforcement steel		f_{yk}	=	Fe500
Grade of steel for stirrups		f_{ywk}	=	Fe500
Tensile strength of concrete	Table 6.5 of IRC 112	f_{ctm}	=	2.8 MPa
Partial safety factor for concrete for Basic & Seismic comb.		γ_m	=	1.5
Partial safety factor for reinforcement		γ_s	=	1.15
Design compressive strength of concrete		f_{cd}	=	$\frac{\alpha}{\gamma m} * fck$
Factor	Cl 6.4.2.8 of IRC 112-2011	α	=	0.67
Design compressive strength of concrete		f_{cd}	=	15.6 MPa
Design tensile strength of reinforcement		f_{yd}	=	434.8 MPa
Design tensile strength of reinforcement stirrups		f_{ywd}	=	434.8 MPa
Secant modulus elasticity of Concrete		E_{cm}	=	32 GPa
Elastic modulus of Steel		E_s	=	200 GPa
Ultimate compressive strain in concrete	table 6.5 of IRC 112	εcu3	=	0.0035
Ultimate tensile strain in steel		εst	=	2.17.E-03

limiting neutral axis to depth ratio $\frac{x_{u,max}}{d} = \frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{st}}$

limiting neutral axis to depth ratio $X_{u,max}$ / d = 0.617

7.4.2 Design of pier at Top

7.4.2.1 Check for Ultimate Limit State (ULS)

	Description	units	End pier P1		Inner Pier P2 / P3		Remarks / Reference
			For MT	For ML	For MT	For ML	
	Width(b)	mm	680	3000	800	3000	
	Depth (D)	mm	3000	680	3000	800	
	Clear cover (c)	mm	45	45	45	45	
	Dia of bar	mm	40	32	40	20	
	Dia of links if any	mm	16	16	16	16	
	Effective depth (d)	mm	2919	603	2919	729	
a)	**Check for flexure**						
	Mu	kNm	**4944**	**2884**	**5699**	**1854**	Refer load comb.-ULS
	Xu,max	mm	1801	372	1801	450	=+0.617×729
	Factor η		1.0	1.0	1.0	1.0	Refer A2.9 of IRC 112-2011
	Factor λ		0.8	0.8	0.8	0.8	
	Depth required	mm	1118	407	1107	326	**dreqd < dprov**
							Depth is adquate
	Mu,limit	kNm	33670	6339	39612	9265	
	Netural axis Xu for Mu	$x = \frac{d - \sqrt{d^2 - \frac{2Mu}{\eta fcd * b}}}{\lambda}$					
	X_u	mm	204.90	140.58	200.64	70.52	**Xu < Xu,max**
							Under reinforced
	Ast required for Mu	$Ast = \frac{\eta fcd * \lambda * b * x}{fyd}$					
	Ast required	mm^2	4008	12131	4617	6085	
	Min Ast	mm^2	2448	2448	2880	2880	Cl 16.3.1 of IRC 112
	Max Ast	mm^2	40800	40800	48000	48000	Cl 16.3.1of IRC 112

Ast Required	mm^2	4008	12131	4617	6085	
Dia of bar	mm	40	32	40	20	
No. of bars	mm	6	20	8	18	OK
Spacing of bar provide	mm	104	150	92	169	
Max spacing b/w bars	mm	200	200	200	200	Cl 16.3.1 of IRC 112
Ast provided	mm^2	7540	18598	10053	8168	**Ast pro > Ast reqd**
Note:Corner bars (2-no's) are considered for calculating moment capacity.						**OK**
Xu for Ast provided	mm	385.5	215.5	436.9	94.7	
Lever arm z	mm	2726.3	495.2	2700.6	681.7	
MuR for Ast pro	kNm	8937	4005	11804	2421	**MuR > Mu**
						OK
Horizontal reinforcement , Cl 16.3.2 of IRC 112 - 2011						
Ast, distribution	mm^2		1550		681	=0.25×18598/(3000/1000)
Diameter of bar	mm	16	16	16	16	
Spacing of bar (s_{pro})	mm	120	120	200	200	
Ast provided	mm^2	1608	1608	1005	1005	**Ast pro > Ast reqd**
						OK
Max spacing (s_{max})	mm	300	300	300	300	**Smax > Spro**
						OK

b.1) **Check for shear ,Cl 10.3 of IRC 112 - 2011**

Description	**units**	**End Pier -HT**	**Inner Pier -HT**	**Remarks / Reference**
Max Shear V_{Ed}	kN	**586**	**613**	
Shear resistance of concrete $VRd,c = \left[0.12K(80\rho 1.fck)^{0.33} + 0.15\sigma_{cp}\right]b_w.d$ $VRd,c\ min = \left[0.031K^{3/2}fck^{0.5} + 0.15\sigma_{cp}\right]b_w.d$				
bw	mm	680	800	
ρ1		0.004	0.0043	ρ1 ≤ 0.02
K		1.26	1.26	K ≤ 2
Axial force N_{ED}	kN	**0**	**0**	
C/S area Ac	mm^2	1984920	2335200	
Concrete comp. σcp	MPa	0.00	0.00	σcp < 0.2fcd
$V_{Rd,c}$	kN	656	804	
$V_{Rd,c\ min}$	kN	516	607	
so ,$V_{Rd,c}$	kN	656	804	**max of $V_{Rd,c}$ and $V_{Rd,c}$ min**
~~Shear R/F requirement~~		**Not required**	**Not required**	
		VRd,c > VEd		**Shear R/F not required**
Max shear capacity of concrete strut $V_{Rd,max} = \alpha_{cw} * b_w * z * v * \frac{fcd}{(cot\theta + tan\theta)}$				
Concrete comp. σcp	MPa	0.00	0.00	=+0×1000/1984920
Factor αcw		1.00	1.00	
lever arm z	mm	2627	2627	z = 0.9 d
Strength reduction facor v		0.53	0.53	eq^{n} 10.6 of IRC 112
Inclination of Compression strut $\theta = \frac{\sin^{-1}\left(\frac{2V_{Ed}}{\alpha_{cw} * b_W * Z * V_1 * f_{cd}}\right)}{2}$				
Inclination of Compression strut θ	degree	2.3	2.0	
Max θ	degree	45	45	Cl10.2.2.2 of IRC 112
Min θ	degree	21.8	21.8	
hence θ	degree	21.8	21.8	
$V_{Rd,max}$	kN	5126	6030	**VRd,max > VEd**

	Safe against brittle failure

b.2) Check for shear ,Cl 10.3 of IRC 112 - 2011

Description	units	End Pier -HL	Inner Pier -HL	Remarks / Reference
Max Shear V_{Ed}	kN	510	294	
Shear resistance of concrete	$VRd,c = [0.12K(80\rho 1.fck)^{0.33} + 0.15\sigma_{cp}]b_w.d$ $VRd,c\ min = [0.031K^{3/2}fck^{0.5} + 0.15\sigma_{cp}]b_w.d$			
bw	mm	3000	3000	
ρ1		0.010	0.0037	ρ1 ≤ 0.02
K		1.58	1.52	K ≤ 2
Axial force N_{ED}	kN	0	0	
C/S area Ac	mm^2	1809000	2187000	
Concrete comp. σcp	MPa	0.00	0.00	σcp < 0.2fcd
$V_{Rd,c}$	kN	1037	868	
$V_{Rd,c\ min}$	kN	656	754	
so ,$V_{Rd,c}$	kN	1037	868	**max of $V_{Rd,c}$ and $V_{Rd,c}$ min**
Shear R/F requirement		**Not required**	**Not required**	
		VRd,c > VEd		**Shear R/F not required**
Max shear capacity of concrete strut	$V_{Rd,max} = \alpha_{cw} * b_w * z * v * \frac{fcd}{(cot\theta + tan\theta)}$			
Concrete comp. σcp	MPa	0.00	0.00	=+0×1000/1809000
Factor αcw		1.00	1.00	
lever arm z	mm	543	656	z = 0.9 d
Strength reduction facor v		0.53	0.53	eq^{n} 10.6 of IRC 112
Inclination of Compression strut	$\theta = \frac{\sin^{-1}(\frac{2V_{Ed}}{\alpha_{cw} * b_W * Z * V_1 * f_{cd}})}{2}$			
Inclination of Compression strut θ	degree	2.2	1.0	
Max θ	degree	45	45	Cl10.2.2.2 of IRC 112
Min θ	degree	21.8	21.8	
hence θ	degree	21.8	21.8	
$V_{Rd,max}$	kN	4671	5647	**VRd,max > VEd**
				Safe against brittle failure

7.4.2.2 Check for Serviceability Limit State (SLS)

a) Check for stress limitation

Description	units	End pier P1		Inner Pier P2 / P3		Remarks / Reference
		For MT	For ML	For MT	For ML	
Max moment - Rare	kNm	**3294**	**2597**	**3807**	**1563**	From load combinations
Max moment - Quasi	kNm	**8**	**1745**	**33**	**1074**	
Permissible stress limitation - Rare combination Cl 12.2 of IRC 112-2011						
Compressive stress in concrete, σc	MPa	16.80	16.80	16.80	16.80	0.48 fck
Tensile stress in reinforcement, σs	MPa	300	300	300	300	0.6 fyk
Permissible stress limitation - Ouasi permanent combination						
Compressive stress in concrete, σc	MPa	12.60	12.60	12.60	12.60	0.36 fck
Tensile stress in reinforcement, σs	MPa	300	300	300	300	0.6 fyk
Calculation of Stress in concrete and reinforcement						
Ecm	MPa	32000	32000	32000	32000	
Modular ratio m (Long term)		12.50	12.50	12.50	12.50	=+200×1000/(32000×0.5)

Ast provided	mm^2	7540	18598	10053	8168	
Stress calculation for Rare combination						
Depth of neutral axis x	$x = \frac{-mAst + \sqrt{(mAst)^2 + 2mAst.bd}}{b}$					
Depth of neutral axis	mm	772	238	813	191	
Cracked moment of Inertia	$I_c = \frac{bx^3}{3} + mAst\,(d-x)^2$					
I_c	mm^4	5.4.E+11	4.4.E+10	7.0.E+11	3.7.E+10	
Stress in concrete and R/F	$\sigma_c = \frac{M * x}{I_c}$ $\sigma_s = m * \frac{M * (d-x)}{I_c}$					
σ_c - Rare comb	MPa	4.72	13.90	4.42	8.19	**σc < 0.48fck**
σ_{st} - Rare comb	MPa	164.13	266.63	143.00	287.59	**σst < 0.6fyk**
Stress calculation for Quasi permanent combination						
σ_c - Quasi comb	MPa	0.01	9.34	0.04	5.63	**σc < 0.36fck**
σ_{st} - Quasi comb	MPa	0.40	179.16	1.23	197.66	**σst < 0.6fyk**
			Stresses are within permissible limit			
Check for Crack width - Quasi permanent						
Permissible limit	mm	0.30	0.30	0.30	0.30	Moderate exposure
Effective ht hceff	mm	203	193	203	178	Cl 12.3.4 of IRC 112
Aceff	mm^2	137700	577500	162000	532500	
α_e		6.25	6.25	6.25	6.25	Ratio of Es/Ecm
Factor k_t		0.5	0.5	0.5	0.5	Cl 12.3.4 of IRC 112
Factor k_1		0.8	0.8	0.8	0.8	Cl 12.3.4 of IRC 112
Factor k_2		0.5	0.5	0.5	0.5	Cl 12.3.4 of IRC 112
Dia of bar 1	mm	40	32	40	20	
No of bar 1	nos	**6**	**20**	**8**	**18**	
Dia of bar 2	mm	0	0	0	0	
No of bar 2	nos	7	21	9	18	
Equivalent dia Φ	mm	40	32	40	20	Eq 12.9 of IRC 112
Factor $\rho_{p.eff}$		0.0548	0.0322	0.0621	0.0153	=+8168/532500
Max crack spacing	$s_{r.max} = 3.4c + \frac{0.425 k_1 k_2 \phi}{\rho_{p.eff}}$					
$S_{r,max}$	mm	277	322	263	375	
mean strain in concrete	$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_{st} - kt\,\frac{f_{ct,eff}}{\rho_{p.eff}}\,(1 + \alpha_e\,\rho_{p.eff})}{E_s} \geq 0.6\frac{\sigma_{st}}{E_s}$					
ε_{sm}-ε_{cm}		0.00000	0.00063	0.00000	0.00059	
Crack width W_k	mm	0.000	0.204	0.001	0.222	**Wk < 0.3 mm**
				Crack width is with limit		

8 *Staad Results and load combination for foundation design*

Impact factor for live load	For Class A	1
	For 70R wheeled	1

Summary of forces from staad at Bottom of Pier

Load Case - LC	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		Fx kN	Fy kN	Fz kN	My kNm	Mz kNm	Fx kN	Fy kN	Fz kN	My kNm	Mz kNm	Fx kN	Fy kN	Fz kN	My kNm	Mz kNm
		P-kN	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*	*P-kN*	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*	*P-kN*	*HL-kN*	*HT-kN*	*MT-kNm*	*ML-kNm*
1	Dead load -DL															
1.1	DL of Girder	1513	0	0	1	0	2040	-44	0	22	158	1757	0	0	1	0
1.2	DL of Diaphragm	1137	0	0	0	0	1026	0	0	0	0	1027	0	0	0	0
1.3	DL of Deck slab	1802	0	1	17	0	2522	-22	-2	8	81	2119	0	1	9	0
1.4	DL of Pier	1103	0	0	0	0	649	0	0	0	0	649	0	0	0	0
	Total Dead load	5555	0	1	18	0	6237	-66	-2	30	238	5551	0	1	9	0
2	Super Imposed Dead load -SIDL															
2.1	Crash barrier -CB	481	0	0	0	0	687	-6	0	0	21	569	0	0	0	0
2.2	Wearing Coat- WC	478	0	0	-16	0	674	-6	0	-12	21	562	0	0	-14	0
3	Differential Settlement -DS	133	49	0	0	0	203	-16	0	0	71	272	-10	0	0	-49
4	Live load															
4.1	Live load - Without impact															
4.1.1	LL- 70 R _ Most ecc															
	Max P	787	10	-56	1690	-57	963	-4	-142	418	23	816	4	-91	1154	-21
	Max MT	727	7	2	2640	-43	684	4	39	2822	-20	646	-12	-1	2265	78
	Max ML	515	15	-10	1701	-94	682	-16	-53	994	104	746	14	-61	1409	-83
4.1.2	LL- Class A _ Most ecc															
	Max P	335	6	-19	1297	-34	516	-4	-35	1552	27	467	-3	-60	1032	20
	Max MT	302	4	25	2018	-26	478	-1	0	2034	9	412	1	1	1943	-9
	Max ML	274	6	-5	1297	-38	333	-7	-26	846	43	292	4	-21	977	-27
4.1.3	LL- 1_Class A for 70 R															
	Max P	1085	16	-41	1451	-98	1481	-5	-142	471	32	1270	10	-89	1294	-58
	Max MT	996	16	27	2748	-100	1153	11	2	2680	-65	1055	18	1	2566	-116
	Max ML	791	25	-11	1775	-154	1034	-27	-48	1079	170	862	-21	-35	1200	132
4.1.4	LL-2_70R															
	Max P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max ML	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.5	LL-3 Class A															
	Max P	1007	22	-15	993	-136	1550	-6	-78	274	35	1402	-15	-46	785	89
	Max MT	910	18	19	1545	-113	1430	-4	0	1558	26	1233	8	1	1488	-51
	Max ML	822	24	-4	994	-148	1121	-26	-31	580	167	819	-19	-14	708	123

4.2	Live load - Impact															
4.2.1	LL- 70 R _ Most ecc															
	Max P	787	10	-56	1690	-57	963	-4	-142	418	23	816	4	-91	1154	-21
	Max MT	727	7	2	2640	-43	684	4	39	2822	-20	646	-12	-1	2265	78
	Max ML	515	15	-10	1701	-94	682	-16	-53	994	104	746	14	-61	1409	-83
4.2.2	LL- Class A _ Most ecc															
	Max P	335	6	-19	1297	-34	516	-4	-35	1552	27	467	-3	-60	1032	20
	Max MT	302	4	25	2018	-26	478	-1	0	2034	9	412	1	1	1943	-9
	Max ML	274	6	-5	1297	-38	333	-7	-26	846	43	292	4	-21	977	-27
4.2.3	LL-70R+1 Class A															
	Max P	1085	16	-41	1451	-98	1481	-5	-142	471	32	1270	10	-89	1294	-58
	Max MT	996	16	27	2748	-100	1153	11	2	2680	-65	1055	18	1	2566	-116
	Max ML	791	25	-11	1775	-154	1034	-27	-48	1079	170	862	-21	-35	1200	132
4.2.4	LL-2_70R															
	Max P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max MT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Max ML	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.2.5	LL-3 Class A															
	Max P	1007	22	-15	993	-136	1550	-6	-78	274	35	1402	-15	-46	785	89
	Max MT	910	18	19	1545	-113	1430	-4	0	1558	26	1233	8	1	1488	-51
	Max ML	822	24	-4	994	-148	1121	-26	-31	580	167	819	-19	-14	708	123
4.3	Governing live load															
4.3.1	LL - Max P	1085	16	-41	1451	-98	1550	-6	-78	274	35	1402	-15	-46	785	89
4.3.2	LL - Max MT	996	16	27	2748	-100	684	4	39	2822	-20	646	-12	-1	2566	78
4.3.3	LL - Max ML	791	25	-11	1775	-154	1121	-26	-31	580	170	819	-19	-14	708	132
5	Braking force															
5.1	Braking force															
5.1.1	LL- 70 R _ Most ecc	47	110	0	0	-623	-4	97	0	0	-532	0	96	0	0	-530
5.1.2	LL- Class A _ Most ecc	26	61	0	0	-346	-2	54	0	0	-295	0	53	0	0	-294
5.1.3	LL-70R+1 Class A	57	133	0	0	-753	-5	117	0	0	-642	0	116	0	0	-640
5.1.4	LL-2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.1.5	LL-3 Class A	36	84	0	0	-475	-3	74	0	0	-405	0	73	0	0	-403
5.2	Governing braking force															
5.2.1	LL - Max P	57	133	0	0	-753	-3	74	0	0	-405	0	73	0	0	-403
5.2.2	LL - Max MT	57	133	0	0	-753	-4	97	0	0	-532	0	96	0	0	-530
5.2.3	LL - Max ML	57	133	0	0	-753	-3	74	0	0	-405	0	73	0	0	-403
6	Wind load -WL															
6.1	Wind load downwards -28.5 m/sec	377	226	484	5410	-1034	470	149	373	4189	-734	396	153	404	4517	-748
6.2	Wind load downwards -29 m/sec	354	198	367	3907	-880	450	126	286	3036	-607	379	130	308	3268	-621
7	Temperature															
7.1	Temperature Rise	104	363	0	-4	0	-41	157	0	1	-857	-21	3	0	2	-15
7.2	Temperature Fall	-104	-363	0	4	0	41	-157	0	-1	857	21	-3	0	-2	15

8	Temperature gradient															
8.1	Positive Temperature	-194	-52	0	-2	0	118	-48	-1	-3	248	-43	0	1	5	1
8.2	Reverse Temperature	89	48	0	1	0	-53	32	0	3	-170	17	0	0	-3	-1
9	Differential shrinkage	-199	-15	0	-2	0	124	-36	-1	-2	178	-49	0	1	4	1
10	Seismic force															
10.1	Long.Seismic DL+SIDL	101	340	0	0	-1824	-5	284	0	0	-1513	0	283	0	0	-1510
10.2	Trans. Seismic DL+SIDL	0	0	827	8456	0	0	0	448	4567	0	0	0	436	4440	0
10.3	Trans. Seismic 70 R_Most ecc	0	0	19	200	0	0	0	10	107	0	0	0	10	104	0
10.4	Trans. Seismic Class A_Most ecc	0	0	10	111	0	0	0	6	60	0	0	0	5	58	0
10.5	Trans. Seismic 70R+1 CLASS A	0	0	29	310	0	0	0	15	167	0	0	0	15	162	0
10.6	Trans. Seismic 2_70R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.7	Trans. Seismic 3 Class A	0	0	31	332	0	0	0	17	179	0	0	0	16	173	0

Governing Trans. Seismic Live load

Max P	0	0	29	310	0	0	0	17	179	0	0	0	16	173	0
Max MT	0	0	29	310	0	0	0	10	107	0	0	0	10	104	0
Max ML	0	0	29	310	0	0	0	17	179	0	0	0	16	173	0

Seismic Combinations:(As per IRC-6:2014- Cl.219.4)

Load Case	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
11	**Seismic - Longitudinal**															
11.1	(L+0.3T-0.3V) Max. P	-30	340	257	2630	-1824	1	284	139	1424	-1513	0	283	136	1384	-1510
11.2	(L+0.3T+0.3V) Max. P	30	340	257	2630	-1824	-1	284	139	1424	-1513	0	283	136	1384	-1510
11.3	(L+0.3T-0.3V) Max. M_T	-30	340	257	2630	-1824	1	284	137	1402	-1513	0	283	134	1363	-1510
11.4	(L+0.3T+0.3V) Max. M_T	30	340	257	2630	-1824	-1	284	137	1402	-1513	0	283	134	1363	-1510
11.5	(L+0.3T-0.3V) Max. M_L	-30	340	257	2630	-1824	1	284	139	1424	-1513	0	283	136	1384	-1510
11.6	(L+0.3T+0.3V) Max. M_L	30	340	257	2630	-1824	-1	284	139	1424	-1513	0	283	136	1384	-1510
12	**Seismic - Transverse**															
12.1	(0.3L+T-0.3V) Max. P	0	102	856	8766	-547	0	85	464	4746	-454	0	85	452	4613	-453
12.2	(0.3L+T+0.3V) Max. P	0	102	856	8766	-547	0	85	464	4746	-454	0	85	452	4613	-453
12.3	(0.3L+T-0.3V) Max. M_T	0	102	856	8766	-547	0	85	458	4675	-454	0	85	445	4544	-453
12.4	(0.3L+T+0.3V) Max. M_T	0	102	856	8766	-547	0	85	458	4675	-454	0	85	445	4544	-453
12.5	(0.3L+T-0.3V) Max. M_L	0	102	856	8766	-547	0	85	464	4746	-454	0	85	452	4613	-453
12.6	(0.3L+T+0.3V) Max. M_L	0	102	856	8766	-547	0	85	464	4746	-454	0	85	452	4613	-453

8.1 Load combination - Ultimate Limit State

Load Case - LC	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
	Basic combination															
	I. Live load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load -1.5, Wind-0.9														
	Except Live load															
100	1.35 DL+ 1.35 C/B + 1.75 WC +0.9 WL-28.5m/sec	9303	179	331	3513	-792	10931	6	256	2751	-158	9588	117	278	2930	-559
101	1.35 DL+ 1.35 C/B + 1.75 WC +0.9 WL-29m/sec	9324	204	437	4865	-931	10949	26	334	3789	-272	9603	138	365	4053	-674
	Including live load															
102	LC 101 + 1.5 x LL 4.3.1 + 1.5 x LL 5.2.1	11037	428	376	7041	-2207	13270	129	217	4200	-828	11706	225	295	5231	-1145
103	LC 101 + 1.5 x LL 4.3.2 + 1.5 x LL 5.2.2	10904	428	477	8987	-2210	11969	177	392	8022	-1100	10572	264	364	7902	-1351
104	LC 101 + 1.5 x LL 4.3.3 + 1.5 x LL 5.2.3	10596	441	420	7527	-2291	12626	97	288	4659	-625	10831	219	343	5115	-1081
	II.Wind load leading	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Wind-1.5,Live load -1.15														
	Except Live load															
105	1.35 DL+ 1.35 C/B + 1.75 WC +1.5 WL-28.5m/sec	9516	298	551	5857	-1320	11201	81	427	4573	-522	9815	195	464	4890	-932
106	1.35 DL+ 1.35 C/B + 1.75 WC +1.5 WL-29m/sec	9551	340	727	8111	-1551	11231	116	558	6302	-713	9840	229	607	6763	-1122
	Including live load															
107	LC 106 + 1.15 x LL 4.3.1 + 1.15 x LL 5.2.1	10864	511	680	9779	-2530	13010	194	468	6617	-1138	11453	296	554	7666	-1484
108	LC 106 + 1.15 x LL 4.3.2 + 1.15 x LL 5.2.2	10761	511	758	11271	-2532	12013	231	602	9547	-1347	10583	326	606	9714	-1642
109	LC 106 + 1.15 x LL 4.3.3 + 1.15 x LL 5.2.3	10526	522	715	10152	-2594	12516	170	522	6969	-983	10782	292	591	7578	-1435
	Seismic combination	Partial safety factors:- DL-1.35 , SIDL -1.75 (C/B-1.35 & WC-1.75) ,Live load - 0.2, Seismic factor 1.5														
	Seismic longitudinal Case (with -P)															
	Except Live load															
110	1.35 DL+ 1.35 C/B + 1.75 WC	8985	0	1	-4	0	10526	-108	-2	19	388	9247	0	1	-12	0
	Including live load															
111	LC 110 +0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.1	9167	540	378	4231	-2907	10838	332	192	2210	-1956	9527	436	195	2221	-2328
112	LC 110 +0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.3	9150	540	392	4491	-2907	10664	338	212	2687	-1992	9376	442	201	2546	-2355
113	LC 110 +0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.5	9109	542	384	4296	-2918	10752	328	201	2271	-1929	9411	436	201	2206	-2319
	Seismic longitudinal Case (with +P)															
	Except Live load															
114	1.35 DL+ 1.35 C/B + 1.75 WC	8985	0	1	-4	0	10526	-108	-2	19	388	9247	0	1	-12	0
	Including live load															
115	LC 114 +0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.2	9259	540	378	4231	-2907	10833	332	192	2210	-1956	9527	436	195	2221	-2328
116	LC 114 +0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.4	9241	540	392	4491	-2907	10660	338	212	2687	-1992	9376	442	201	2546	-2355
117	LC 114 +0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.6	9200	542	384	4296	-2918	10747	328	201	2271	-1929	9411	436	201	2206	-2319
	Seismic Transverse Case (with -P)															
	Except Live load															
118	1.35 DL+ 1.35 C/B + 1.75 WC	8985	0	1	-4	0	10526	-108	-2	19	388	9247	0	1	-12	0

	Including live load														
119	LC 118+ 0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.1	9213	183	1278	13436	-991	10836	34	679	7193	-367	9527	139	669	7065	-742
120	LC 118+ 0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.3	9195	183	1291	13695	-992	10662	40	693	7596	-403	9376	144	669	7317	-770
121	LC 118+ 0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.5	9154	185	1283	13501	-1002	10750	30	689	7254	-340	9411	138	676	7049	-734
	Seismic Transverse Case (with +P)															
	Except Live load															
122	1.35 DL+ 1.35 C/B + 1.75 WC	8985	0	1	-4	0	10526	-108	-2	19	388	9247	0	1	-12	0
	Including live load															
123	LC 122+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.2	9213	183	1278	13436	-991	10836	34	679	7193	-367	9527	139	669	7065	-742
124	LC 122+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.4	9195	183	1291	13695	-992	10662	40	693	7596	-403	9376	144	669	7317	-770
125	LC 122+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.6	9154	185	1283	13501	-1002	10750	30	689	7254	-340	9411	138	676	7049	-734

Summary of load combination - Ultimate Limit State

Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
Basic combination															
I. Live load leading	11037	441	477	8987	-2291	13270	177	392	8022	-1100	11706	264	365	7902	-1351
II. Wind load leading	10864	522	758	11271	-2594	13010	231	602	9547	-1347	11453	326	607	9714	-1642
Seismic combination															
Seismic longitudinal Case	9259	542	392	4491	-2918	10838	338	212	2687	-1992	9527	442	201	2546	-2355
Seismic Transverse Case	9213	185	1291	13695	-1002	10836	-108	693	7596	-403	9527	144	676	7317	-770
Design Forces	**11037**	**542**	**1291**	**13695**	**-2918**	**13270**	**338**	**693**	**9547**	**-1992**	**11706**	**442**	**676**	**9714**	**-2355**

8.2 load combination- Serviceability Limit State

Load Case -	Description	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm
	Rare Combination															
	I. Live load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Live load -1,Wind-0.6, Shrinkage - 1														
	Except Live load															
200	1 DL+ 1 SIDL+1 DS +0.6 WL (28.5m/s)+Diff. shrinkag	6660	153	221	2345	-528	8194	-54	170	1837	165	7133	68	186	1960	-421
201	1 DL+ 1 SIDL+1 DS +0.6 WL(29m/)+Diff. shrinkage	6674	170	292	3246	-620	8206	-40	222	2528	89	7143	82	244	2709	-497
	Including live load															
202	LC 201 + 1 x LL 4.3.1 + 1 x LL 5.2.1	7816	319	251	4697	-1471	9753	28	144	2802	-281	8546	140	197	3494	-811
203	LC 201 + 1 x LL 4.3.2 + 1 x LL 5.2.2	7727	319	318	5994	-1473	8885	60	261	5350	-463	7789	166	243	5275	-949
204	LC 201 + 1 x LL 4.3.3 + 1 x LL 5.2.3	7522	328	281	5021	-1527	9323	7	191	3108	-146	7962	136	229	3417	-768
	II. Wind load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 , Live load -0.75, Wind-1 , Shrinkage - 1														
	Except Live load															
205	1 DL+ 1 SIDL+1 DS+1 WL -28.5 m/sec+Diff. shrinkag	6802	233	368	3908	-880	8374	-4	284	3051	-77	7285	120	310	3267	-669
206	1 DL+ 1 SIDL+1 DS+1 WL -29 m/sec+Diff. shrinkage	6825	260	485	5410	-1034	8393	19	371	4204	-204	7302	143	406	4516	-796
	Including live load															
207	LC 206 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	7681	372	455	6498	-1672	9554	70	313	4409	-482	8353	186	371	5105	-1032
208	LC 206 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	7615	372	505	7471	-1674	8903	94	400	6320	-618	7786	206	405	6440	-1135
209	LC 206 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	7461	379	477	6741	-1714	9232	55	348	4639	-381	7916	183	395	5047	-1000
	III. Temperature load leading	Partial safety factors:- DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-1 ,Live load -0.75, Shrinkage - 1														
	Bridge temperature															
	Temperature rise Case															
	Except Live load															
210	1 DL+ 1 SIDL+1 DS+ 1 Temp. rise +Diff. shrinkage	6552	398	1	-3	0	7882	27	-2	17	-327	6885	-7	1	1	-64
	Including live load															
211	LC 210 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	7409	510	-30	1085	-638	9043	78	-60	222	-605	7937	36	-33	590	-299
212	LC 210 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	7342	510	21	2058	-640	8392	102	27	2133	-741	7369	56	1	1925	-402
213	LC 210 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	7188	516	-7	1328	-680	8721	62	-25	452	-504	7499	33	-9	532	-267
	Temperature Fall Case															
	Except Live load															
214	1 DL+ 1 SIDL+1 DS + 1 Temp. Fall +Diff. shrinkage	6343	-329	2	4	0	7965	-286	-2	14	1386	6927	-13	1	-2	-33
	Including live load															
215	LC 214 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	7200	-217	-29	1092	-638	9125	-235	-61	219	1109	7979	31	-34	586	-268
216	LC 214 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	7133	-217	22	2065	-640	8475	-211	27	2130	972	7412	50	1	1922	-371
217	LC 214 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	6979	-211	-7	1335	-680	8803	-251	-25	449	1210	7542	28	-10	529	-236
	Temperature gradient															
	Positive Temperature															
	Except Live load															
218	1 DL+ 1 SIDL+1 DS+ 1 Positive temp. +Diff. shrinkag	6254	-18	1	-2	0	8042	-178	-3	12	777	6863	-10	2	4	-47
	Including live load															
219	LC 218 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	7110	94	-29	1086	-638	9202	-127	-61	217	499	7914	33	-33	593	-283
220	LC 218 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	7044	94	21	2059	-640	8552	-103	26	2128	363	7347	53	1	1929	-386
221	LC 218 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	6890	101	-7	1329	-680	8880	-142	-26	447	601	7477	30	-9	535	-251

	Reverse Temperature														
	Except Live load														
222	1 DL+ 1 SIDL+1 DS + 1 Reverse temp.+Diff. shrinkag	6537	83	1	1	0	7871	-97	-2	18	360	6923	-10	1	-4	-49
	Including live load														
223	LC 222 + 0.75 x LL 4.3.1 + 0.75 x LL 5.2.1	7393	195	-29	1090	-638	9031	-46	-60	224	82	7974	34	-34	585	-284
224	LC 222 + 0.75 x LL 4.3.2 + 0.75 x LL 5.2.2	7327	195	21	2062	-640	8381	-22	28	2135	-54	7407	53	0	1920	-387
225	LC 222 + 0.75 x LL 4.3.3 + 0.75 x LL 5.2.3	7173	201	-7	1333	-680	8709	-62	-25	453	183	7537	31	-10	527	-252
	Quasi-permanent Combination	safety factors:-			DL-1 , SIDL -1 (C/B-1 & WC-1) ,Settlement -1 ,Thermal-0.5, Shrinkage -1											
226	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Rise+ Diff. Shrinkag	6500	216	1	-1	0	7903	-51	-2	16	101	6896	-9	1	0	-56
227	1 DL+ 1 SIDL+1 DS + 0.5 Temp. Fall+ Diff. Shrinkage	6395	-148	1	2	0	7944	-208	-2	15	958	6917	-12	1	-2	-40
228	1 DL+ 1 SIDL+1 DS + 0.5 Positive temp.+ Diff. Shrink	6351	8	1	-1	0	7983	-154	-2	14	653	6884	-10	2	2	-48
229	1 DL+ 1 SIDL+1 DS + 0.5 Reverse temp.l+ Diff. Shrin	6492	58	1	1	0	7897	-114	-2	17	445	6914	-10	1	-3	-48

Summary of load combinaton -Serviceability Limit State

Description	**End pier - P1**					**Intermediate pier - P2**					**Intermediate pier - P3**				
	P-kN	**HL-kN**	**HT-kN**	**MT-kNm**	**ML-kNm**	**P-kN**	**HL-kN**	**HT-kN**	**MT-kNm**	**ML-kNm**	**P-kN**	**HL-kN**	**HT-kN**	**MT-kNm**	**ML-kNm**
Rare Combination															
I. Live load leading	7816	328	318	5994	-1527	9753	60	261	5350	-463	8546	166	244	5275	-949
II. Wind load leading	7681	379	505	7471	-1714	9554	94	400	6320	-618	8353	206	406	6440	-1135
III. Temperature load leading	7409	516	-30	2065	-680	9202	-286	-61	2135	1386	7979	56	-34	1929	-402
Design Forces	***7816***	***516***	***505***	***7471***	***-1714***	***9753***	***-286***	***400***	***6320***	***1386***	***8546***	***206***	***406***	***6440***	***-1135***
Quasi-permanent Combination	**6500**	**216**	**1**	**2**	**0**	**7983**	**-208**	**-2**	**17**	**958**	**6917**	**-12**	**2**	**-3**	**-56**

8.3 Load combination - Base Pressure

Load Case - LC	Description		MT	ML		End pier - P1					Intermediate pier - P2					
						P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN	HL-kN	HT-kN	MT-kNm	ML-kNm	P-kN
	Combination 1															
	I. Normal Load Case					Partial safety factors:-		DL-1, C/B-1, WC-1, DS - 1 and Live load -1								
	Except Live load															
300	1 DL + 1 C/B + 1 WC + 1 DS					6647	49	1	2	0	7800	-94	-1	18	352	6955
	Including live load															
301	LC 300 + 1 x LL 4.3.1 + 1 x LL 5.2.1					7788	199	-40	1453	-851	9347	-26	-79	292	-18	8357
302	LC 300 + 1 x LL 4.3.2 + 1 x LL 5.2.2					7699	199	28	2750	-853	8480	6	37	2840	-200	7601
303	LC 300 + 1 x LL 4.3.3 + 1 x LL 5.2.3					7494	207	-10	1777	-907	8918	-47	-32	598	117	7774
	Combination II															
	II. Temperature Case					Partial safety factors:-		DL-1 , SIDL -1 (C/B-1 & WC-1) , DS -1, Live load -1, Temp. - 1								
	Except Live load															
304	1 DL+ 1 SIDL+1 DS + 1 Temp. Rise					6751	413	1	-2	0	7759	63	-1	19	-505	6934
305	2 DL+ 1 SIDL+1 DS + 1 Temp. Fall					6542	-314	1	6	0	7841	-251	-1	16	1209	6976
	Including live load															
306	LC 304 + 1 x LL 4.3.1 + 1 x LL 5.2.1					7893	562	-40	1449	-851	9306	131	-79	293	-875	8336
307	LC 304 + 1 x LL 4.3.2 + 1 x LL 5.2.2					7804	562	27	2746	-853	8439	163	37	2841	-1057	7580
308	LC 304 + 1 x LL 4.3.3 + 1 x LL 5.2.3					7599	571	-10	1773	-907	8877	110	-32	599	-740	7753
309	LC 305 + 1 x LL 4.3.1 + 1 x LL 5.2.1					7684	-165	-39	1457	-851	9389	-182	-79	290	838	8379
310	LC 305 + 1 x LL 4.3.2 + 1 x LL 5.2.2					7595	-165	28	2754	-853	8521	-150	37	2838	657	7622
311	LC 305 + 1 x LL 4.3.3 + 1 x LL 5.2.3					7390	-156	-10	1781	-907	8959	-203	-32	596	973	7795
	Except Live load															
312	1 DL+ 1 SIDL+1 DS +1 Positive Temp					6453	-3	1	0	0	7918	-142	-2	14	599	6912
313	1 DL+ 1 SIDL+1 DS +1 Reverse Temp					6647	49	1	2	0	7800	-94	-1	18	352	6955
	Including live load															
314	LC 312 + 1 x LL 4.3.1 + 1 x LL 5.2.1					7595	147	-40	1451	-851	9466	-74	-80	288	229	8314
315	LC 312 + 1 x LL 4.3.2 + 1 x LL 5.2.2					7506	147	28	2748	-853	8598	-42	37	2836	47	7558
316	LC 312 + 1 x LL 4.3.3 + 1 x LL 5.2.3					7301	156	-10	1775	-907	9036	-95	-33	594	364	7731
317	LC 313 + 1 x LL 4.3.1 + 1 x LL 5.2.1					7788	199	-40	1453	-851	9347	-26	-79	292	-18	8357
318	LC 313 + 1 x LL 4.3.2 + 1 x LL 5.2.2					7699	199	28	2750	-853	8480	6	37	2840	-200	7601
319	LC 313 + 1 x LL 4.3.3 + 1 x LL 5.2.3					7494	207	-10	1777	-907	8918	-47	-32	598	117	7774
	Combination III															
	III. Wind Load Case					Partial safety factors:-		DL-1 , SIDL -1 (C/B-1 & WC-1) ,Wind-1,Live load -1								
	Except Live load															
320	1 DL+ 1 SIDL + 1DS + 1 WL-28.5m/sec					7001	198	368	3909	-880	8048	48	285	3053	-326	7061
321	1 DL+ 1 SIDL+ 1DS + 1 WL-29m/sec					7024	226	485	5412	-1034	8067	71	372	4206	-453	7078
	Including live load															
322	LC 321 + 1 x LL 4.3.1 + 1 x LL 5.2.1					8166	376	444	6863	-1885	9615	139	294	4480	-823	8481
323	LC 321 + 1 x LL 4.3.2 + 1 x LL 5.2.2					8077	376	512	8160	-1887	8747	171	410	7028	-1004	7724
324	LC 321 + 1 x LL 4.3.3 + 1 x LL 5.2.3					7872	385	474	7187	-1941	9185	118	341	4786	-688	7898

	Combination IV															
	Seismic combination					Partial safety factors:- DL-1, SIDL -1 (C/B-1 & WC-1), Live load - 0.2, Seismic factor 1.25										
	Seismic longitudinal Case (with -P)															
	Except Live load															
325	1 DL+ 1 C/B + 1 WC + 1 DS					6647	0	1	2	0	7800	-78	-1	18	281	6955
	Including live load															
326	LC 325+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.1					6837	455	314	3580	-2451	8111	291	157	1852	-1684	7236
327	LC 325+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.3					6819	455	328	3839	-2451	7938	297	178	2335	-1721	7084
328	LC 325+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.5					6778	457	320	3644	-2462	8025	286	167	1913	-1657	7119
	Seismic longitudinal Case (with +P)															
	Except Live load															
329	1DL+ 1 C/B + 1 WC + 1 DS					6647	0	1	2	0	7800	-78	-1	18	281	6683
	Including live load															
330	LC 329+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC11.2					6913	455	314	3580	-2451	8108	291	157	1852	-1684	6963
331	LC 329+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC11.3					6819	455	328	3839	-2451	7938	297	181	2362	-1721	6812
332	LC 329+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC11.4					6778	457	320	3644	-2462	8025	286	167	1913	-1657	6847
	Seismic Transverse Case (with -P)															
	Except Live load															
333	1DL+ 1 C/B + 1 WC + 1 DS					6647	49	1	2	0	7800	-94	-1	18	352	6683
	Including live load															
334	LC 333+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.1					6875	207	1063	11250	-854	8110	26	563	6005	-290	6963
335	LC 333+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.3					6857	207	1077	11510	-855	7936	33	579	6426	-326	6812
336	LC 333+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.5					6816	208	1069	11315	-866	8024	22	573	6066	-263	6847
	Seismic Transverse Case (with +P)															
	Except Live load															
337	1DL+ 1 C/B + 1 WC + 1 DS					6647	49	1	2	0	7800	-94	-1	18	352	6955
	Including live load															
338	LC 337+0.2xLL4.3.1+0.2xLL5.2.1+1.5xLC12.2					6875	207	1063	11250	-854	8110	26	563	6005	-290	7236
339	LC 337+0.2xLL4.3.2+0.2xLL5.2.2+1.5xLC12.4					6857	207	1077	11510	-855	7936	33	579	6426	-326	7084
340	LC 337+0.2xLL4.3.3+0.2xLL5.2.3+1.5xLC12.6					6816	208	1069	11315	-866	8024	22	573	6066	-263	7119

Intermediate pier - P3			
HL-kN	**HT-kN**	**MT-kNm**	**ML-kNm**
-10	1	-5	-49
48	-46	780	-363
74	0	2561	-501
44	-14	703	-320
-7	1	-3	-64
-13	1	-6	-33
51	-46	782	-379
77	0	2563	-516
47	-14	705	-336
46	-46	779	-348
71	0	2560	-485
42	-14	702	-305
-10	1	1	-48
-10	1	-5	-49
48	-45	786	-362
74	1	2567	-500
44	-13	709	-319
48	-46	780	-363
74	0	2561	-501
44	-14	703	-320
130	309	3263	-621
153	405	4512	-748
211	359	5297	-1063
237	404	7078	-1200
207	391	5220	-1020

0	1	-4	0
366	161	1882	-1950
371	168	2213	-1978
365	167	1867	-1942
0	1	-4	0
366	161	1882	-1950
371	170	2239	-1978
365	167	1867	-1942
0	1	-4	0
118	556	5919	-629
123	557	6189	-657
117	562	5903	-621
-10	1	-5	-49
108	556	5919	-678
113	557	6189	-705
107	562	5903	-669

8.4 Summary of load combinaton - At Bottom of Pier

Load combination- Base pressure check

	Load	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	Case -	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm
Normal Load Case	LC 300	6647	49	1	0	2	7800	-94	-1	352	18	6955	-10	1	-49	-5
	LC 301	7788	199	-40	-851	1453	9347	-26	-79	-18	292	8357	48	-46	-363	780
	LC 302	7699	199	28	-853	2750	8480	6	37	-200	2840	7601	74	0	-501	2561
	LC 303	7494	207	-10	-907	1777	8918	-47	-32	117	598	7774	44	-14	-320	703
Temperature Case	LC 304	6751	413	1	0	-2	7759	63	-1	-505	19	6934	-7	1	-64	-3
	LC 305	6542	-314	1	0	6	7841	-251	-1	1209	16	6976	-13	1	-33	-6
	LC 306	7893	562	-40	-851	1449	9306	131	-79	-875	293	8336	51	-46	-379	782
	LC 307	7804	562	27	-853	2746	8439	163	37	-1057	2841	7580	77	0	-516	2563
	LC 308	7599	571	-10	-907	1773	8877	110	-32	-740	599	7753	47	-14	-336	705
	LC 309	7684	-165	-39	-851	1457	9389	-182	-79	838	290	8379	46	-46	-348	779
	LC 310	7595	-165	28	-853	2754	8521	-150	37	657	2838	7622	71	0	-485	2560
	LC 311	7390	-156	-10	-907	1781	8959	-203	-32	973	596	7795	42	-14	-305	702
	LC 312	6453	-3	1	0	0	7918	-142	-2	599	14	6912	-10	1	-48	1
	LC 313	6647	49	1	0	2	7800	-94	-1	352	18	6955	-10	1	-49	-5
	LC 314	7595	147	-40	-851	1451	9466	-74	-80	229	288	8314	48	-45	-362	786
	LC 315	7506	147	28	-853	2748	8598	-42	37	47	2836	7558	74	1	-500	2567
	LC 316	7301	156	-10	-907	1775	9036	-95	-33	364	594	7731	44	-13	-319	709
	LC 317	7788	199	-40	-851	1453	9347	-26	-79	-18	292	8357	48	-46	-363	780
	LC 318	7699	199	28	-853	2750	8480	6	37	-200	2840	7601	74	0	-501	2561
	LC 319	7494	207	-10	-907	1777	8918	-47	-32	117	598	7774	44	-14	-320	703
Wind Load Case	LC 320	7001	198	368	-880	3909	8048	48	285	-326	3053	7061	130	309	-621	3263
	LC 321	7024	226	485	-1034	5412	8067	71	372	-453	4206	7078	153	405	-748	4512
	LC 322	8166	376	444	-1885	6863	9615	139	294	-823	4480	8481	211	359	-1063	5297
	LC 323	8077	376	512	-1887	8160	8747	171	410	-1004	7028	7724	237	404	-1200	7078
	LC 324	7872	385	474	-1941	7187	9185	118	341	-688	4786	7898	207	391	-1020	5220
Seismic longitudinal Case (with -P)	LC 325	6647	0	1	0	2	7800	-78	-1	281	18	6955	0	1	0	-4
	LC 326	6837	455	314	-2451	3580	8111	291	157	-1684	1852	7236	366	161	-1950	1882
	LC 327	6819	455	328	-2451	3839	7938	297	178	-1721	2335	7084	371	168	-1978	2213
	LC 328	6778	457	320	-2462	3644	8025	286	167	-1657	1913	7119	365	167	-1942	1867
Seismic longitudinal Case (with +P)	LC 329	6647	0	1	0	2	7800	-78	-1	281	18	6683	0	1	0	-4
	LC 330	6913	455	314	-2451	3580	8108	291	157	-1684	1852	6963	366	161	-1950	1882
	LC 331	6819	455	328	-2451	3839	7938	297	181	-1721	2362	6812	371	170	-1978	2239
	LC 332	6778	457	320	-2462	3644	8025	286	167	-1657	1913	6847	365	167	-1942	1867
Seismic Transverse Case (with -P)	LC 333	6647	49	1	0	2	7800	-94	-1	352	18	6683	0	1	0	-4
	LC 334	6875	207	1063	-854	11250	8110	26	563	-290	6005	6963	118	556	-629	5919
	LC 335	6857	207	1077	-855	11510	7936	33	579	-326	6426	6812	123	557	-657	6189
	LC 336	6816	208	1069	-866	11315	8024	22	573	-263	6066	6847	117	562	-621	5903
Seismic Transverse Case (with +P)	LC 337	6647	49	1	0	2	7800	-94	-1	352	18	6955	-10	1	-49	-5
	LC 338	6875	207	1063	-854	11250	8110	26	563	-290	6005	7236	108	556	-678	5919
	LC 339	6857	207	1077	-855	11510	7936	33	579	-326	6426	7084	113	557	-705	6189
	LC 340	6816	208	1069	-866	11315	8024	22	573	-263	6066	7119	107	562	-669	5903

Load combination - Ultimate Limit State

	Load	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
	Case -	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm
	Basic combination															
Normal Case	LC 100	9303	179	331	-792	3513	10931	6	256	-158	2751	9588	117	278	-559	2930
	LC 101	9324	204	437	-931	4865	10949	26	334	-272	3789	9603	138	365	-674	4053
	LC 102	11037	428	376	-2207	7041	13270	129	217	-828	4200	11706	225	295	-1145	5231
	LC 103	10904	428	477	-2210	8987	11969	177	392	-1100	8022	10572	264	364	-1351	7902
	LC 104	10596	441	420	-2291	7527	12626	97	288	-625	4659	10831	219	343	-1081	5115
Wind case	LC 105	9516	298	551	-1320	5857	11201	81	427	-522	4573	9815	195	464	-932	4890
	LC 106	9551	340	727	-1551	8111	11231	116	558	-713	6302	9840	229	607	-1122	6763
	LC 107	10864	511	680	-2530	9779	13010	194	468	-1138	6617	11453	296	554	-1484	7666
	LC 108	10761	511	758	-2532	11271	12013	231	602	-1347	9547	10583	326	606	-1642	9714
	LC 109	10526	522	715	-2594	10152	12516	170	522	-983	6969	10782	292	591	-1435	7578
Seismic longitudinal Case (with -P)	LC 110	8985	0	1	0	-4	10526	-108	-2	388	19	9247	0	1	0	-12
	LC 111	9167	540	378	-2907	4231	10838	332	192	-1956	2210	9527	436	195	-2328	2221
	LC 112	9150	540	392	-2907	4491	10664	338	212	-1992	2687	9376	442	201	-2355	2546
	LC 113	9109	542	384	-2918	4296	10752	328	201	-1929	2271	9411	436	201	-2319	2206

Seismic longitudinal Case (with +P)	LC 114	8985	0	1	0	-4	10526	-108	-2	388	19	9247	0	1	0	-12
	LC 115	9259	540	378	-2907	4231	10833	332	192	-1956	2210	9527	436	195	-2328	2221
	LC 116	9241	540	392	-2907	4491	10660	338	212	-1992	2687	9376	442	201	-2355	2546
	LC 117	9200	542	384	-2918	4296	10747	328	201	-1929	2271	9411	436	201	-2319	2206
Seismic Transverse Case (with -P)	LC 118	8985	0	1	0	-4	10526	-108	-2	388	19	9247	0	1	0	-12
	LC 119	9213	183	1278	-991	13436	10836	34	679	-367	7193	9527	139	669	-742	7065
	LC 120	9195	183	1291	-992	13695	10662	40	693	-403	7596	9376	144	669	-770	7317
	LC 121	9154	185	1283	-1002	13501	10750	30	689	-340	7254	9411	138	676	-734	7049
Seismic Transverse Case (with +P)	LC 122	8985	0	1	0	-4	10526	-108	-2	388	19	9247	0	1	0	-12
	LC 123	9213	183	1278	-991	13436	10836	34	679	-367	7193	9527	139	669	-742	7065
	LC 124	9195	183	1291	-992	13695	10662	40	693	-403	7596	9376	144	669	-770	7317
	LC 125	9154	185	1283	-1002	13501	10750	30	689	-340	7254	9411	138	676	-734	7049

load combination- Serviceability Limit State

	Load Case -	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm
Normal	LC 200	6660	153	221	-528	2345	8194	-54	170	165	1837	7133	68	186	-421	1960
	LC 201	6674	170	292	-620	3246	8206	-40	222	89	2528	7143	82	244	-497	2709
	LC 202	7816	319	251	-1471	4697	9753	28	144	-281	2802	8546	140	197	-811	3494
	LC 203	7727	319	318	-1473	5994	8885	60	261	-463	5350	7789	166	243	-949	5275
	LC 204	7522	328	281	-1527	5021	9323	7	191	-146	3108	7962	136	229	-768	3417
Wind load Case	LC 205	6802	233	368	-880	3908	8374	-4	284	-77	3051	7285	120	310	-669	3267
	LC 206	6825	260	485	-1034	5410	8393	19	371	-204	4204	7302	143	406	-796	4516
	LC 207	7681	372	455	-1672	6498	9554	70	313	-482	4409	8353	186	371	-1032	5105
	LC 208	7615	372	505	-1674	7471	8903	94	400	-618	6320	7786	206	405	-1135	6440
	LC 209	7461	379	477	-1714	6741	9232	55	348	-381	4639	7916	183	395	-1000	5047
Temperature rise Case	LC 210	6552	398	1	0	-3	7882	27	-2	-327	17	6885	-7	1	-64	1
	LC 211	7409	510	-30	-638	1085	9043	78	-60	-605	222	7937	36	-33	-299	590
	LC 212	7342	510	21	-640	2058	8392	102	27	-741	2133	7369	56	1	-402	1925
	LC 213	7188	516	-7	-680	1328	8721	62	-25	-504	452	7499	33	-9	-267	532
Temperature Fall Case	LC 214	6343	-329	2	0	4	7965	-286	-2	1386	14	6927	-13	1	-33	-2
	LC 215	7200	-217	-29	-638	1092	9125	-235	-61	1109	219	7979	31	-34	-268	586
	LC 216	7133	-217	22	-640	2065	8475	-211	27	972	2130	7412	50	1	-371	1922
	LC 217	6979	-211	-7	-680	1335	8803	-251	-25	1210	449	7542	28	-10	-236	529
Positive Temperature	LC 218	6254	-18	1	0	-2	8042	-178	-3	777	12	6863	-10	2	-47	4
	LC 219	7110	94	-29	-638	1086	9202	-127	-61	499	217	7914	33	-33	-283	593
	LC 220	7044	94	21	-640	2059	8552	-103	26	363	2128	7347	53	1	-386	1929
	LC 221	6890	101	-7	-680	1329	8880	-142	-26	601	447	7477	30	-9	-251	535
Reverse Temperature	LC 222	6537	83	1	0	1	7871	-97	-2	360	18	6923	-10	1	-49	-4
	LC 223	7393	195	-29	-638	1090	9031	-46	-60	82	224	7974	34	-34	-284	585
	LC 224	7327	195	21	-640	2062	8381	-22	28	-54	2135	7407	53	0	-387	1920
	LC 225	7173	201	-7	-680	1333	8709	-62	-25	183	453	7537	31	-10	-252	527
Quasi-permanent Combination	LC 226	6500	216	1	0	-1	7903	-51	-2	101	16	6896	-9	1	-56	0
	LC 227	6395	-148	1	0	2	7944	-208	-2	958	15	6917	-12	1	-40	-2
	LC 228	6351	8	1	0	-1	7983	-154	-2	653	14	6884	-10	2	-48	2
	LC 229	6492	58	1	0	1	7897	-114	-2	445	17	6914	-10	1	-48	-3

8.5 Summary of load combinaton - At Bottom of Pile cap

Depth of pile cap 1.8 m

Load combination- Base pressure check

	Load Case -	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm
Normal Load Case	LC 300	6647	49	1	88	4	7800	-94	-1	521	20	6955	-10	1	-67	-6
	LC 301	7788	199	-40	-1208	1525	9347	-26	-79	-65	434	8357	48	-46	-451	863
	LC 302	7699	199	28	-1210	2800	8480	6	37	-212	2907	7601	74	0	-634	2562
	LC 303	7494	207	-10	-1280	1795	8918	-47	-32	201	655	7774	44	-14	-400	728
Temperature Case	LC 304	6751	413	1	743	-3	7759	63	-1	-618	21	6934	-7	1	-77	-4
	LC 305	6542	-314	1	566	8	7841	-251	-1	1660	19	6976	-13	1	-56	-7
	LC 306	7893	562	-40	-1862	1522	9306	131	-79	-1111	435	8336	51	-46	-471	864
	LC 307	7804	562	27	-1864	2796	8439	163	37	-1350	2908	7580	77	0	-654	2563
	LC 308	7599	571	-10	-1934	1792	8877	110	-32	-938	657	7753	47	-14	-421	730
	LC 309	7684	-165	-39	-1148	1528	9389	-182	-79	1167	433	8379	46	-46	-430	861
	LC 310	7595	-165	28	-1150	2804	8521	-150	37	927	2905	7622	71	0	-613	2560
	LC 311	7390	-156	-10	-1188	1798	8959	-203	-32	1339	654	7795	42	-14	-380	727
	LC 312	6453	-3	1	5	-2	7918	-142	-2	855	18	6912	-10	1	-66	3
	LC 313	6647	49	1	88	4	7800	-94	-1	521	20	6955	-10	1	-67	-6
	LC 314	7595	147	-40	-1115	1522	9466	-74	-80	362	432	8314	48	-45	-449	867
	LC 315	7506	147	28	-1117	2798	8598	-42	37	123	2902	7558	74	1	-633	2567
	LC 316	7301	156	-10	-1187	1793	9036	-95	-33	535	653	7731	44	-13	-399	732
	LC 317	7788	199	-40	-1208	1525	9347	-26	-79	-65	434	8357	48	-46	-451	863
	LC 318	7699	199	28	-1210	2800	8480	6	37	-212	2907	7601	74	0	-634	2562
	LC 319	7494	207	-10	-1280	1795	8918	-47	-32	201	655	7774	44	-14	-400	728
Wind Load Case	LC 320	7001	198	368	-1237	4571	8048	48	285	-412	3566	7061	130	309	-855	3820
	LC 321	7024	226	485	-1442	6285	8067	71	372	-580	4875	7078	153	405	-1024	5241
	LC 322	8166	376	444	-2561	7662	9615	139	294	-1073	5009	8481	211	359	-1443	5942
	LC 323	8077	376	512	-2563	9081	8747	171	410	-1313	7767	7724	237	404	-1626	7806
	LC 324	7872	385	474	-2633	8040	9185	118	341	-901	5400	7898	207	391	-1393	5923
Seismic longitudina l Case (with	LC 325	6647	0	1	0	4	7800	-78	-1	421	20	6955	0	1	0	-6
	LC 326	6837	455	314	-3270	4145	8111	291	157	-2207	2135	7236	366	161	-2609	2172
	LC 327	6819	455	328	-3270	4429	7938	297	178	-2255	2656	7084	371	168	-2645	2514
	LC 328	6778	457	320	-3284	4220	8025	286	167	-2173	2213	7119	365	167	-2598	2168
Seismic longitudina l Case	LC 329	6647	0	1	0	4	7800	-78	-1	421	20	6683	0	1	0	-6
	LC 330	6913	455	314	-3270	4145	8108	291	157	-2207	2135	6963	366	161	-2609	2172
	LC 331	6819	455	328	-3270	4429	7938	297	181	-2255	2687	6812	371	170	-2645	2544
	LC 332	6778	457	320	-3284	4220	8025	286	167	-2173	2213	6847	365	167	-2598	2168
Seismic Transverse Case (with -	LC 333	6647	49	1	88	4	7800	-94	-1	521	20	6683	0	1	0	-6
	LC 334	6875	207	1063	-1226	13164	8110	26	563	-337	7019	6963	118	556	-841	6920
	LC 335	6857	207	1077	-1226	13448	7936	33	579	-385	7467	6812	123	557	-878	7192
	LC 336	6816	208	1069	-1240	13240	8024	22	573	-302	7097	6847	117	562	-831	6916
Seismic Transverse Case (with	LC 337	6647	49	1	88	4	7800	-94	-1	521	20	6955	-10	1	-67	-6
	LC 338	6875	207	1063	-1226	13164	8110	26	563	-337	7019	7236	108	556	-872	6920
	LC 339	6857	207	1077	-1226	13448	7936	33	579	-385	7467	7084	113	557	-909	7192
	LC 340	6816	208	1069	-1240	13240	8024	22	573	-302	7097	7119	107	562	-862	6916

Load combination - Ultimate Limit State

	Load Case -	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm
	Basic combination															
Normal Case	LC 100	9303	179	331	-1113	4109	10931	6	256	-168	3212	9588	117	278	-769	3431
	LC 101	9324	204	437	-1297	5651	10949	26	334	-320	4390	9603	138	365	-921	4710
	LC 102	11037	428	376	-2977	7718	13270	129	217	-1059	4591	11706	225	295	-1551	5762
	LC 103	10904	428	477	-2980	9846	11969	177	392	-1418	8727	10572	264	364	-1826	8557
	LC 104	10596	441	420	-3085	8284	12626	97	288	-800	5177	10831	219	343	-1475	5733
Wind case	LC 105	9516	298	551	-1855	6850	11201	81	427	-668	5342	9815	195	464	-1282	5725
	LC 106	9551	340	727	-2162	9420	11231	116	558	-921	7306	9840	229	607	-1535	7856
	LC 107	10864	511	680	-3450	11004	13010	194	468	-1487	7460	11453	296	554	-2018	8663
	LC 108	10761	511	758	-3452	12635	12013	231	602	-1763	10631	10583	326	606	-2229	10806
	LC 109	10526	522	715	-3533	11438	12516	170	522	-1289	7909	10782	292	591	-1960	8641
Seismic longitudina l Case	LC 110	8985	0	1	0	-6	10526	-108	-2	582	22	9247	0	1	0	-13
	LC 111	9167	540	378	-3879	4913	10838	332	192	-2553	2554	9527	436	195	-3113	2572
	LC 112	9150	540	392	-3879	5196	10664	338	212	-2601	3069	9376	442	201	-3150	2908
	LC 113	9109	542	384	-3893	4988	10752	328	201	-2519	2633	9411	436	201	-3103	2568

Seismic longitudinal Case	LC 114	8985	0	1	0	-6	10526	-108	-2	582	22	9247	0	1	0	-13
	LC 115	9259	540	378	-3879	4913	10833	332	192	-2553	2554	9527	436	195	-3113	2572
	LC 116	9241	540	392	-3879	5196	10660	338	212	-2601	3069	9376	442	201	-3150	2908
	LC 117	9200	542	384	-3893	4988	10747	328	201	-2519	2633	9411	436	201	-3103	2568
Seismic Transverse Case (with -	LC 118	8985	0	1	0	-6	10526	-108	-2	582	22	9247	0	1	0	-13
	LC 119	9213	183	1278	-1320	15736	10836	34	679	-428	8415	9527	139	669	-993	8269
	LC 120	9195	183	1291	-1321	16019	10662	40	693	-476	8842	9376	144	669	-1030	8521
	LC 121	9154	185	1283	-1335	15811	10750	30	689	-393	8494	9411	138	676	-983	8266
Seismic Transverse Case (with	LC 122	8985	0	1	0	-6	10526	-108	-2	582	22	9247	0	1	0	-13
	LC 123	9213	183	1278	-1320	15736	10836	34	679	-428	8415	9527	139	669	-993	8269
	LC 124	9195	183	1291	-1321	16019	10662	40	693	-476	8842	9376	144	669	-1030	8521
	LC 125	9154	185	1283	-1335	15811	10750	30	689	-393	8494	9411	138	676	-983	8266

load combination- Serviceability Limit State

	Load Case -	End pier - P1					Intermediate pier - P2					Intermediate pier - P3				
		P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm	P-kN	HL-kN	HT-kN	ML-kNm	MT-kNm
Normal	LC 200	6660	153	221	-803	2743	8194	-54	170	263	2142	7133	68	186	-542	2295
	LC 201	6674	170	292	-926	3771	8206	-40	222	162	2928	7143	82	244	-644	3148
	LC 202	7816	319	251	-2046	5149	9753	28	144	-331	3062	8546	140	197	-1063	3850
	LC 203	7727	319	318	-2048	6567	8885	60	261	-570	5819	7789	166	243	-1247	5713
	LC 204	7522	328	281	-2118	5526	9323	7	191	-158	3452	7962	136	229	-1013	3830
Wind load Case	LC 205	6802	233	368	-1298	4570	8374	-4	284	-84	3563	7285	120	310	-884	3825
	LC 206	6825	260	485	-1503	6284	8393	19	371	-239	4872	7302	143	406	-1053	5246
	LC 207	7681	372	455	-2343	7317	9554	70	313	-608	4972	8353	186	371	-1368	5772
	LC 208	7615	372	505	-2344	8381	8903	94	400	-788	7040	7786	206	405	-1505	7169
	LC 209	7461	379	477	-2397	7600	9232	55	348	-479	5265	7916	183	395	-1330	5757
Temperature rise Case	LC 210	6552	398	1	716	-5	7882	27	-2	-376	20	6885	-7	1	-77	3
	LC 211	7409	510	-30	-1555	1139	9043	78	-60	-745	331	7937	36	-33	-365	650
	LC 212	7342	510	21	-1557	2095	8392	102	27	-925	2182	7369	56	1	-502	1927
	LC 213	7188	516	-7	-1609	1341	8721	62	-25	-616	496	7499	33	-9	-327	549
Temperature Fall Case	LC 214	6343	-329	2	593	7	7965	-286	-2	1902	18	6927	-13	1	-56	-4
	LC 215	7200	-217	-29	-1029	1145	9125	-235	-61	1532	328	7979	31	-34	-324	647
	LC 216	7133	-217	22	-1031	2104	8475	-211	27	1352	2179	7412	50	1	-461	1923
	LC 217	6979	-211	-7	-1059	1348	8803	-251	-25	1661	494	7542	28	-10	-286	546
Positive Temperature	LC 218	6254	-18	1	32	-4	8042	-178	-3	1097	16	6863	-10	2	-66	8
	LC 219	7110	94	-29	-808	1139	9202	-127	-61	728	327	7914	33	-33	-343	652
	LC 220	7044	94	21	-810	2098	8552	-103	26	548	2176	7347	53	1	-481	1931
	LC 221	6890	101	-7	-862	1342	8880	-142	-26	857	493	7477	30	-9	-306	551
Reverse Temperature	LC 222	6537	83	1	149	4	7871	-97	-2	535	21	6923	-10	1	-67	-6
	LC 223	7393	195	-29	-988	1143	9031	-46	-60	166	332	7974	34	-34	-345	646
	LC 224	7327	195	21	-990	2101	8381	-22	28	-94	2184	7407	53	0	-483	1921
	LC 225	7173	201	-7	-1042	1346	8709	-62	-25	295	497	7537	31	-10	-308	545
Quasi-permanent Combinatio	LC 226	6500	216	1	388	-3	7903	-51	-2	194	19	6896	-9	1	-72	2
	LC 227	6395	-148	1	266	5	7944	-208	-2	1332	18	6917	-12	1	-61	-4
	LC 228	6351	8	1	15	-3	7983	-154	-2	930	18	6884	-10	2	-66	5
	LC 229	6492	58	1	105	3	7897	-114	-2	649	20	6914	-10	1	-67	-4

9 Analysis and Design of Pile Foundation for Left Pier P1

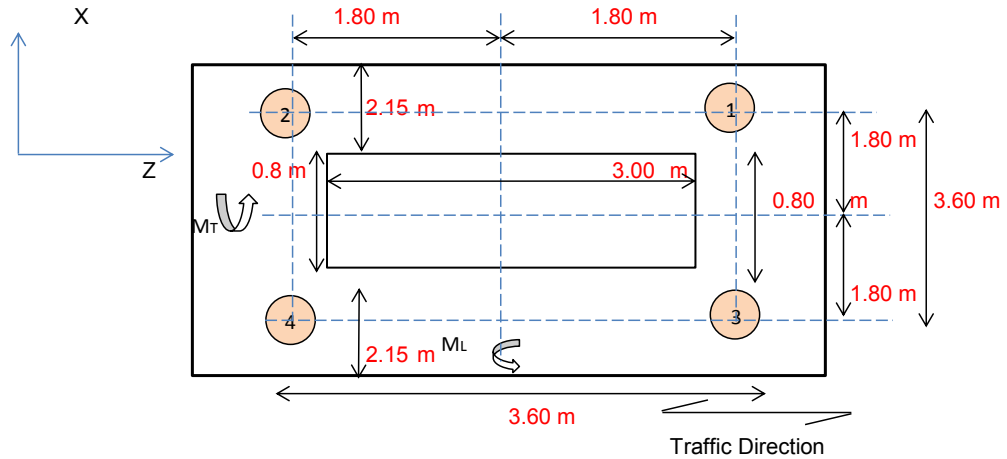
9.1 Calculation of Pile Reactions

9.1.1 Input Data

No of piles		n	=	4	nos.
Length of pile		L	=	30.00	m
Pile embedment length		L2	=	29.95	m
Fixidity length below scour depth		Lf	=	10.00	m
Diameter of the Pile		d	=	1.20	m
Offset from face of pile	(IRC: 78-2014, 709.5.1)		=	0.15	m
Pile Cap dimension in Transverse Direction		L_F	=	5.10	m
Pile Cap dimension in Longitudinal Direction		B_F	=	5.10	m
Plan area of pile cap		A	=	26.01	m^2
Depth of Pile Cap		D_F	=	1.8	m
Soil height above top of pile cap			=	0.75	m
Unit weight of concrete			=	25	kN/m^3
Unit weight of Soil			=	20	kN/m^3
Design vertical capacity of pile (Normal Case)			=	3500	kN
Design vertical capacity of pile (Seismic case)			=	4375	kN (IRC: 78-2014, 706.1.2)
Design vertical capacity of pile (Wind case)			=	4375	kN (IRC: 78-2014, 706.1.2)
Design vertical capacity of pile (Temperature case)			=	4025	kN (IRC: 78-2014, 706.1.2)
Lateral capacity of Pile (Normal Case)			=	350	kN
Lateral capacity of Pile (Seismic Case)			=	438	kN
Lateral capacity of Pile (Wind Case)			=	438	kN
Lateral capacity of Pile (Temperature Case)			=	403	kN
Pier dimension (Rect portion) in Transverse Direction		B_C	=	3.00	m
Pier dimension in Longitudinal Direction			=	0.80	m
Total Pier dimension in Longitudinal Direction		D_C	=	0.80	m
Reduction factor for bending moment in pile			=	0.82	(IS 2911 (Part 1 / Sec.-2) - 2010, Fig-5)
Total C/S area of pier			=	2.4	m^2
Weight of pile cap	=26.01×1.8×25		=	1170	kN
Weight of soil above pile cap	=(26.01-2.4)×0.75×20		=	354	kN

Pile Coordinates:

Pile	1	2	3	4		
x	1.80	1.80	-1.80	-1.80		
z	1.80	-1.80	1.80	-1.80		
x^2	3.24	3.24	3.24	3.24	Σx^2	**12.96**
z^2	3.24	3.24	3.24	3.24	Σz^2	**12.96**



Pile Arrangement

Loads on Pile		Normal		Seismic		Wind		Temperature	
Maximum Pile Load	=	**2806 kN**	OK	**3813 kN**	OK	**3796 kN**	OK	**2832 kN**	OK
Minimum Pile Load	=	**1806 kN**	OK	**378 kN**	OK	**1005 kN**	OK	**1758 kN**	OK
Max Horizontal load	=	**52 kN**	OK	**274 kN**	OK	**159 kN**	OK	**143 kN**	OK

9.1.2 Check for Base Pressure

Col. No.	1	2	3	4	5	6	7	8	9	10	11	12
Load case no.	P (kN)	H_L (kN)	H_T (kN)	M_L (kNm)	M_T (kNm)	P / n	Load due to M_L (P1 TO P4)	Load due to M_T (P1 to P4)	Max. load (kN)	Min. load (kN)	Resultant Hor. load per pile (kN)	Remarks
LC 300	8171	49	1	0	2	2043	0	0	2043	2043	12	Normal Load Case
LC 301	9313	199	-40	-851	1453	2328	-118	202	2648	2008	51	
LC 302	9224	199	28	-853	2750	2306	-118	382	2806	1806	50	
LC 303	9019	207	-10	-907	1777	2255	-126	247	2627	1882	52	
LC 304	8276	413	1	0	-2	2069	0	0	2069	2069	103	Temperature Case
LC 305	8067	-314	1	0	6	2017	0	1	2017	2016	79	
LC 306	9417	562	-40	-851	1449	2354	-118	201	2674	2035	141	
LC 307	9328	562	27	-853	2746	2332	-118	381	2832	1832	141	
LC 308	9123	571	-10	-907	1773	2281	-126	246	2653	1909	143	
LC 309	9208	-165	-39	-851	1457	2302	-118	202	2623	1982	42	
LC 310	9119	-165	28	-853	2754	2280	-118	382	2781	1779	42	
LC 311	8914	-156	-10	-907	1781	2229	-126	247	2602	1855	39	
LC 312	7978	-3	1	0	0	1994	0	0	1994	1994	1	
LC 313	8171	49	1	0	2	2043	0	0	2043	2043	12	
LC 314	9119	147	-40	-851	1451	2280	-118	201	2599	1960	38	
LC 315	9030	147	28	-853	2748	2258	-118	382	2758	1758	37	
LC 316	8825	156	-10	-907	1775	2206	-126	246	2579	1834	39	
LC 317	9313	199	-40	-851	1453	2328	-118	202	2648	2008	51	
LC 318	9224	199	28	-853	2750	2306	-118	382	2806	1806	50	
LC 319	9019	207	-10	-907	1777	2255	-126	247	2627	1882	52	
LC 320	8525	198	368	-880	3909	2131	-122	543	2796	1466	104	Wind Load Case
LC 321	8548	226	485	-1034	5412	2137	-144	752	3032	1242	134	
LC 322	9690	376	444	-1885	6863	2423	-262	953	3637	1208	145	
LC 323	9601	376	512	-1887	8160	2400	-262	1133	3796	1005	159	
LC 324	9396	385	474	-1941	7187	2349	-270	998	3617	1081	153	
LC 325	8171	0	1	0	2	2043	0	0	2043	2042	0	Seismic longitudinal Case (with -P)
LC 326	8361	455	314	-2451	3580	2090	-340	497	2928	1253	138	
LC 327	8344	455	328	-2451	3839	2086	-340	533	2960	1212	140	
LC 328	8303	457	320	-2462	3644	2076	-342	506	2924	1228	139	
LC 329	8171	0	1	0	2	2043	0	0	2043	2042	0	Seismic longitudinal Case (with
LC 330	8437	455	314	-2451	3580	2109	-340	497	2947	1272	138	
LC 331	8344	455	328	-2451	3839	2086	-340	533	2960	1212	140	
LC 332	8303	457	320	-2462	3644	2076	-342	506	2924	1228	139	
LC 333	8171	49	1	0	2	2043	0	0	2043	2043	12	Seismic Transverse Case (with -P)
LC 334	8399	207	1063	-854	11250	2100	-119	1563	3781	419	271	
LC 335	8382	207	1077	-855	11510	2095	-119	1599	3813	378	274	
LC 336	8341	208	1069	-866	11315	2085	-120	1572	3777	393	272	
LC 337	8171	49	1	0	2	2043	0	0	2043	2043	12	Seismic Transverse Case (with +P)
LC 338	8399	207	1063	-854	11250	2100	-119	1563	3781	419	271	
LC 339	8382	207	1077	-855	11510	2095	-119	1599	3813	378	274	
LC 340	8341	208	1069	-866	11315	2085	-120	1572	3777	393	272	

Weight of pilecap & soil self weight is considered in Column 1.

9.1.3 Pile Loads for Structural Design (ULS Condition)

Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Load case no.	P (kN)	H_L (kN)	H_T (kN)	M_L (kNm)	M_T (kNm)	P / n	Load due to M_L (P1 TO P4)	Load due to M_T (P1 to P4)	Max. load (kN)	Min. load (kN)	Resultant Hor. load per pile (kN)	BM for pile = H*(Lf)/2 (kN-m)	Remarks
LC 100	11361	179	331	-792	3513	2840	-110	488	3438	2243	94	386	Normal Case
LC 101	11383	204	437	-931	4865	2846	-129	676	3651	2041	121	494	
LC 102	13095	428	376	-2207	7041	3274	-307	978	4558	1989	142	584	
LC 103	12962	428	477	-2210	8987	3240	-307	1248	4796	1685	160	657	
LC 104	12654	441	420	-2291	7527	3164	-318	1045	4527	1800	152	625	

LC 105	11574	298	551	-1320	5857	2893	-183	813	3890	1897	157	642	Wind case
LC 106	11609	340	727	-1551	8111	2902	-215	1126	4244	1560	201	823	
LC 107	12922	511	680	-2530	9779	3231	-351	1358	4940	1521	213	872	
LC 108	12820	511	758	-2532	11271	3205	-352	1565	5122	1288	229	937	
LC 109	12584	522	715	-2594	10152	3146	-360	1410	4916	1376	221	907	
LC 110	10509	0	1	0	-4	2627	0	-1	2628	2627	0	1	Seismic long. Case (with -P)
LC 111	10692	540	378	-2907	4231	2673	-404	588	3664	1682	165	676	
LC 112	10674	540	392	-2907	4491	2669	-404	624	3696	1641	167	684	
LC 113	10633	542	384	-2918	4296	2658	-405	597	3660	1656	166	681	
LC 114	10509	0	1	0	-4	2627	0	-1	2628	2627	0	1	Seismic long. Case (with +P)
LC 115	10783	540	378	-2907	4231	2696	-404	588	3687	1704	165	676	
LC 116	10765	540	392	-2907	4491	2691	-404	624	3719	1664	167	684	
LC 117	10724	542	384	-2918	4296	2681	-405	597	3683	1679	166	681	
LC 118	10509	0	1	0	-4	2627	0	-1	2628	2627	0	1	Seismic Trans. Case (with -P)
LC 119	10738	183	1278	-991	13436	2684	-138	1866	4688	681	323	1323	
LC 120	10720	183	1291	-992	13695	2680	-138	1902	4720	640	326	1337	
LC 121	10679	185	1283	-1002	13501	2670	-139	1875	4684	655	324	1329	
LC 122	10509	0	1	0	-4	2627	0	-1	2628	2627	0	1	Seismic Trans. Case (with +P)
LC 123	10738	183	1278	-991	13436	2684	-138	1866	4688	681	323	1323	
LC 124	10720	183	1291	-992	13695	2680	-138	1902	4720	640	326	1337	
LC 125	10679	185	1283	-1002	13501	2670	-139	1875	4684	655	324	1329	

Note: *Weight of pilecap & soil self weight is considered in Column 1.*

P1 (kN)	P2 (kN)	P3 (kN)	P4 (kN)	Along transverse direction				Along longitudinal direction			
				P1+P2	P3+P4	Shear Force	B.M	P1+P3	P2+P4	Shear Force	B.M
3218	2243	3438	2462	5461	5901	5901	8261	6657	4705	6657	1997
3392	2041	3651	2299	5433	5950	5950	8330	7043	4340	7043	2113
3945	1989	4558	2602	5935	7161	7161	10025	8504	4592	8504	2551
4182	1685	4796	2299	5867	7095	7095	9933	8977	3985	8977	2693
3891	1800	4527	2436	5691	6963	6963	9749	8418	4236	8418	2525
3524	1897	3890	2263	5420	6153	6153	8615	7414	4160	7414	2224
3813	1560	4244	1991	5374	6235	6235	8729	8057	3552	8057	2417
4237	1521	4940	2224	5758	7164	7164	10029	9177	3745	9177	2753
4419	1288	5122	1991	5707	7113	7113	9958	9541	3279	9541	2862
4196	1376	4916	2096	5571	7012	7012	9817	9112	3472	9112	2734
2627	2628	2627	2628	5255	5255	5255	7357	5254	5256	5256	1577
2857	1682	3664	2489	4539	6153	6153	8615	6521	4171	6521	1956
2889	1641	3696	2449	4530	6145	6145	8603	6585	4090	6585	1975
2850	1656	3660	2467	4506	6127	6127	8578	6510	4123	6510	1953
2627	2628	2627	2628	5255	5255	5255	7357	5254	5256	5256	1577
2880	1704	3687	2512	4584	6199	6199	8679	6567	4216	6567	1970
2911	1664	3719	2471	4575	6190	6190	8666	6630	4135	6630	1989
2873	1679	3683	2490	4552	6173	6173	8642	6556	4169	6556	1967
2627	2628	2627	2628	5255	5255	5255	7357	5254	5256	5256	1577
4413	681	4688	956	5094	5644	5644	7902	9101	1637	9101	2730
4444	640	4720	916	5085	5635	5635	7890	9164	1556	9164	2749
4406	655	4684	934	5061	5618	5618	7865	9090	1589	9090	2727
2627	2628	2627	2628	5255	5255	5255	7357	5254	5256	5256	1577
4413	681	4688	956	5094	5644	5644	7902	9101	1637	9101	2730
4444	640	4720	916	5085	5635	5635	7890	9164	1556	9164	2749
4406	655	4684	934	5061	5618	5618	7865	9090	1589	9090	2727

Net values	Shear Force (kN)	BM (kN-m)
Longitudinal	6275	9074
Transverse	9107	2634

Sample calculation for Net Bending moment & Shear force

BM	*Longitudinal*	0029-((5.1-0.8)/2×5.1×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×((5.10-0.80)/2/2)×1	=	9074 kNm
	Transverse	*=2862-((5.1-3.0)/2×5.1×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×((5.10-3.00)/2/2)×*	=	2634 kNm
SF	*Longitudinal*	*=7164-((5.10-0.80)/2×5.10×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×1.35*	=	6275 kN
	Transverse	*=9541-((5.10-3.00)/2×5.10×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×1.35*	=	9107 kN

** Net BM = BM due to pile reaction - BM due to self weight of pile cap and overburden soil*

9.1.4 Pile Loads for Serviceability Verification (SLS Condition)

Col. No.	1	2	3	4	5	6	7	8	10	11	12	13	14
Load case no.	P (kN)	H_L (kN)	H_T (kN)	M_L (kNm)	M_T (kNm)	P / n	Load due to M_L (P1 TO P4)	Load due to M_T (P1 to P4)	Max. load (kN)	Min. load (kN)	Resultant Hor. load per pile (kN)	BM for pile =H*(Lf)/2 (kN-m)	Remarks
LC 200	8185	153	221	-528	2345	2046	-73	326	2445	1647	67	276	Normal
LC 201	8199	170	292	-620	3246	2050	-86	451	2587	1513	84	346	
LC 202	9341	319	251	-1471	4697	2335	-204	652	3192	1478	102	416	
LC 203	9252	319	318	-1473	5994	2313	-205	833	3350	1276	113	462	
LC 204	9047	328	281	-1527	5021	2262	-212	697	3171	1352	108	443	
LC 205	8326	233	368	-880	3908	2082	-122	543	2746	1417	109	446	Wind load Case
LC 206	8350	260	485	-1034	5410	2087	-144	751	2982	1192	138	565	
LC 207	9206	372	455	-1672	6498	2302	-232	903	3436	1167	147	602	
LC 208	9139	372	505	-1674	7471	2285	-232	1038	3555	1015	157	644	
LC 209	8986	379	477	-1714	6741	2246	-238	936	3421	1072	152	625	
LC 210	8077	398	1	0	-3	2019	0	0	2020	2019	99	407	Temperature rise Case
LC 211	8933	510	-30	-638	1085	2233	-89	151	2473	1994	128	523	
LC 212	8866	510	21	-640	2058	2217	-89	286	2591	1842	128	523	
LC 213	8713	516	-7	-680	1328	2178	-94	184	2457	1899	129	529	
LC 214	7868	-329	2	0	4	1967	0	1	1968	1966	82	338	Temperature Fall Case
LC 215	8724	-217	-29	-638	1092	2181	-89	152	2421	1941	55	225	
LC 216	8657	-217	22	-640	2065	2164	-89	287	2540	1789	55	224	
LC 217	8504	-211	-7	-680	1335	2126	-94	185	2406	1846	53	216	
LC 218	7779	-18	1	0	-2	1945	0	0	1945	1944	4	18	Positive Temperature
LC 219	8635	94	-29	-638	1086	2159	-89	151	2398	1919	25	101	
LC 220	8568	94	21	-640	2059	2142	-89	286	2517	1767	24	99	
LC 221	8415	101	-7	-680	1329	2104	-94	185	2383	1825	25	104	
LC 222	8062	83	1	0	1	2015	0	0	2016	2015	21	85	Reverse Temperature
LC 223	8918	195	-29	-638	1090	2229	-89	151	2469	1990	49	202	
LC 224	8851	195	21	-640	2062	2213	-89	286	2588	1838	49	201	
LC 225	8697	201	-7	-680	1333	2174	-94	185	2454	1895	50	206	
LC 226	8025	216	1	0	-1	2006	0	0	2006	2006	54	221	Quasi-permanent Combinatio
LC 227	7920	-148	1	0	2	1980	0	0	1980	1980	37	151	
LC 228	7876	8	1	0	-1	1969	0	0	1969	1969	2	9	
LC 229	8017	58	1	0	1	2004	0	0	2004	2004	15	60	

Note: *Weight of pilecap,soil & surcharge load is considered in Column 1 and surcharge moment in Column 5 of above table.*

P1 (kN)	P2 (kN)	P3 (kN)	P4 (kN)	Along transverse direction				Along longitudinal direction			
				P1+P2	P3+P4	Shear Force	B.M	P1+P3	P2+P4	Shear Force	B.M
2299	1647	2445	1794	3946	4239	4239	5935	4744	3441	4744	1423
2414	1513	2587	1685	3927	4272	4272	5980	5001	3198	5001	1500
2783	1478	3192	1887	4262	5079	5079	7111	5975	3366	5975	1793
2941	1276	3350	1685	4217	5035	5035	7049	6291	2961	6291	1887
2747	1352	3171	1776	4099	4947	4947	6926	5918	3129	5918	1775
2502	1417	2746	1661	3919	4408	4408	6171	5249	3078	5249	1575
2695	1192	2982	1480	3888	4462	4462	6247	5678	2672	5678	1703
2972	1167	3436	1631	4139	5068	5068	7095	6408	2798	6408	1922
3090	1015	3555	1480	4105	5035	5035	7048	6645	2494	6645	1993
2945	1072	3421	1548	4017	4969	4969	6956	6365	2620	6365	1910
2019	2020	2019	2020	4038	4038	4038	5654	4037	4039	4039	1212
2295	1994	2473	2171	4289	4644	4644	6501	4768	4165	4768	1430
2414	1842	2591	2020	4256	4611	4611	6455	5005	3862	5005	1501
2268	1899	2457	2088	4167	4545	4545	6363	4725	3987	4725	1418
1968	1966	1968	1966	3934	3934	3934	5508	3935	3933	3935	1181
2244	1941	2421	2118	4185	4539	4539	6355	4666	4059	4666	1400
2362	1789	2540	1966	4151	4506	4506	6309	4902	3755	4902	1471
2217	1846	2406	2035	4063	4441	4441	6217	4623	3881	4623	1387
1944	1945	1944	1945	3889	3889	3889	5445	3889	3890	3890	1167
2221	1919	2398	2097	4140	4495	4495	6293	4619	4016	4619	1386

Rare Combination	Net BM (kN-m)
Maximum Transverse	6403
Maximum Longitudinal	1825

Quasi permanent Combination	Net BM (kN-m)
Maximum Transverse	5585
Maximum Longitudinal	1217

** Net BM = BM due to pile reaction - BM due to self weight of pile cap and overburden soil*

Sample calculation for Net Bending moment

Rare comb.	*Transverse*	=7111-((5.10-0.80)/2×5.10×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×((5.10-0.80)/2/2) =	6403 kNm
	Longitudinal	*=1993-((5.10-3.00)/2×5.10×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×((5.10-3.00)/2/2) =*	1825 kNm
Quasi comb.	*Transverse*	*=5612-((5.10-0.80)/2×5.10×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×((5.10-0.80)/2/2) =*	5585 kNm
	Longitudinal	*=1203-((5.10-3.00)/2×5.10×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×((5.10-3.00)/2/2) =*	1217 kNm

9.2 Design of Pile Cap

9.2.1 Transverse Direction - Design Parameters

9.2.1.1 Design for Maximum Bending Moment about Pier Face

Breadth of the section	b	=	5100	mm	
Depth of the section	D	=	1800	mm	
Effective depth of the section	d	=	1701	mm	
Clear cover		=	75	mm	
Cover to the main reinforcement	c_s	=	100	mm	
Characteristic concrete compression strength	f_{ck}	=	35	MPa	
Characteristic concrete tensile strength	f_{ctm}	=	2.77	MPa	
Characteristic reinforcement yield strength	f_{yk}	=	500	MPa	
Partial safety factor for Concrete	γ_c	=	1.50		
Partial safety factor for steel	γ_s	=	1.15		
Design reinforcement yield strength	f_{yd}	=	434.8	MPa	
Design concrete compression strength	f_{cd}	=	15.63	MPa	
	$R_{lim} = 0.167 f_{ck}$	=	5.85		=0.167×35
	$d_{reqd.} = \text{sqrt}(M/R_{lim}\, b)$ =		552	mm	
					SAFE
For rectangular stress block,					
(for fck till 60MPa)	λ	=	0.8		
	ή	=	1		
(rectangular stress block considered)	β	=	0.4		
=+15.63×0.8×1	f_{av}	=	12.51	MPa	
Maximum Moment in longitunal direction	M	=	**9074**	kNm	
Diameter of bars in 1st layer	ø	=	25	mm	
Number of bars in 1st layer	n_s	=	34		
C/C Spacing of bars in 1st layer	a_s	=	150	mm	
Diameter of stirrups		=	12	mm	
Reinforcement area provided	A_s	=	16690	mm^2	
=(9074×10^6)/(5100×1701×1701×12.51)	K_{av}	=	0.049		
The deg of reinforcement required , w or x/d		=	0.05		
Thus x		=	85	mm	
Lever arm z		=	1666	mm	
check limit to ensure yielding in reinforcement		=	0.62		OK
Reinforcement area required for design moment		=	12525	mm^2	
Minimum area of reinforcement	=		$0.26*f_{ctm}/f_{yk}*b_t*d$		= 12498 mm2
			$< 0.0013*b_t*d$		= 11274 mm2
					OK

Reinforcement at top of pile cap

Minimum area of reinforcement		=	6249	mm^2	
Diameter of bars	ø	=	16	mm	
Number of bars required	n_s	=	34	nos.	
Diameter of bars	ø	=	0	mm	
Number of bars required	n_s	=	0	nos.	
Reinforcement area provided	A_s	=	6836	mm^2	
					OK

9.2.1.2 Check for Shear (Cl 10.3.2, IRC 112)

Width of section	b	=	5100	mm
Main reinforcement area	A_{st}	=	16690	mm^2
Diameter of stirrup	f_{st}	=	12	mm
Number of stirrup legs in width of section	n_{st}	=	15	nos.
Longitudinal spacing of stirrups	s	=	300	mm
c/s area of one leg		=	113	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1696	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Design Shear force	V_{ED}	=	6275	kN
distance from applied load to edge of support	α_v	=	1400	mm
Reduction factor	β	=	α_v/2d	
	β	=	0.41	=1400/(2×1701)
Shear force for checking shear resistance of section	$\beta*V_{ED}$	=	2583	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33}+0.15\sigma_{cp}b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.34	
Main reinforcement ratio	ρ_1	=	0.0019	
	σ_{cp}	=	0	
=0.031×(1.34^1.5)×35^0.5	V_{min}	=	0.29	
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	2475 kN	
			Shear reinforcement required	
Max. Shear Capacity of section with Shear Reinf. $V_{Rd,Max}$ (Limited to crushing of concrete)	$V_{Rd,Max}$	=	$\alpha_{cw}*b_w*z*V1*$ fcd/(cotΘ+tanΘ)	
Calculation of Θ:				
	cotΘ+tanΘ	=	$\alpha_{cw}*b_w*z*V_1*$ f_{cd} / V_{ED}	
		=	10.349	
since 1.0<cotΘ<=2.5, governing design	cotΘ	=	2.50	
	Θ	=	21.80	°
	α_{cw}	=	1	
	V_1	=	0.53	
lever arm	z	=	1530	mm
	$V_{Rd,Max}$	=	22396	kN
Max. Shear Capacity of section with Shear Reinf. (Limited to yielding of Reinf.)	$V_{Rd,s}$	=	$(A_{sw}*z*f_{ywd}*$ cotΘ)/S	
	$V_{Rd,s}$	=	9407	kN
Shear Resistance of the Section (min. of $V_{Rd,s}$&$V_{Rd,max}$)		=	9407	kN
				SAFE

Check for min. Shear Reinforcement

Shear reinforcement ratio provided	ρ_w	=	0.0011	
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0009	

Check for max. Shear Reinforcement

	$\frac{A_{sw}*f_{ywd}}{b_w * s}$	< =	$0.5 * \alpha_{cw}*v_1* f_{cd}$	
	0.48	< =	4.16	
				SAFE
Max. longitudinal spacing of vertical stirrups	$s_{l,max}$	=	0.75d	
		=	1275 mm	
				SAFE
Max. transverse spacing of legs	$s_{l,max}$	=	0.75d(or)	< 600mm
		=	1275 mm	SAFE

9.2.2 Longitudinal Direction - Design Parameters

9.2.2.1 Design for Maximum Bending Moment about Pier Face

Breadth of the section	b	=	5100	mm

Depth of section	D	=	1800	mm	
Effective depth of the section	d	=	1676	mm	
Clear Cover		=	75	mm	
Cover to the main reinforcement	c_s	=	125	mm	
Characteristic concrete compression strength	f_{ck}	=	35	MPa	
Characteristic concrete tensile strength	f_{ctm}	=	2.77	MPa	
Characteristic reinforcement yield strength	f_{yk}	=	500	MPa	
Partial safety factor for Concrete	γ_c	=	1.5		
Partial safety factor for steel	γ_s	=	1.15		
Design reinforcement yield strength	f_{yd}	=	435	MPa	
Design concrete compression strength	f_{cd}	=	15.63	MPa	
	$R_{lim} = 0.167 f_{ck}$	=	5.85		
	$d_{reqd.} = \text{sqrt}(M/R_{lim}\, b)$ =		297	mm	
					SAFE
For rectangular sress block,					
(for fck till 60MPa)	λ	=	0.8		
	ή	=	1		
(rectangular stress block considered)	β	=	0.4		
=+15.63×0.8×1	f_{av}	=	12.51	MPa	
Maximum Moment about Section BB	M	=	**2634**	KNm	
Diameter of bars in 1st layer	ø	=	25	mm	
Number of bars in 1st layer	n_s	=	34		
C/C Spacing of bars in 1st layer	a_s	=	150	mm	
Diameter of bars in 2nd layer	ø	=	0		
Number of bars in 2nd layer	n_s	=	34		
C/C Spacing of bars in 2nd layer	a_s	=	0		
Diameter of stirrups		=	12	mm	
Reinforcement area provided	A_s	=	16690	mm^2	
Kav considering fav		=	0.015		
The deg of reinforcement required , ω or x/d		=	0.015		
x		=	25	mm	
Lever arm	z	=	1666	mm^2	
Check limit to ensure yielding in reinforcement		=	0.62		OK
Reinforcement area required for design moment		=	3638	mm^2	
Minimum area of reinforcement	=		$0.26*f_{ctm}/f_{yk}*b_t*d$		= 12314 mm2
			(or) $0.0013*b_t*d$		= 11109 mm2
					OK
Reinforcement at top of pile cap					
Minimum area of reinforcement		=	6157	mm^2	
Diameter of bars	ø	=	16	mm	
Number of bars required	n_s	=	34	nos.	
Diameter of bars	ø	=	0	mm	
Number of bars required	n_s	=	0	nos.	
Reinforcement area provided	A_s	=	6836	mm^2	
					OK

9.2.2.2 Check for Shear (Cl 10.3.2, IRC 112)

Width of section	b	=	5100	mm
Main reinforcement area	A_{st}	=	16690	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Design Shear force	V_{ED}	=	9107	kN
distance from P1/P5 pile to support	α_v	=	300	mm
Reduction factor	β	=	α_v/2d	
	β	=	0.09	
Shear force for checking shear resistance of section	β*V_{ED}	=	815	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.35	
Main reinforcement ratio	ρ_1	=	0.0020	
	σ_{cp}	=	0	
=0.031×(1.35^1.5)×35^0.5	V_{min}	=	0.29	
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	2446 kN	
			Shear reinforcement is not required	
Max. Shear Capacity of section with Shear Reinf. $V_{Rd,Max}$ (Limited to crushing of concrete)	$V_{Rd,Max}$	=	$\alpha_{cw}*b_w*z*V1*$ fcd/(cotΘ+tanΘ)	
Calculation of Θ:				
	cotΘ+tanΘ	=	$\alpha_{cw}*b_w*z*V_1*$ f_{cd} / V_{ED}	
=1×5100×1508×0.53×15.63/(815×1000)		=	7.03	
since 1.0<cotΘ<=2.5, for governing design	cotΘ	=	2.50	
	Θ	=	21.80	°
	α_{cw}	=	1	
=0.6×(1-35/310)	V_1	=	0.53	
lever arm	z	=	1508	mm
=(1×5100×1508×0.53×15.63)/(2.5+1/2.5)/1000	$V_{Rd,Max}$	=	22066	kN

Surface Reinforcement (as per clause 16.5.4 of IRC 112-2011)

Area of cover portion outside the stirrups/links	=	75000	mm^2/m
Area of surface reinforcement required, 0.01*$A_{ct,ext}$	=	750	mm^2/m
Provide 12mm dia bar @ 150mm spacing for side reinforcement			
Therefore area of reinforcement provided	=	754	mm^2/m
			SAFE

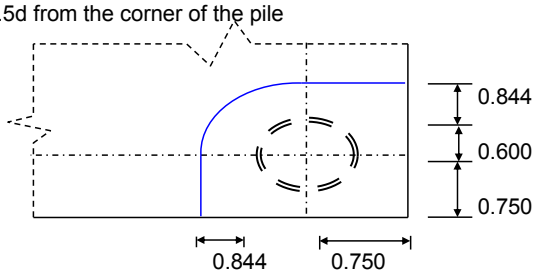
9.2.3 Check for Punching Shear (Cl 10.4.5 of IRC:112-2011)

9.2.3.1 For Pile :

At "0.5d" from face of loaded area:

Characteristic concrete compression strength	f_{ck}	=	35	MPa
Effective depth of pilecap in long. direction,	d_1	=	1701	mm
Effective depth of pilecap in trans. direction,	d_2	=	1676	mm
Effective depth	d	=	1688	mm
Diameter of Pile	φ	=	1200	mm
Edge distance from pile		=	750	mm
Distance from pile face to control perimeter considered	a	=	844	mm

The critical section is at a distance 0.5d from the corner of the pile



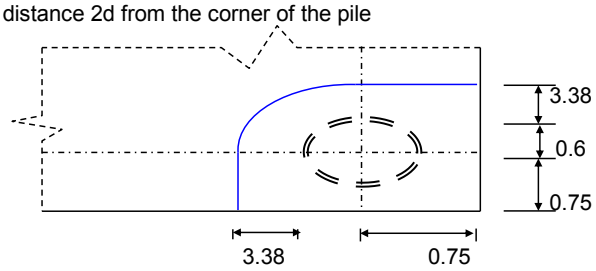
Perimeter (Length around the corner pile)	u_1	=	3768	mm
Punching Area	A	=	6.4	m^2
Punching Shear force	V_{Ed}	=	5122	kN
Counteracting shear force	ΔV_{Ed}	=	0	kN
	K	=	1.34	
	ρ_l	=	0.0019	
Net Punching shear	$V_{ed.red}$	=	5122	kN
Punching shear stress	$vE_{d.red}$	=	0.81	N/mm²
Punching Shear Resistance	V_{Rd}	=	1.1340	N/mm²
	v_{min}	=	0.29	N/mm²
Punching Shear Resistance	V_{Rd}	=	1.1340	N/mm²

SAFE

At distance "2d" from face of loaded area:

Characteristic concrete compression strength	f_{ck}	=	35	MPa
Since it is a pile at the corner of the pilecap,				
Effective depth of pilecap in long. direction,	d_1	=	1701	mm
Effective depth of pilecap in trans. direction,	d_2	=	1676	mm
Effective depth	d	=	1688	mm
Diameter of Pile	φ	=	1200	mm
Pilecap Edge distance from pile center		=	750	mm
Distance from pile face to control perimeter considered	a	=	3376	mm

The critical section is at a distance 2d from the corner of the pile



Perimeter (Length around the corner pile)	u_1	=	7745	mm
Punching Area	A	=	13.1	m^2
Punching Shear force	V_{Ed}	=	5122	kN
Counteracting shear force	ΔV_{Ed}	=	2357	kN
	K	=	1.34	
	ρ_l	=	0.0019	
Net Punching shear	$V_{ed.red}$	=	2765	kN
Punching shear stress	$vE_{d.red}$	=	0.21	N/mm²
Punching Shear Resistance	V_{Rd}	=	0.28	N/mm²
	v_{min}	=	0.29	N/mm²
Punching Shear Resistance	V_{Rd}	=	0.29	N/mm²

SAFE

9.3 Calculation of Pilecap Crack Width

Clear cover to reinforcement c = 75 mm

Long term Modular ratio m = E_s / (0.5 * E_c)
= 12.50

Characteristic compressive strength of concre f_{ck} = 35 N/mm^2

Check for stresses at various sections:

Section	Unit	Transverse Direction	Longitudinal Direction
Depth of Pilecap		1800	1800
Width of the flange, b	mm	5100	5100
Maximum diameter of bar (ϕ)	mm	25	25
CG of section from Top,Y_t	mm	900	900
CG of section from bottom,Y_b	mm	900	900
Area of Steel Provided, A_{st}	mm^2	16690	16690
Effective Depth, d	mm	1701	1676
Distance of N.A. from top, X_u = (0.87*fy*Ast)/(0.36*fck*b)	mm	113	113
f_{ctm} (IRC:112-2011, A2-2)	Mpa	2.77	2.77
Service Moment (Rare Combination)	kN m	6403	1825
Service Moment (Quasi-perm. Combination)	kN m	5585	1217

Properties of Gross Section	Unit	Longitudinal Direction	Transverse Direction
Gross Area, A_{gr}	mm^2	9.18E+06	9.18E+06
Gross Moment of Inertia, I_{gr}	mm^4	2.48E+12	2.48E+12

Properties of Uncracked Section

$$Y_{tT} = \frac{(b * D * D/2) + ((m - 1) * A_{st} * d)}{(b * D) + ((m - 1) * A_{st})}$$

$$Y_{bT} = D - Y_{tT}$$

$$Y_{sT} = d - Y_{tT}$$

$$I_T = (b * D^3/12 + b * D * (D/2 - Y_{tT})^2) + ((m - 1) * A_{st} * (d - Y_{tT})^2)$$

Properties of Uncracked Transformed Section	Unit	Transverse Direction	Longitudinal Direction
CG of Uncracked section from Top,Y_{tT}	mm	916	916
CG of Uncracked section from bottom,Y_{bT}	mm	884	884
CG of Uncracked section from steel,Y_{sT}	mm	784	760
Uncracked Moment of Inertia, I_T	mm^4	2.60E+12	2.59E+12

Properties of Cracked Section

Calculation of C.G. of Cracked Transformed section from Top (Longitudnal)

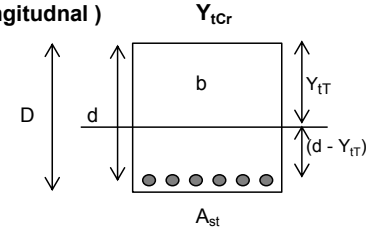
Y_{tCr}

b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})

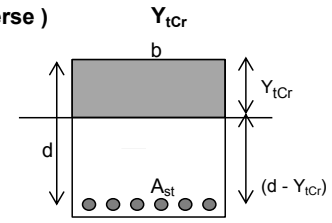
5100 * Y^2_{tCr} / 2 = 12.50 * 16690 * (1701 - YtCr)

2550 Y^2_{tCr} 2.09E+05 Y_{tCr} - 3.55E+08 =

Y_{tCr} = 334



Calculation of C.G. of Cracked Transformed section from Top (Transverse)



$b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$

$5100 * Y^2_{tCr} / 2 = 12.50 * 16690 * (1676 - YtCr)$

$2550\ Y^2_{tCr} + 2.09E+05\ Y_{tCr} - 3.50E+08 = 0$

$Y_{tCr} = 332$ mm

Properties of Cracked Transformed Section	Unit	Transverse Direction	Longitudinal Direction
CG of Cracked section from Top, Y_{tCr}	mm	334	332
CG of Cracked section from bottom, Y_{bCr}	mm	1466	1468
CG of Cracked section from steel, Y_{sCr}	mm	1366	1344
Cracked Moment of Inertia, I_{cr}	mm^4	4.53E+11	4.39E+11

Stresses under Rare Combination	Unit	Transverse Direction	Longitudinal Direction
Comp stress in concrete, fc = (M / I)* Y_t	Mpa	2.26	0.64
Comp stress in concrete (limit to 0.48f_{ck})		SAFE	SAFE
Tensile stress in conc. at steel level, fct_{steel} = (M / I)* Y_s	Mpa	1.93	0.53
Tensile stress in steel, fst = m * fct_{steel}	Mpa	24.15	6.69
Tensile stress in steel (limit to 0.8 f_{yk})	Mpa	SAFE	SAFE

Stresses under Quasi-permanent Combination	Unit	Longitudinal Direction	Transverse Direction
Cracking Moment, $M_{cr} = I_{gr} * f_{ctm} / Y_b$	kN m	7632	7632
State of Section		Uncracked	Uncracked
Comp stress in concrete, fc = (M / I_T)* Y_{tT}	Mpa	1.97	0.43
Comp stress check (limit to 0.36 f_{ck})		Linear Creep	Linear Creep
Tensile stress in conc. at steel level, fct_{steel} = (M / I_T)* Y_{st}	Mpa	1.69	0.36
Tensile stress in concrete (limit to f_{ctm})		Uncracked	Uncracked
Tensile stress in steel, fst = m * fct_{steel}	Mpa	21.06	4.46

9.3.1 Calculation of Crack Width (Transverse Direction)

$W_k = S_{r\,max} (\varepsilon_{sm} - \varepsilon_{cm})$ (IRC:112-2011, Cl 12.3.4)

Where,

W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing (IRC:112-2011, Eq. 12.8, 12.11 or 12.12)

$S_{r\,max} = 3.4c + (0.425 * k_1 * k_2 * \phi / r_{p,eff})$

ϕ = Diameter of Main steel

c = Clear cover to lonfitudnal reinforcement

c	=	75 mm
k_1	=	0.8 for deformed bars
k_2	=	0.5 for bending
ϕ	=	25 mm

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\ \sigma_{sc} / E_s$

Where, σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)
= (D - x)/ 3
= D / 2

k_t = Factor dependent on duration of load

	$h_{c,eff}$	=	249	mm
	$A_{c,eff}$	=	1268625	mm^2
	$\rho_{p,eff}$	=	0.01316	
	k_t	=	0.5	
	σ_{sc}	=	21	N / mm^2
	$f_{ct,eff}$	=	2.77	N / mm^2
Modulus of elasticity of steel	E_s	=	200000	MPa
	α_e	=	12.50	
	$\varepsilon_{sm} - \varepsilon_{cm}$	=	0.0001	
	$S_{r\,max}$	=	578.1	mm
	W_k	=	0.037 mm	< 0.30 mm SAFE

(IRC:112-2011, Table 12.1)

9.3.2 Calculation of Crack Width (Longitudinal Direction)

W_k = $S_{r\,max} (\varepsilon_{sm} - \varepsilon_{cm})$ (IRC:112-2011, Cl 12.3.4)

Where,

W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing (IRC:112-2011, Eq. 12.8, 12.11 or 12.12)

$S_{r\,max}$ = $3.4c + (0.425 * k_1 * k_2 * \phi / r_{p,eff})$

ϕ = Diameter of Main steel

c = Clear cover to lonfitudnal reinforcement

c	=	75	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending
ϕ	=	25	mm

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\ \sigma_{sc} / E_s$

Where, σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)
= (D - x)/ 3
= D / 2

k_t = Factor dependent on duration of load

	$h_{c,eff}$	=	311	mm		
	$A_{c,eff}$	=	1587375	mm^2		
	$\rho_{p,eff}$	=	0.01051			
	k_t	=	0.5			
	σ_{sc}	=	4	N / mm^2		
	$f_{ct,eff}$	=	2.77	N / mm^2		
Modulus of elasticity of steel	E_s	=	200000	MPa		
	α_e	=	12.50			
	$\varepsilon_{sm} - \varepsilon_{cm}$	=	0.0000			
	$S_{r\,max}$	=	659.2	mm		
	W_k	=	0.009	mm	< 0.30 mm	SAFE

(IRC:112-2011, Table 12.1)

9.4 Design of Pile

9.4.1 Input Data

Diameter of the pile	D	=	1200	mm
Characteristic compressive strength of concrete	f_{ck}	=	35	MPa
Characteristic yield strength of steel	f_{yk}	=	500	Mpa
Partial factor for Reinforcement (IRC:112-2011,cl.no.6.2.2)	γ_s	=	1.15	
Design Yield Strength of Reinforcement	f_{yd}	=	435	MPa
Characteristic yield strength of stirrups	f_{ywk}	=	500	N/mm^2
Modulus of elasticity for concrete	E_{cm}	=	3.2E+04	MN/m^2
Clear cover	c	=	75	mm
Gross cross section area of concrete	A_C	=	1130973	mm^2

9.4.2 Check for Axial and Flexure Capacities

Provide Diameter of londitudinal bar		=	20	+	0	mm
Number of longitudinal bars		=	21	+	0	no.
Diameter of lateral ties		=	10	mm		
Spacing of lateral ties provided		=	150	mm		
Effective cover	d'	=	95	mm		
Effective depth of Pile	d_{eff}	=	1105	mm		
Area of reinforcement provided	$A_{st\ provd}$	=	6597	mm^2		
Minimum area of reinforcement required	A_{stmin}	=	0.4% of A_G			
[IRC:78-2014]			4524	mm^2	OK	
Percentage of steel provided	pt %	=	0.58			
Effective cover to Depth Ratio	d' / D	=	0.079			

The pile is checked for maximum BM with corresponding maximum and minimum axial load. The maximum axial capacity of pile is calculated as per IRC112:2011, cl. No. 8.3.2 (4) and flexural capacities are calculated from the interaction diagram as per SP:16.

Maximum compression capacity of pile $P_{uz} = A_c * f_{cd} + A_y * f_{yd}$

[IRC 112:2011, cl.no. 8.3.2 (4)]

where,	A_c	=	1130973	mm^2
	f_{cd}	=	15.6	N/mm^2
	A_y	=	6597	mm^2
	f_{yd}	=	435	N/mm^2

P_{uz} = 20549 kN

Maximum BM and corresponding Minimum Axial Load Case

Maximum Bending moment on Pile	M_{max}	=	1337 kN m
Corresponding minimum Vertical load on Pile	P_{min}	=	640 kN

For, p / f_{ck} = 0.017 Mu/fck.D^3 = 0.035

$P / f_{ck} D^2$ = 0.0127 (From SP 16)

.`. Mu = 2117 kN m

(M / Mu)^2 = **0.40** SAFE

Maximum BM and corresponding Maximum Axial Load Case

Maximum Bending moment on Pile	M_{max}	=	1337	kN m
Corresponding maximum Vertical load on Pile	P_{max}	=	4720	kN

For, p/fck = 0.017 Mu/fck.D^3 = 0.045
P/fckD^2 = 0.094 (From SP 16)

.`. Mu = 2722 kN m
(M / Mu)^2 = **0.24** SAFE

9.4.3 Check for Shear Capacity

(IRC:112-2011, cl.no.10.3.2(2))

Effective depth	d_{eff}	=	968	mm
Width	b	=	600	mm

Design shear force,

	V_{Ed}	=	326	kN
	V_{ccd}	=	0	kN For Uniform cross section
	V_{td}	=	0	kN For Uniform cross section
$V_{Rd\,s}$ =	V_{NS}	=	$V_{ed} - V_{ccd} - V_{td}$	
		=	326	kN

Maximum Allowabe Shear Force (for maximum shear force take Θ = 45 ^{0})

$V_{Rd.max} = \alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ (IRC:112-2011, cl 10.3.3.2, Eq10.8)

where,

αcw = 1.00
z = lever arm = 0.90 (For RCC)

v_1 is the strength reduction factor for concrete cracked in shear

v_1 = 0.53 (IRC:112-2011, Eq10.6)
Θ = 45.00 (CotΘ = 1)

f_{cd} is the design value of concrete compression strength = $\alpha_{cc} \times fck / \gamma_m$ (IRC:112-2011,cl. no. 10.3.1)

α_{cc} = 0.67 (Refer IRC:112-2011, Pg.87)
γ_m = 1.50 (Partial factors for concrete for ULS)
f_{cd} = 15.6 N/mm^2

$V_{Rd.max}$ = 2176 kN Section is Safe

Allowable Shear Force without Shear Reinforcement

$V_{Rd\,c} = (0.12 \times K (80 \times \rho_1 \times f_{ck})^{0.33} + 0.15 \times \sigma_{cp}) b_w \times d$ (IRC:112-2011, cl 10.3.2(2))

But, $V_{Rd.c\,min} = (v_{min} + 0.15 \times \sigma_{cp}) b_w \times d$

where,
K = 1+sqrt(200/d) <=2, where d is the depth in mm.
$V_{Rd\,c}$ = The design shear resistance of the member without shear reinforcement.
v_{min} = 0.031 x K^3/2 x fck^1/2
σ_{cp} = Concrete compressive stress at centroidal axis due to axial load or prestress.
ρ_1 = Reinforcement ratio for longitudinal reinforcement , = $A_{st} / (b_w \times d)$ <=0.02

K	=	1.45	
ρ_1	=	0.006	
N_{ED}	=	950	
σ_{cp}	=	3.13	
$V_{Rd\,c\,min}$	=	894	kN
$V_{Rd\,c}$	=	770	N

Shear reinforcement need not be provided

9.5 Crack width check for Pile:

Parameters for the section

Area of concrete effective in tension			$A_{c,eff}$	=	565488	mm^2
Characteristic concrete compression strength			f_{ck}	=	35	MPa
Effective concrete tensile stress			$f_{ct,eff}$	=	2.77	MPa
Modulus of elasticity of steel			E_s	=	200000	MPa
Short term modulus of elasticity of concrete			E_{cm}	=	32000	MPa
			α_e	=	6.25	
0.8 for deformed bars, 1.6 for plain surface bars			K_1	=	0.8	
0.5 for bending, 1.0 for pure tension, K_2 for eccentric tension K2 =(ε1+ε1)/2ε1			K_2	=	0.5	
			K_3	=	3.4	
			K_4	=	0.425	
Clear cover			c_{s1}	=	75	mm

			Layer1	Layer 2			
Diameter of reinforcement *(layer 1,2)*	$ø_1$	=	20	0			
Number of bars in the tension area of the section	n_{s1}	=	21	0			
Reinforcement area	A_{s1}	=	6597	A_{s2}	=	0	mm^2
Total area of reinforcing steel				A_s	=	6597	mm^2

Design criterias

Maximum allowable compression stress in concrete for rare combination	=	16.8	MPa	
Maximum allowable compression stress in concrete for quasi combination	=	12.6	MPa	
Maximum allowable crack width	=	0.30	mm	

Forces & Stresses in section FOR RARE COMBINATION:

Max Axial load in Pile	=	3555	kN	
Min Axial load in Pile	=	1015	kN	
Max B.M in Pile	=	644	kNm	
Tensile stress in rebar	σ_s =	83.75	MPa	
Compressive stress in concrete	σ_c =	11.37	MPa	SAFE

Forces & Stresses in section FOR QUASI COMBINATION

Max Axial load in Pile	=	#N/A	kN	
Min Axial load in Pile	=	1825	kN	
Max B.M in Pile	=	104	kNm	
Tensile stress in rebar	σ_s =	0.00	MPa	
Compressive stress in concrete	σ_c =	2.70	MPa	SAFE

* Stresses in concrete and rebar are calcluated using in-house developed sofware.

Results

Equivalent diameter of reinforcement		$ø_{eq}$ =	20	mm	
Effective reinforcement ratio	$r_{p,eff} = A_s / A_{c,eff}$	=	0.012		
		K_t =	0.500		
		e_{sm-ecm} =	0.00000		
		$S_{r,max}$ =	546		
The crack width is within the permissible limit		Wk =	0.000	mm	SAFE

10 Analysis and Design of Pile Foundation for Left Pier P2

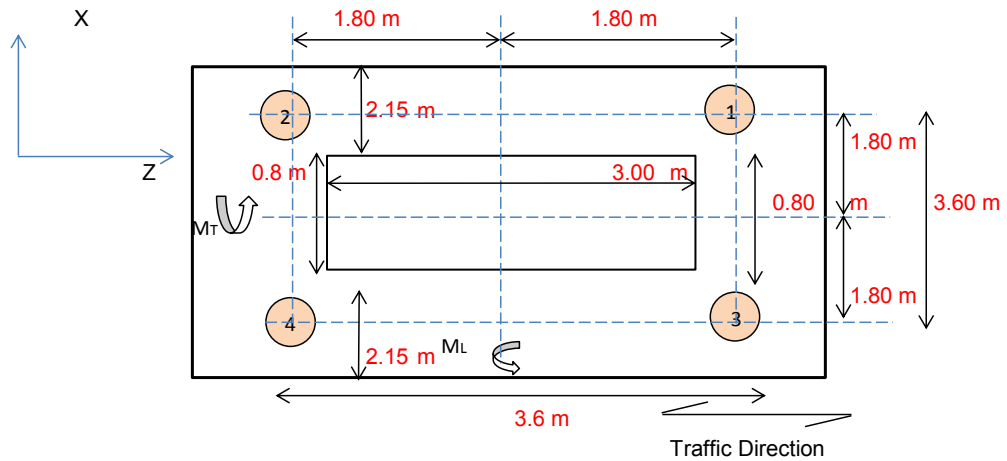
10.1 Calculation of Pile Reactions

10.1.1 Input Data

No of piles		n	=	4	nos.
Length of pile		L	=	30.00	m
Pile embedment length		L2	=	29.95	m
Fixidity length below scour depth		Lf	=	10.00	m
Diameter of the Pile		d	=	1.20	m
Offset from face of pile	(IRC: 78-2014, 709.5.1)		=	0.15	m
Pile Cap dimension in Transverse Direction		L_F	=	5.10	m
Pile Cap dimension in Longitudinal Direction		B_F	=	5.10	m
Plan area of pile cap		A	=	26.01	m^2
Depth of Pile Cap		D_F	=	1.8	m
Soil height above top of pile cap			=	0.75	m
Unit weight of concrete			=	25	kN/m^3
Unit weight of Soil			=	20	kN/m^3
Design vertical capacity of pile (Normal Case)			=	3500	kN
Design vertical capacity of pile (Seismic case)			=	4375	kN (IRC: 78-2014, 706.1.2)
Design vertical capacity of pile (Wind case)			=	4375	kN (IRC: 78-2014, 706.1.2)
Design vertical capacity of pile (Temperature case)			=	4025	kN (IRC: 78-2014, 706.1.2)
Lateral capacity of Pile (Normal Case)			=	350	kN
Lateral capacity of Pile (Seismic Case)			=	438	kN
Lateral capacity of Pile (Wind Case)			=	438	kN
Lateral capacity of Pile (Temperature Case)			=	403	kN
Pier dimension (Rect portion) in Transverse Direction		B_C	=	3.00	m
Pier dimension in Longitudinal Direction			=	0.80	m
Total Pier dimension in Longitudinal Direction		D_C	=	0.80	m
Reduction factor for bending moment in pile			=	0.82	(IS 2911 (Part 1 / Sec.-2) - 2010, Fig-5)
Total C/S area of pier			=	2.4	m^2
Weight of pile cap	=26.01×1.8×25		=	1170	kN
Weight of soil above pile cap	=(26.01-2.4)×0.75×20		=	354	kN

Pile Coordinates:

Pile	1	2	3	4		
x	1.80	1.80	-1.80	-1.80		
z	1.80	-1.80	1.80	-1.80		
x^2	3.24	3.24	3.24	3.24	Σx^2	**12.96**
z^2	3.24	3.24	3.24	3.24	Σz^2	**12.96**



Pile Arrangement

Loads on Pile		Normal		Seismic		Wind		Temperature	
Maximum Pile Load	=	**2923 kN**	OK	**3303 kN**	OK	**3684 kN**	OK	**3032 kN**	OK
Minimum Pile Load	=	**2079 kN**	OK	**381 kN**	OK	**1452 kN**	OK	**1949 kN**	OK
Max Horizontal load	=	**23 kN**	OK	**145 kN**	OK	**111 kN**	OK	**63 kN**	OK

10.1.2 Check for Base Pressure

Col. No.	1	2	3	4	5	6	7	8	9	10	11	12
Load case no.	P (kN)	H_L (kN)	H_T (kN)	M_L (kNm)	M_T (kNm)	P / n	Load due to M_L (P1 TO P4)	Load due to M_T (P1 to P4)	Max. load (kN)	Min. load (kN)	Resultant Hor. load per pile (kN)	Remarks
LC 300	9325	-94	-1	352	18	2331	49	2	2382	2280	23	Normal Load Case
LC 301	10872	-26	-79	-18	292	2718	-3	41	2761	2675	21	
LC 302	10005	6	37	-200	2840	2501	-28	394	2923	2079	9	
LC 303	10442	-47	-32	117	598	2611	16	83	2710	2511	14	
LC 304	9283	63	-1	-505	19	2321	-70	3	2394	2248	16	Temperature Case
LC 305	9366	-251	-1	1209	16	2342	168	2	2512	2171	63	
LC 306	10831	131	-79	-875	293	2708	-122	41	2870	2545	38	
LC 307	9963	163	37	-1057	2841	2491	-147	395	3032	1949	42	
LC 308	10401	110	-32	-740	599	2600	-103	83	2786	2414	29	
LC 309	10913	-182	-79	838	290	2728	116	40	2885	2572	50	
LC 310	10046	-150	37	657	2838	2511	91	394	2997	2026	39	
LC 311	10484	-203	-32	973	596	2621	135	83	2839	2403	51	
LC 312	9443	-142	-2	599	14	2361	83	2	2446	2276	36	
LC 313	9325	-94	-1	352	18	2331	49	2	2382	2280	23	
LC 314	10990	-74	-80	229	288	2748	32	40	2819	2676	27	
LC 315	10123	-42	37	47	2836	2531	7	394	2931	2130	14	
LC 316	10561	-95	-33	364	594	2640	51	83	2773	2507	25	
LC 317	10872	-26	-79	-18	292	2718	-3	41	2761	2675	21	
LC 318	10005	6	37	-200	2840	2501	-28	394	2923	2079	9	
LC 319	10442	-47	-32	117	598	2611	16	83	2710	2511	14	
LC 320	9572	48	285	-326	3053	2393	-45	424	2862	1924	72	Wind Load Case
LC 321	9592	71	372	-453	4206	2398	-63	584	3045	1751	95	
LC 322	11139	139	294	-823	4480	2785	-114	622	3521	2048	81	
LC 323	10272	171	410	-1004	7028	2568	-140	976	3684	1452	111	
LC 324	10710	118	341	-688	4786	2677	-96	665	3438	1917	90	
LC 325	9325	-78	-1	281	18	2331	39	2	2373	2290	19	Seismic longitudinal Case (with -P)
LC 326	9636	291	157	-1684	1852	2409	-234	257	2900	1918	83	
LC 327	9462	297	178	-1721	2335	2366	-239	324	2929	1802	87	
LC 328	9550	286	167	-1657	1913	2388	-230	266	2883	1892	83	
LC 329	9325	-78	-1	281	18	2331	39	2	2373	2290	19	Seismic longitudinal Case (with
LC 330	9632	291	157	-1684	1852	2408	-234	257	2899	1917	83	
LC 331	9462	297	181	-1721	2362	2366	-239	328	2933	1799	87	
LC 332	9550	286	167	-1657	1913	2388	-230	266	2883	1892	83	
LC 333	9325	-94	-1	352	18	2331	49	2	2382	2280	23	Seismic Transverse Case (with -P)
LC 334	9634	26	563	-290	6005	2409	-40	834	3283	1534	141	
LC 335	9461	33	579	-326	6426	2365	-45	892	3303	1427	145	
LC 336	9548	22	573	-263	6066	2387	-36	843	3266	1508	143	
LC 337	9325	-94	-1	352	18	2331	49	2	2382	2280	23	Seismic Transverse Case (with +P)
LC 338	9634	26	563	-290	6005	2409	-40	834	3283	1534	141	
LC 339	9461	33	579	-326	6426	2365	-45	892	3303	1427	145	
LC 340	9548	22	573	-263	6066	2387	-36	843	3266	1508	143	

Weight of pilecap & soil self weight is considered in Column 1.

10.1.3 Pile Loads for Structural Design (ULS Condition)

Col. No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Load case no.	P (kN)	H_L (kN)	H_T (kN)	M_L (kNm)	M_T (kNm)	P / n	Load due to M_L (P1 TO P4)	Load due to M_T (P1 to P4)	Max. load (kN)	Min. load (kN)	Resultant Hor. load per pile (kN)	BM for pile = H*(Lf)/2 (kN-m)	Remarks
LC 100	12989	6	256	-158	2751	3247	-22	382	3651	2843	64	262	Normal Case
LC 101	13007	26	334	-272	3789	3252	-38	526	3816	2688	84	343	
LC 102	15328	129	217	-828	4200	3832	-115	583	4530	3134	63	259	
LC 103	14027	177	392	-1100	8022	3507	-153	1114	4774	2240	108	441	
LC 104	14684	97	288	-625	4659	3671	-87	647	4405	2937	76	311	

LC 105	13259	81	427	-522	4573	3315	-73	635	4022	2607	109	446	Wind case
LC 106	13289	116	558	-713	6302	3322	-99	875	4296	2348	142	584	
LC 107	15068	194	468	-1138	6617	3767	-158	919	4844	2690	127	519	
LC 108	14071	231	602	-1347	9547	3518	-187	1326	5031	2005	161	661	
LC 109	14574	170	522	-983	6969	3644	-137	968	4748	2539	137	563	
LC 110	12051	-108	-2	388	19	3013	54	3	3069	2956	27	110	Seismic long. Case (with -P)
LC 111	12362	332	192	-1956	2210	3091	-272	307	3669	2512	96	393	
LC 112	12189	338	212	-1992	2687	3047	-277	373	3697	2397	100	409	
LC 113	12276	328	201	-1929	2271	3069	-268	315	3652	2486	96	394	
LC 114	12051	-108	-2	388	19	3013	54	3	3069	2956	27	110	Seismic long. Case (with +P)
LC 115	12358	332	192	-1956	2210	3090	-272	307	3668	2511	96	393	
LC 116	12185	338	212	-1992	2687	3046	-277	373	3696	2396	100	409	
LC 117	12272	328	201	-1929	2271	3068	-268	315	3651	2485	96	394	
LC 118	12051	-108	-2	388	19	3013	54	3	3069	2956	27	110	Seismic Trans. Case (with -P)
LC 119	12360	34	679	-367	7193	3090	-51	999	4140	2040	170	697	
LC 120	12187	40	693	-403	7596	3047	-56	1055	4158	1936	173	711	
LC 121	12274	30	689	-340	7254	3069	-47	1008	4123	2014	172	706	
LC 122	12051	-108	-2	388	19	3013	54	3	3069	2956	27	110	Seismic Trans. Case (with +P)
LC 123	12360	34	679	-367	7193	3090	-51	999	4140	2040	170	697	
LC 124	12187	40	693	-403	7596	3047	-56	1055	4158	1936	173	711	
LC 125	12274	30	689	-340	7254	3069	-47	1008	4123	2014	172	706	

Note: *Weight of pilecap & soil self weight is considered in Column 1.*

P1 (kN)	P2 (kN)	P3 (kN)	P4 (kN)	Along transverse direction				Along longitudinal direction			
				P1+P2	P3+P4	Shear Force	B.M	P1+P3	P2+P4	Shear Force	B.M
3607	2843	3651	2887	6451	6539	6539	9154	7259	5730	7259	2178
3740	2688	3816	2763	6428	6579	6579	9211	7556	5451	7556	2267
4300	3134	4530	3364	7434	7894	7894	11052	8831	6497	8831	2649
4468	2240	4774	2545	6708	7319	7319	10247	9242	4785	9242	2773
4231	2937	4405	3111	7168	7515	7515	10522	8636	6048	8636	2591
3877	2607	4022	2752	6485	6775	6775	9485	7900	5359	7900	2370
4099	2348	4296	2546	6447	6842	6842	9579	8395	4894	8395	2519
4528	2690	4844	3006	7218	7850	7850	10991	9372	5696	9372	2812
4657	2005	5031	2379	6661	7410	7410	10374	9687	4383	9687	2906
4475	2539	4748	2812	7014	7560	7560	10584	9223	5351	9223	2767
3069	3064	2961	2956	6133	5918	6133	8586	6031	6020	6031	1809
3126	2512	3669	3055	5638	6724	6724	9414	6795	5567	6795	2038
3144	2397	3697	2951	5541	6648	6648	9307	6841	5348	6841	2052
3117	2486	3652	3022	5602	6674	6674	9343	6769	5507	6769	2031
3069	3064	2961	2956	6133	5918	6133	8586	6031	6020	6031	1809
3125	2511	3668	3054	5636	6722	6722	9411	6793	5565	6793	2038
3143	2396	3696	2950	5539	6646	6646	9304	6839	5346	6839	2052
3116	2485	3651	3021	5600	6672	6672	9340	6767	5505	6767	2030
3069	3064	2961	2956	6133	5918	6133	8586	6031	6020	6031	1809
4038	2040	4140	2142	6078	6282	6282	8795	8178	4182	8178	2453
4046	1936	4158	2048	5981	6205	6205	8687	8203	3983	8203	2461
4029	2014	4123	2108	6043	6232	6232	8724	8152	4122	8152	2446
3069	3064	2961	2956	6133	5918	6133	8586	6031	6020	6031	1809
4038	2040	4140	2142	6078	6282	6282	8795	8178	4182	8178	2453
4046	1936	4158	2048	5981	6205	6205	8687	8203	3983	8203	2461
4029	2014	4123	2108	6043	6232	6232	8724	8152	4122	8152	2446

Net values	Shear Force (kN)	BM (kN-m)
Longitudinal	7006	10097
Transverse	9254	2679

Sample calculation for Net Bending moment & Shear force

BM	*Longitudinal*	*1052-((5.1-0.8)/2×5.1×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×((5.10-0.80)/2/2)×1*	=	10097 kNm
	Transverse	*=2906-((5.1-3.0)/2×5.1×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×((5.10-3.00)/2/2)×*	=	2679 kNm
SF	*Longitudinal*	*=7894-((5.10-0.80)/2×5.10×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×1.35*	=	7006 kN
	Transverse	*=9687-((5.10-3.00)/2×5.10×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×1.35*	=	9254 kN

** Net BM = BM due to pile reaction - BM due to self weight of pile cap and overburden soil*

10.1.4 Pile Loads for Serviceability Verification (SLS Condition)

Col. No.	1	2	3	4	5	6	7	8	10	11	12	13	14
Load case no.	P (kN)	H_L (kN)	H_T (kN)	M_L (kNm)	M_T (kNm)	P / n	Load due to M_L (P1 TO P4)	Load due to M_T (P1 to P4)	Max. load (kN)	Min. load (kN)	Resultant Hor. load per pile (kN)	BM for pile =H*(Lf)/2 (kN-m)	Remarks
LC 200	9718	-54	170	165	1837	2430	23	255	2708	2151	45	183	Normal
LC 201	9730	-40	222	89	2528	2433	12	351	2796	2069	56	231	
LC 202	11277	28	144	-281	2802	2819	-39	389	3248	2391	37	150	
LC 203	10410	60	261	-463	5350	2603	-64	743	3410	1795	67	274	
LC 204	10848	7	191	-146	3108	2712	-20	432	3164	2260	48	196	
LC 205	9898	-4	284	-77	3051	2475	-11	424	2909	2040	71	291	Wind load Case
LC 206	9918	19	371	-204	4204	2480	-28	584	3092	1867	93	381	
LC 207	11079	70	313	-482	4409	2770	-67	612	3449	2090	80	328	
LC 208	10428	94	400	-618	6320	2607	-86	878	3571	1643	103	421	
LC 209	10756	55	348	-381	4639	2689	-53	644	3386	1992	88	361	
LC 210	9407	27	-2	-327	17	2352	-45	2	2400	2304	7	28	Temperature rise Case
LC 211	10567	78	-60	-605	222	2642	-84	31	2757	2527	25	101	
LC 212	9917	102	27	-741	2133	2479	-103	296	2878	2080	26	108	
LC 213	10245	62	-25	-504	452	2561	-70	63	2694	2429	17	69	
LC 214	9490	-286	-2	1386	14	2372	193	2	2567	2178	72	293	Temperature Fall Case
LC 215	10650	-235	-61	1109	219	2663	154	30	2847	2478	61	249	
LC 216	9999	-211	27	972	2130	2500	135	296	2931	2069	53	218	
LC 217	10328	-251	-25	1210	449	2582	168	62	2812	2352	63	258	
LC 218	9566	-178	-3	777	12	2392	108	2	2501	2282	44	182	Positive Temperature
LC 219	10727	-127	-61	499	217	2682	69	30	2781	2582	35	144	
LC 220	10076	-103	26	363	2128	2519	50	296	2865	2173	26	109	
LC 221	10405	-142	-26	601	447	2601	83	62	2747	2456	36	148	
LC 222	9396	-97	-2	360	18	2349	50	3	2401	2296	24	100	Reverse Temperature
LC 223	10556	-46	-60	82	224	2639	11	31	2681	2597	19	78	
LC 224	9906	-22	28	-54	2135	2476	-8	296	2780	2172	9	36	
LC 225	10234	-62	-25	183	453	2558	25	63	2647	2470	17	68	
LC 226	9428	-51	-2	101	16	2357	14	2	2373	2341	13	53	Quasi-permanent Combinatio
LC 227	9469	-208	-2	958	15	2367	133	2	2502	2232	52	213	
LC 228	9507	-154	-2	653	14	2377	91	2	2469	2284	38	158	
LC 229	9422	-114	-2	445	17	2355	62	2	2420	2291	28	116	

Note: *Weight of pilecap,soil & surcharge load is considered in Column 1 and surcharge moment in Column 5 of above table.*

P1 (kN)	P2 (kN)	P3 (kN)	P4 (kN)	Along transverse direction				Along longitudinal direction			
				P1+P2	P3+P4	Shear Force	B.M	P1+P3	P2+P4	Shear Force	B.M
2708	2197	2662	2151	4905	4813	4905	6867	5369	4349	5369	1611
2796	2094	2771	2069	4890	4840	4890	6846	5567	4163	5567	1670
3170	2391	3248	2469	5561	5717	5717	8003	6417	4860	6417	1925
3281	1795	3410	1924	5077	5334	5334	7467	6691	3719	6691	2007
3123	2260	3164	2301	5383	5464	5464	7650	6287	4560	6287	1886
2888	2040	2909	2062	4928	4971	4971	6959	5797	4102	5797	1739
3035	1867	3092	1924	4902	5016	5016	7022	6127	3791	6127	1838
3315	2090	3449	2224	5405	5673	5673	7942	6764	4314	6764	2029
3399	1643	3571	1815	5042	5386	5386	7540	6970	3458	6970	2091
3281	1992	3386	2098	5272	5484	5484	7677	6667	4090	6667	2000
2309	2304	2400	2395	4613	4794	4794	6712	4708	4699	4708	1412
2589	2527	2757	2695	5116	5452	5452	7632	5345	5222	5345	1604
2673	2080	2878	2286	4753	5164	5164	7230	5551	4366	5551	1665
2554	2429	2694	2569	4983	5263	5263	7368	5248	4997	5248	1574
2567	2563	2182	2178	5130	4360	5130	7182	4749	4741	4749	1425
2847	2786	2539	2478	5633	5017	5633	7886	5386	5264	5386	1616
2931	2339	2661	2069	5270	4730	5270	7378	5592	4408	5592	1677
2812	2688	2476	2352	5500	4828	5500	7700	5289	5039	5289	1587
2501	2498	2285	2282	4999	4567	4999	6999	4786	4780	4786	1436
2781	2721	2643	2582	5502	5225	5502	7703	5424	5303	5424	1627

Rare Combination	Net BM (kN-m)
Maximum Transverse	7296
Maximum Longitudinal	1922

Quasi permanent Combination	Net BM (kN-m)
Maximum Transverse	6996
Maximum Longitudinal	1458

** Net BM = BM due to pile reaction - BM due to self weight of pile cap and overburden soil*

Sample calculation for Net Bending moment

Rare comb.	*Transverse*	=8003-((5.10-0.80)/2×5.10×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×((5.10-0.80)/2/2) =	7296 kNm
	Longitudinal	*=2091-((5.10-3.00)/2×5.10×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×((5.10-3.00)/2/2) =*	1922 kNm
Quasi comb.	*Transverse*	*=6909-((5.10-0.80)/2×5.10×1.8×25+(5.10-0.80)/2×5.10×0.75×20)×((5.10-0.80)/2/2) =*	6996 kNm
	Longitudinal	*=1427-((5.10-3.00)/2×5.10×1.8×25+(5.10-3.00)/2×5.10×0.75×20)×((5.10-3.00)/2/2) =*	1458 kNm

10.2 Design of Pile Cap

10.2.1 Transverse Direction - Design Parameters

10.2.1.1 Design for Maximum Bending Moment about Pier Face

Breadth of the section	b	=	5100	mm	
Depth of the section	D	=	1800	mm	
Effective depth of the section	d	=	1701	mm	
Clear cover		=	75	mm	
Cover to the main reinforcement	c_s	=	100	mm	
Characteristic concrete compression strength	f_{ck}	=	35	MPa	
Characteristic concrete tensile strength	f_{ctm}	=	2.77	MPa	
Characteristic reinforcement yield strength	f_{yk}	=	500	MPa	
Partial safety factor for Concrete	γ_c	=	1.50		
Partial safety factor for steel	γ_s	=	1.15		
Design reinforcement yield strength	f_{yd}	=	434.8	MPa	
Design concrete compression strength	f_{cd}	=	15.63	MPa	
	$R_{lim} = 0.167 f_{ck}$	=	5.85		=0.167×35
	$d_{reqd.} = \text{sqrt}(M/R_{lim}\, b)$ =		582	mm	
					SAFE
For rectangular stress block,					
(for fck till 60MPa)	λ	=	0.8		
	ή	=	1		
(rectangular stress block considered)	β	=	0.4		
=+15.63×0.8×1	f_{av}	=	12.51	MPa	
Maximum Moment in longitunal direction	M	=	**10097**	kNm	
Diameter of bars in 1st layer	ø	=	25	mm	
Number of bars in 1st layer	n_s	=	34		
C/C Spacing of bars in 1st layer	a_s	=	150	mm	
Diameter of stirrups		=	12	mm	
Reinforcement area provided	A_s	=	16690	mm^2	
=(10097×10^6)/(5100×1701×1701×12.51)	K_{av}	=	0.055		
The deg of reinforcement required , w or x/d		=	0.06		
Thus x		=	95	mm	
Lever arm z		=	1662	mm	
check limit to ensure yielding in reinforcement		=	0.62		OK
Reinforcement area required for design moment		=	13969	mm^2	
Minimum area of reinforcement	=		$0.26*f_{ctm}/f_{yk}*b_t*d$		= 12498 mm2
			$< 0.0013*b_t*d$		= 11274 mm2
					OK

Reinforcement at top of pile cap

Minimum area of reinforcement		=	6249	mm^2	
Diameter of bars	ø	=	16	mm	
Number of bars required	n_s	=	34	nos.	
Diameter of bars	ø	=	0	mm	
Number of bars required	n_s	=	0	nos.	
Reinforcement area provided	A_s	=	6836	mm^2	
					OK

10.2.1.2 Check for Shear (Cl 10.3.2, IRC 112)

Width of section	b	=	5100	mm
Main reinforcement area	A_{st}	=	16690	mm^2
Diameter of stirrup	f_{st}	=	12	mm
Number of stirrup legs in width of section	n_{st}	=	15	nos.
Longitudinal spacing of stirrups	s	=	300	mm
c/s area of one leg		=	113	mm^2
Total reinforcement area of stirrups in section	A_{sw}	=	1696	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Design Shear force	V_{ED}	=	7006	kN
distance from applied load to edge of support	α_v	=	1400	mm
Reduction factor	β	=	α_v/2d	
	β	=	0.41	=1400/(2×1701)
Shear force for checking shear resistance of section	β*V_{ED}	=	2884	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33}+0.15\sigma_{cp}b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.34	
Main reinforcement ratio	ρ_1	=	0.0019	
	σ_{cp}	=	0	
=0.031×(1.34^1.5)×35^0.5	V_{min}	=	0.29	
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	2475 kN	
			Shear reinforcement required	
Max. Shear Capacity of section with Shear Reinf. $V_{Rd,Max}$ (Limited to crushing of concrete)	$V_{Rd,Max}$	=	$\alpha_{cw}*b_w*z*V1*$ fcd/(cotΘ+tanΘ)	
Calculation of Θ:				
	cotΘ+tanΘ	=	$\alpha_{cw}*b_w*z*V_1*$ f_{cd} / V_{ED}	
		=	9.271	
since 1.0<cotΘ<=2.5, governing design	cotΘ	=	2.50	
	Θ	=	21.80	°
	α_{cw}	=	1	
	V_1	=	0.53	
lever arm	z	=	1530	mm
	$V_{Rd,Max}$	=	22396	kN
Max. Shear Capacity of section with Shear Reinf. (Limited to yielding of Reinf.)	$V_{Rd,s}$	=	$(A_{sw}*z*f_{ywd}*$ cotΘ)/S	
	$V_{Rd,s}$	=	9407	kN
Shear Resistance of the Section (min. of $V_{Rd,s}$&$V_{Rd,max}$)		=	9407	kN
				SAFE

Check for min. Shear Reinforcement

Shear reinforcement ratio provided	ρ_w	=	0.0011	
Min. Shear reinforcement ratio required	ρ_{min}	=	0.0009	

Check for max. Shear Reinforcement

	$\frac{A_{sw}*f_{ywd}}{b_w * s}$	< =	0.5 * $\alpha_{cw}*v_1*$ f_{cd}	
	0.48	< =	4.16	
				SAFE
Max. longitudinal spacing of vertical stirrups	$s_{l,max}$	=	0.75d	
		=	1275 mm	
				SAFE
Max. transverse spacing of legs	$s_{l,max}$	=	0.75d(or)	< 600mm
		=	1275 mm	SAFE

10.2.2 Longitudinal Direction - Design Parameters

10.2.2.1 Design for Maximum Bending Moment about Pier Face

Breadth of the section	b	=	5100	mm

Depth of section	D	=	1800	mm	
Effective depth of the section	d	=	1676	mm	
Clear Cover		=	75	mm	
Cover to the main reinforcement	c_s	=	125	mm	
Characteristic concrete compression strength	f_{ck}	=	35	MPa	
Characteristic concrete tensile strength	f_{ctm}	=	2.77	MPa	
Characteristic reinforcement yield strength	f_{yk}	=	500	MPa	
Partial safety factor for Concrete	γ_c	=	1.5		
Partial safety factor for steel	γ_s	=	1.15		
Design reinforcement yield strength	f_{yd}	=	435	MPa	
Design concrete compression strength	f_{cd}	=	15.63	MPa	
	$R_{lim} = 0.167 f_{ck}$	=	5.85		
	$d_{reqd.} = \text{sqrt}(M/R_{lim}\, b)$ =		300	mm	
					SAFE
For rectangular sress block,					
(for fck till 60MPa)	λ	=	0.8		
	ή	=	1		
(rectangular stress block considered)	β	=	0.4		
=+15.63×0.8×1	f_{av}	=	12.51	MPa	
Maximum Moment about Section BB	M	=	**2679**	KNm	
Diameter of bars in 1st layer	ø	=	25	mm	
Number of bars in 1st layer	n_s	=	34		
C/C Spacing of bars in 1st layer	a_s	=	150	mm	
Diameter of bars in 2nd layer	ø	=	0		
Number of bars in 2nd layer	n_s	=	34		
C/C Spacing of bars in 2nd layer	a_s	=	0		
Diameter of stirrups		=	12	mm	
Reinforcement area provided	A_s	=	16690	mm^2	
Kav considering fav		=	0.015		
The deg of reinforcement required , ω or x/d		=	0.015		
x		=	25	mm	
Lever arm	z	=	1665	mm^2	
Check limit to ensure yielding in reinforcement		=	0.62		OK
Reinforcement area required for design moment		=	3699	mm^2	
Minimum area of reinforcement	=		$0.26*f_{ctm}/f_{yk}*b_t*d$		= 12314 mm2
			(or) $0.0013*b_t*d$		= 11109 mm2
					OK
Reinforcement at top of pile cap					
Minimum area of reinforcement		=	6157	mm^2	
Diameter of bars	ø	=	16	mm	
Number of bars required	n_s	=	34	nos.	
Diameter of bars	ø	=	0	mm	
Number of bars required	n_s	=	0	nos.	
Reinforcement area provided	A_s	=	6836	mm^2	
					OK

10.2.2.2 Check for Shear (Cl 10.3.2, IRC 112)

Width of section	b	=	5100	mm
Main reinforcement area	A_{st}	=	16690	mm^2
Characteristic Yield Strength of Stirrup	f_{ywk}	=	500	MPa
Design Yield Strength of Stirrup	f_{ywd}	=	435	MPa
Design Shear force	V_{ED}	=	9254	kN
distance from P1/P5 pile to support	α_v	=	300	mm
Reduction factor	β	=	α_v/2d	
	β	=	0.09	
Shear force for checking shear resistance of section	β*V_{ED}	=	828	kN
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	$(0.12K(80\rho_1.f_{ck})^{0.33} + .15\sigma_{cp})b_w.d$	
	$V_{Rd,c}$	≥	$(V_{min}+0.15\sigma_{cp})b_w.d$	
	k	=	1.35	
Main reinforcement ratio	ρ_1	=	0.0020	
	σ_{cp}	=	0	
=0.031×(1.35^1.5)×35^0.5	V_{min}	=	0.29	
Shear Capacity of section without Shear Reinf. $V_{Rd,c}$		=	2446	kN

Shear reinforcement is not required

Max. Shear Capacity of section with Shear Reinf. $V_{Rd,Max}$ (Limited to crushing of concrete)	$V_{Rd,Max}$	=	$\alpha_{cw}*b_w*z*V1*$ fcd/(cotΘ+tanΘ)	
Calculation of Θ:				
	cotΘ+tanΘ	=	$\alpha_{cw}*b_w*z*V_1*$ f_{cd} / V_{ED}	
=1×5100×1508×0.53×15.63/(828×1000)		=	6.92	
since 1.0<cotΘ<=2.5, for governing design	cotΘ	=	2.50	
	Θ	=	21.80	°
	α_{cw}	=	1	
=0.6×(1-35/310)	V_1	=	0.53	
lever arm	z	=	1508	mm
=(1×5100×1508×0.53×15.63)/(2.5+1/2.5)/1000	$V_{Rd,Max}$	=	22066	kN

Surface Reinforcement (as per clause 16.5.4 of IRC 112-2011)

Area of cover portion outside the stirrups/links	=	75000	mm^2/m
Area of surface reinforcement required, 0.01*$A_{ct,ext}$	=	750	mm^2/m
Provide 12mm dia bar @ 150mm spacing for side reinforcement			
Therefore area of reinforcement provided	=	754	mm^2/m

SAFE

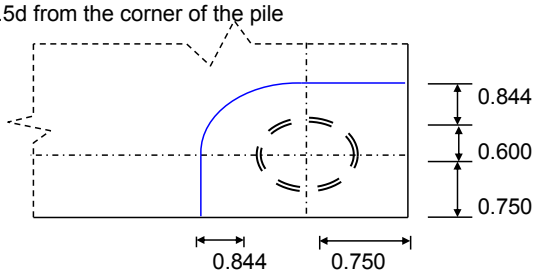
10.2.3 Check for Punching Shear (Cl 10.4.5 of IRC:112-2011)

10.2.3.1 For Pile :

At "0.5d" from face of loaded area:

Characteristic concrete compression strength	f_{ck}	=	35	MPa
Effective depth of pilecap in long. direction,	d_1	=	1701	mm
Effective depth of pilecap in trans. direction,	d_2	=	1676	mm
Effective depth	d	=	1688	mm
Diameter of Pile	φ	=	1200	mm
Edge distance from pile		=	750	mm
Distance from pile face to control perimeter considered	a	=	844	mm

The critical section is at a distance 0.5d from the corner of the pile



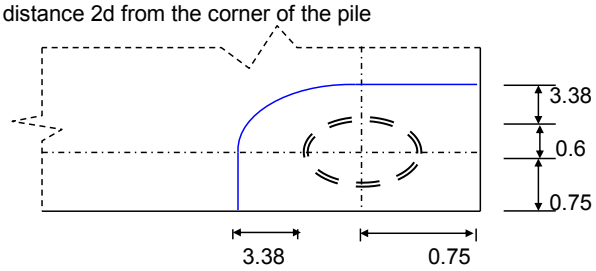
Perimeter (Length around the corner pile)	u_1	=	3768	mm
Punching Area	A	=	6.4	m^2
Punching Shear force	V_{Ed}	=	5031	kN
Counteracting shear force	ΔV_{Ed}	=	0	kN
	K	=	1.34	
	ρ_l	=	0.0019	
Net Punching shear	$V_{ed.red}$	=	5031	kN
Punching shear stress	$vE_{d.red}$	=	0.79	N/mm²
Punching Shear Resistance	V_{Rd}	=	1.1340	N/mm²
	v_{min}	=	0.29	N/mm²
Punching Shear Resistance	V_{Rd}	=	1.1340	N/mm²

SAFE

At distance "2d" from face of loaded area:

Characteristic concrete compression strength	f_{ck}	=	35	MPa
Since it is a pile at the corner of the pilecap,				
Effective depth of pilecap in long. direction,	d_1	=	1701	mm
Effective depth of pilecap in trans. direction,	d_2	=	1676	mm
Effective depth	d	=	1688	mm
Diameter of Pile	φ	=	1200	mm
Pilecap Edge distance from pile center		=	750	mm
Distance from pile face to control perimeter considered	a	=	3376	mm

The critical section is at a distance 2d from the corner of the pile



Perimeter (Length around the corner pile)	u_1	=	7745	mm
Punching Area	A	=	13.1	m^2
Punching Shear force	V_{Ed}	=	5031	kN
Counteracting shear force	ΔV_{Ed}	=	2759	kN
	K	=	1.34	
	ρ_l	=	0.0019	
Net Punching shear	$V_{ed.red}$	=	2272	kN
Punching shear stress	$vE_{d.red}$	=	0.17	N/mm²
Punching Shear Resistance	V_{Rd}	=	0.28	N/mm²
	v_{min}	=	0.29	N/mm²
Punching Shear Resistance	V_{Rd}	=	0.29	N/mm²

SAFE

10.3 Calculation of Pilecap Crack Width

Clear cover to reinforcement c = 75 mm

Long term Modular ratio m = E_s / (0.5 * E_c)
= 12.50

Characteristic compressive strength of concre f_{ck} = 35 N/mm^2

Check for stresses at various sections:

Section	Unit	Transverse Direction	Longitudinal Direction
Depth of Pilecap		1800	1800
Width of the flange, b	mm	5100	5100
Maximum diameter of bar (ϕ)	mm	25	25
CG of section from Top,Y_t	mm	900	900
CG of section from bottom,Y_b	mm	900	900
Area of Steel Provided, A_{st}	mm^2	16690	16690
Effective Depth, d	mm	1701	1676
Distance of N.A. from top, X_u = (0.87*fy*Ast)/(0.36*fck*b)	mm	113	113
f_{ctm} (IRC:112-2011, A2-2)	Mpa	2.77	2.77
Service Moment (Rare Combination)	kN m	7296	1922
Service Moment (Quasi-perm. Combination)	kN m	6996	1458

Properties of Gross Section	Unit	Longitudinal Direction	Transverse Direction
Gross Area, A_{gr}	mm^2	9.18E+06	9.18E+06
Gross Moment of Inertia, I_{gr}	mm^4	2.48E+12	2.48E+12

Properties of Uncracked Section

$$Y_{tT} = \frac{(b * D * D/2) + ((m - 1) * A_{st} * d)}{(b * D) + ((m - 1) * A_{st})}$$

$$Y_{bT} = D - Y_{tT}$$

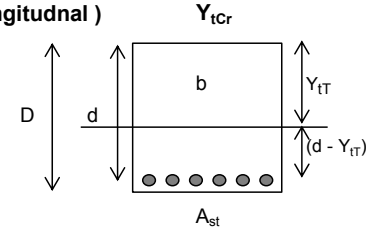
$$Y_{sT} = d - Y_{tT}$$

$$I_T = (b * D^3/12 + b * D * (D/2 - Y_{tT})^2) + ((m - 1) * A_{st} * (d - Y_{tT})^2)$$

Properties of Uncracked Transformed Section	Unit	Transverse Direction	Longitudinal Direction
CG of Uncracked section from Top,Y_{tT}	mm	916	916
CG of Uncracked section from bottom,Y_{bT}	mm	884	884
CG of Uncracked section from steel,Y_{sT}	mm	784	760
Uncracked Moment of Inertia, I_T	mm^4	2.60E+12	2.59E+12

Properties of Cracked Section

Calculation of C.G. of Cracked Transformed section from Top (Longitudnal)



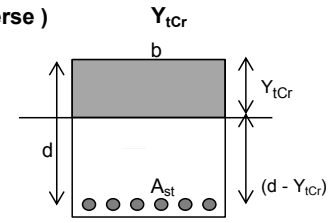
b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})

5100 * Y^2_{tCr} / 2 = 12.50 * 16690 * (1701 - YtCr)

2550 Y^2_{tCr} 2.09E+05 Y_{tCr} - 3.55E+08 =

Y_{tCr} = 334

Calculation of C.G. of Cracked Transformed section from Top (Transverse)



$b * Y^2_{tCr} / 2 = m * A_{st} * (d - Y_{tCr})$

$5100 * Y^2_{tCr} / 2 = 12.50 * 16690 * (1676 - YtCr)$

$2550\ Y^2_{tCr} + 2.09E+05\ Y_{tCr} - 3.50E+08 = 0$

$Y_{tCr} = 332$ mm

Properties of Cracked Transformed Section	Unit	Transverse Direction	Longitudinal Direction
CG of Cracked section from Top, Y_{tCr}	mm	334	332
CG of Cracked section from bottom, Y_{bCr}	mm	1466	1468
CG of Cracked section from steel, Y_{sCr}	mm	1366	1344
Cracked Moment of Inertia, I_{cr}	mm^4	4.53E+11	4.39E+11

Stresses under Rare Combination	Unit	Transverse Direction	Longitudinal Direction
Comp stress in concrete, fc = (M / I)* Y_t	Mpa	2.57	0.68
Comp stress in concrete (limit to 0.48f_{ck})		SAFE	SAFE
Tensile stress in conc. at steel level, fct_{steel} = (M / I)* Y_s	Mpa	2.20	0.56
Tensile stress in steel, fst = m * fct_{steel}	Mpa	27.51	7.04
Tensile stress in steel (limit to 0.8 f_{yk})	Mpa	SAFE	SAFE

Stresses under Quasi-permanent Combination	Unit	Longitudinal Direction	Transverse Direction
Cracking Moment, $M_{cr} = I_{gr} * f_{ctm} / Y_b$	kN m	7632	7632
State of Section		Uncracked	Uncracked
Comp stress in concrete, fc = (M / I_T)* Y_{tT}	Mpa	2.47	0.52
Comp stress check (limit to 0.36 f_{ck})		Linear Creep	Linear Creep
Tensile stress in conc. at steel level, fct_{steel} = (M / I_T)* Y_{st}	Mpa	2.11	0.43
Tensile stress in concrete (limit to f_{ctm})		Uncracked	Uncracked
Tensile stress in steel, fst = m * fct_{steel}	Mpa	26.38	5.34

10.3.1 Calculation of Crack Width (Transverse Direction)

$W_k = S_{r\,max} (\varepsilon_{sm} - \varepsilon_{cm})$ (IRC:112-2011, Cl 12.3.4)

Where,

W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing (IRC:112-2011, Eq. 12.8, 12.11 or 12.12)

$S_{r\,max} = 3.4c + (0.425 * k_1 * k_2 * \phi / r_{p,eff})$

ϕ = Diameter of Main steel

c = Clear cover to lonfitudnal reinforcement

c = 75 mm

k_1 = 0.8 for deformed bars

k_2 = 0.5 for bending

ϕ = 25 mm

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\ \sigma_{sc} / E_s$

Where, σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)
= (D - x)/ 3
= D / 2

k_t = Factor dependent on duration of load

	$h_{c,eff}$	=	249	mm
	$A_{c,eff}$	=	1268625	mm^2
	$\rho_{p,eff}$	=	0.01316	
	k_t	=	0.5	
	σ_{sc}	=	26	N / mm^2
	$f_{ct,eff}$	=	2.77	N / mm^2
Modulus of elasticity of steel	E_s	=	200000	MPa
	α_e	=	12.50	
	$\varepsilon_{sm} - \varepsilon_{cm}$	=	0.0001	
	$S_{r\,max}$	=	578.1	mm
	W_k	=	0.046 mm	< 0.30 mm SAFE

(IRC:112-2011, Table 12.1)

10.3.2 Calculation of Crack Width (Longitudinal Direction)

W_k = $S_{r\,max} (\varepsilon_{sm} - \varepsilon_{cm})$ (IRC:112-2011, Cl 12.3.4)

Where,

W_k = Crack width

$S_{r\,max}$ = Maximum crack spacing (IRC:112-2011, Eq. 12.8, 12.11 or 12.12)

$S_{r\,max}$ = $3.4c + (0.425 * k_1 * k_2 * \phi / r_{p,eff})$

ϕ = Diameter of Main steel

c = Clear cover to lonfitudnal reinforcement

c	=	75	mm
k_1	=	0.8	for deformed bars
k_2	=	0.5	for bending
ϕ	=	25	mm

ε_{sm} = Mean strain in the reinforcement

ε_{cm} = Mean strain in the concrete between cracks

Now, $\varepsilon_{sm} - \varepsilon_{cm} = \dfrac{\sigma_{sc} - (k_t * f_{ct,eff} / \rho_{p,eff}) (1 + \alpha_e * \rho_{p,eff})}{E_s}$ >= $0.6\ \sigma_{sc} / E_s$

Where, σ_{sc} = Stress in the tension reinforcement assuming a cracked section

α_e = E_s / E_{cm}

$\rho_{p,eff}$ = $A_s / A_{c,eff}$

$A_{c,eff}$ = Effective area of concrete in tension surrounding the reinforcement = $b_w * h_{c,eff}$

$h_{c,eff}$ is the lesser of = 2.5 (D - d)
= (D - x)/ 3
= D / 2

k_t = Factor dependent on duration of load

	$h_{c,eff}$	=	311	mm		
	$A_{c,eff}$	=	1587375	mm^2		
	$\rho_{p,eff}$	=	0.01051			
	k_t	=	0.5			
	σ_{sc}	=	5	N / mm^2		
	$f_{ct,eff}$	=	2.77	N / mm^2		
Modulus of elasticity of steel	E_s	=	200000	MPa		
	α_e	=	12.50			
	$\varepsilon_{sm} - \varepsilon_{cm}$	=	0.0000			
	$S_{r\,max}$	=	659.2	mm		
	W_k	=	0.011	mm	< 0.30 mm	SAFE

(IRC:112-2011, Table 12.1)

10.4 Design of Pile

10.4.1 Input Data

Diameter of the pile	D	=	1200	mm
Characteristic compressive strength of concrete	f_{ck}	=	35	MPa
Characteristic yield strength of steel	f_{yk}	=	500	Mpa
Partial factor for Reinforcement (IRC:112-2011,cl.no.6.2.2)	γ_s	=	1.15	
Design Yield Strength of Reinforcement	f_{yd}	=	435	MPa
Characteristic yield strength of stirrups	f_{ywk}	=	500	N/mm^2
Modulus of elasticity for concrete	E_{cm}	=	3.2E+04	MN/m^2
Clear cover	c	=	75	mm
Gross cross section area of concrete	A_C	=	1130973	mm^2

10.4.2 Check for Axial and Flexure Capacities

Provide Diameter of londitudinal bar		=	20	+	0	mm
Number of longitudinal bars		=	21	+	0	no.
Diameter of lateral ties		=	10	mm		
Spacing of lateral ties provided		=	150	mm		
Effective cover	d'	=	95	mm		
Effective depth of Pile	d_{eff}	=	1105	mm		
Area of reinforcement provided	$A_{st\ provd}$	=	6597	mm^2		
Minimum area of reinforcement required	A_{stmin}	=	0.4% of A_G			
[IRC:78-2014]			4524	mm^2	OK	
Percentage of steel provided	pt %	=	0.58			
Effective cover to Depth Ratio	d' / D	=	0.079			

The pile is checked for maximum BM with corresponding maximum and minimum axial load. The maximum axial capacity of pile is calculated as per IRC112:2011, cl. No. 8.3.2 (4) and flexural capacities are calculated from the interaction diagram as per SP:16.

Maximum compression capacity of pile $P_{uz} = A_c * f_{cd} + A_y * f_{yd}$

[IRC 112:2011, cl.no. 8.3.2 (4)]

where,	A_c	=	1130973	mm^2
	f_{cd}	=	15.6	N/mm^2
	A_y	=	6597	mm^2
	f_{yd}	=	435	N/mm^2

P_{uz} = 20549 kN

Maximum BM and corresponding Minimum Axial Load Case

Maximum Bending moment on Pile	M_{max}	=	711 kN m
Corresponding minimum Vertical load on Pile	P_{min}	=	1936 kN

For, p / f_{ck} = 0.017 Mu/fck.D^3 = 0.035

$P / f_{ck} D^2$ = 0.0384 (From SP 16)

.`. Mu = 2117 kN m

(M / Mu)^2 = **0.11** SAFE

Maximum BM and corresponding Maximum Axial Load Case

Maximum Bending moment on Pile	M_{max}	=	711	kN m
Corresponding maximum Vertical load on Pile	P_{max}	=	4158	kN

For, p/fck = 0.017 Mu/fck.D^3 = 0.045
P/fckD^2 = 0.082 (From SP 16)

.`. Mu = 2722 kN m
(M / Mu)^2 = **0.07** SAFE

10.4.3 Check for Shear Capacity

(IRC:112-2011, cl.no.10.3.2(2))

Effective depth d_{eff} = 968 mm
Width b = 600 mm

Design shear force,

V_{Ed} = 173 kN
V_{ccd} = 0 kN For Uniform cross section
V_{td} = 0 kN For Uniform cross section
$V_{Rd\,s}$ = V_{NS} = $V_{ed} - V_{ccd} - V_{td}$
= 173 kN

Maximum Allowabe Shear Force (for maximum shear force take Θ = 45 ^{0})

$V_{Rd.max} = \alpha_{cw} \times b_w \times z \times v_1 \times (f_{cd}/(\cot\Theta+\tan\Theta))$ (IRC:112-2011, cl 10.3.3.2, Eq10.8)

where,

αcw = 1.00
z = lever arm = 0.90 (For RCC)

v_1 is the strength reduction factor for concrete cracked in shear

v_1 = 0.53 (IRC:112-2011, Eq10.6)
Θ = 45.00 (CotΘ = 1)

f_{cd} is the design value of concrete compression strength = $\alpha_{cc} \times fck / \gamma_m$ (IRC:112-2011,cl. no. 10.3.1)

α_{cc} = 0.67 (Refer IRC:112-2011, Pg.87)
γ_m = 1.50 (Partial factors for concrete for ULS)
f_{cd} = 15.6 N/mm^2

$V_{Rd.max}$ = 2176 kN Section is Safe

Allowable Shear Force without Shear Reinforcement

$V_{Rd\,c} = (0.12 \times K (80 \times \rho_1 \times f_{ck})^{0.33} + 0.15 \times \sigma_{cp}) b_w \times d$ (IRC:112-2011, cl 10.3.2(2))

But, $V_{Rd.c\,min} = (v_{min} + 0.15 \times \sigma_{cp}) b_w \times d$

where,
K = 1+sqrt(200/d) <=2, where d is the depth in mm.
$V_{Rd\,c}$ = The design shear resistance of the member without shear reinforcement.
v_{min} = 0.031 x K^3/2 x fck^1/2
σ_{cp} = Concrete compressive stress at centroidal axis due to axial load or prestress.
ρ_1 = Reinforcement ratio for longitudinal reinforcement , = $A_{st} / (b_w \times d)$ <=0.02

K = 1.45
ρ_1 = 0.006
N_{ED} = 950
σ_{cp} = 3.13
$V_{Rd\,c\,min}$ = 894 kN
$V_{Rd\,c}$ = 770 N

Shear reinforcement need not be provided

10.5 Crack width check for Pile:

Parameters for the section

Area of concrete effective in tension			$A_{c,eff}$	=	565488	mm^2
Characteristic concrete compression strength			f_{ck}	=	35	MPa
Effective concrete tensile stress			$f_{ct,eff}$	=	2.77	MPa
Modulus of elasticity of steel			E_s	=	200000	MPa
Short term modulus of elasticity of concrete			E_{cm}	=	32000	MPa
			α_e	=	6.25	
0.8 for deformed bars, 1.6 for plain surface bars			K_1	=	0.8	
0.5 for bending, 1.0 for pure tension, K_2 for eccentric tension K2 =(ε1+ε1)/2ε1			K_2	=	0.5	
			K_3	=	3.4	
			K_4	=	0.425	
Clear cover			c_{s1}	=	75	mm

			Layer1	Layer 2			
Diameter of reinforcement *(layer 1,2)*	$ø_1$	=	20	0			
Number of bars in the tension area of the section	n_{s1}	=	21	0			
Reinforcement area	A_{s1}	=	6597	A_{s2}	=	0	mm^2
Total area of reinforcing steel				A_s	=	6597	mm^2

Design criterias

Maximum allowable compression stress in concrete for rare combination	=	16.8	MPa	
Maximum allowable compression stress in concrete for quasi combination	=	12.6	MPa	
Maximum allowable crack width	=	0.30	mm	

Forces & Stresses in section FOR RARE COMBINATION:

Max Axial load in Pile	=	3571	kN	
Min Axial load in Pile	=	1643	kN	
Max B.M in Pile	=	421	kNm	
Tensile stress in rebar	σ_s =	83.75	MPa	
Compressive stress in concrete	σ_c =	11.37	MPa	SAFE

Forces & Stresses in section FOR QUASI COMBINATION

Max Axial load in Pile	=	2501	kN	
Min Axial load in Pile	=	2282	kN	
Max B.M in Pile	=	182	kNm	
Tensile stress in rebar	σ_s =	0.00	MPa	
Compressive stress in concrete	σ_c =	2.70	MPa	SAFE

* Stresses in concrete and rebar are calcluated using in-house developed sofware.

Results

Equivalent diameter of reinforcement	$ø_{eq}$	=	20	mm	
Effective reinforcement ratio	$r_{p,eff} = A_s / A_{c,eff}$	=	0.012		
	K_t	=	0.500		
	e_{sm-ecm}	=	0.00000		
	$S_{r,max}$	=	546		
The crack width is within the permissible limit	Wk	=	0.000	mm	SAFE

PART-II

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

Client:	**Roads and Bridges Development Corporation of Kerala Limited (RBDCK)** (A Government of Kerala Undertaking)		
Project:	Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches in the state of Kerala	**Project No.:** C1193601	
Title:	Detailed Project Report (Volume-II Design Report)	**Document No.:** RP010	**Rev.:** 0

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Notes:

1.

Revision Details:

Rev.	Date	Details	Prepared Init.	Prepared Sign.	Checked Init.	Checked Sign.	Approved Init.	Approved Sign.
0	11/03/2020	First Submission	HMS		NCB		KGN	

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1 Introduction

Roads and Bridges Development Corporation of Kerala Limited (RBDCK) (the "Client/Authority") has been entrusted with the assignment of ***'Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala'.*** In this context, the Client has appointed **L&T Infrastructure Engineering (L&TIEL) (the "Consultant")** for carrying out Feasibility Study, to establish the technical, economic and financial viability of the aforesaid project and to prepare Detailed Project Report.

This report pertains to the "Feasibility Study", wherein the various aspects of the project like Alignment options, traffic analysis, alignment plan, typical cross sections, Preliminary environmental and social assessments, Land acquisition/resettlement plans, cost estimates & Economical/Financial analysis are discussed in detail and accordingly conclusions and recommendations are made for the feasibility of the aforesaid project.

1.1 Project Description

The Project Starts at the Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) and ends at Padinjarekara beach. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock.

The project is a part of Coastal Highway and the proposed alignment will be linking the two points; on southern side the Ponnani Junction (NH66 Bypass) and Northern side Padinjarekara- Kuttayi Road. At present the two sides of the river is connected by Jenkar services in the day time. The road connectivity between the two banks is via Chamravattam Bridge which takes around 20Km. Hence the proposed Bridge will be the life line of the Ponnani Beach and its surrounding area. This road will act as a parallel road to NH 66 and reduces the travelling distance from Ernakulum to Kozhikode around 30 Km.

Table 1-1: Salient Features of Project Corridor

Salient Features	Description
Length of Project Road (Km)	4.8 Km (Project starts from Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) and follows the existing PWD road up to Ponnani Harbour afterwards crossing the Bharathupuzha River through a cable stayed bridge meeting at the government tourist park location and ends at PWD road at the distance of 700 m from the situated park.
Terrain	Plain
Right of way (m)	Existing Right of Way – 7m to 11m varies
Existing Road Configuration	Intermediate to Two lane

Salient Features	Description
Existing Road width (in m)	4.5 m to 10.5 m
Existing Pavement Type	Flexible pavement
Existing Railway Level Crossing (Nos.)	Nil
Land Use	Port area and Encroachments / Settlements near bank of Bharathupuzha River. Built up Area (Ponnani junction to Harbor)
Level Crossing	Nil
MRTS / CMRL Lines	Nil

Finalised corridor – This option starts from Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) which follows the existing PWD road up to the cross junction of Ponnani main road and then turns towards the ferry terminal, afterwards follows the proposed structure and crossing the Bharathupuzha River through an Iconic bridge of 200 m obligatory span and then parallel path to existing road up to proposed km 4.50 and then merge with existing PWD road. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock.

The total length of alignment is **4.8 km** in which about **2.75 km** passes through existing PWD road.

Table 1-2: Sections of finalised corridor

Sl.No	Section	Chainage
1	Ponnani Junction – Ponnani Court	(0/000 Km – 2/750 Km)
2	Structure portion	(2/750 Km – 4/800 Km)

It can be noted that Ponnani junction – before structure starts section has a length of 2.75 km which is about 50% of the total length of alignment.

.

Figure 1-1: Project Map

2 Review of Salient Features and Facilities on Existing Road

Table 2-1: Details of Existing Structures

S. No	Type of structure	Numbers
1	Major Bridges	Nil
2	Railway Over Bridges	Nil
3	Minor Bridges	Nil
4	Railway Level Crossings	Nil
5	Vehicular and Non-Vehicular Underpasses	Nil

Table 2-2 : Details of Existing Project Facilities

Sl No	Items	Numbers
1	Major Junctions	Nil
2	Bus Shelters	Nil

3 Overview of Proposed Design Standards

As per IRC: SP:73-2018 “Manual of Specifications & Standards for Two laning of Highways with Paved Shoulder” clause 1.4 to 1.10, IRC SP 48: Hill Road Manual, the Codes, Standards and Technical Specifications applicable for the design and construction of project components are:

- Indian Roads Congress (IRC) Codes and Standards shall invariably be followed.
- Specifications for Road and Bridge Works issued by the Ministry of Road Transport & Highways (MORTH) hereinafter referred to as MORTH or Ministry’s Specifications.
- New Techniques for Road Building
- Pavement Design for Reconstruction / New Construction/ Widening Portion
- Design of Traffic Control and Safety Devices

4 Road Design

4.1 Design Controls

4.1.1 Terrain Classification

The Project section primarily of Plain terrain**.** The Project section passes through settlements and Port area.

4.1.2 Design Speed

Ruling design speed will be the guiding criteria for correlating the various design features as far as possible. However, minimum design speed will be adopted in constrained sections.

The design speed shall be the minimum design speed of 40 to 65 kmph

4.1.3 Typical Cross Section

Two options of TCS have been proposed to this project. The proposed approach road cross section is followed as per the guidelines given for Coastal Highway in KIIFB manual is adopted.

Table 4-1: Typical cross section

SI.NO	TCS type	Location	Width (m)		
			Carriageway	Paved Shoulder	Footpath cum drain
1	TCS-2	Chainage 0.000 to 2.750	7	1.5	1.8

2	TCS-1	Chainage 4.660 to 4.800	7	1.5	1.8

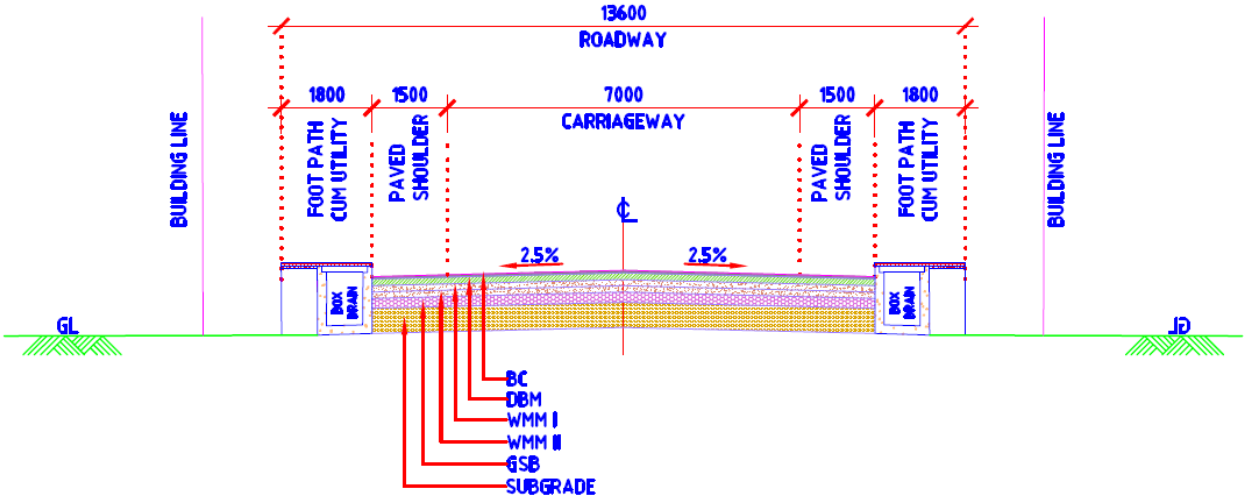

Figure 4-1: Typical cross section for New Construction (TCS-1)

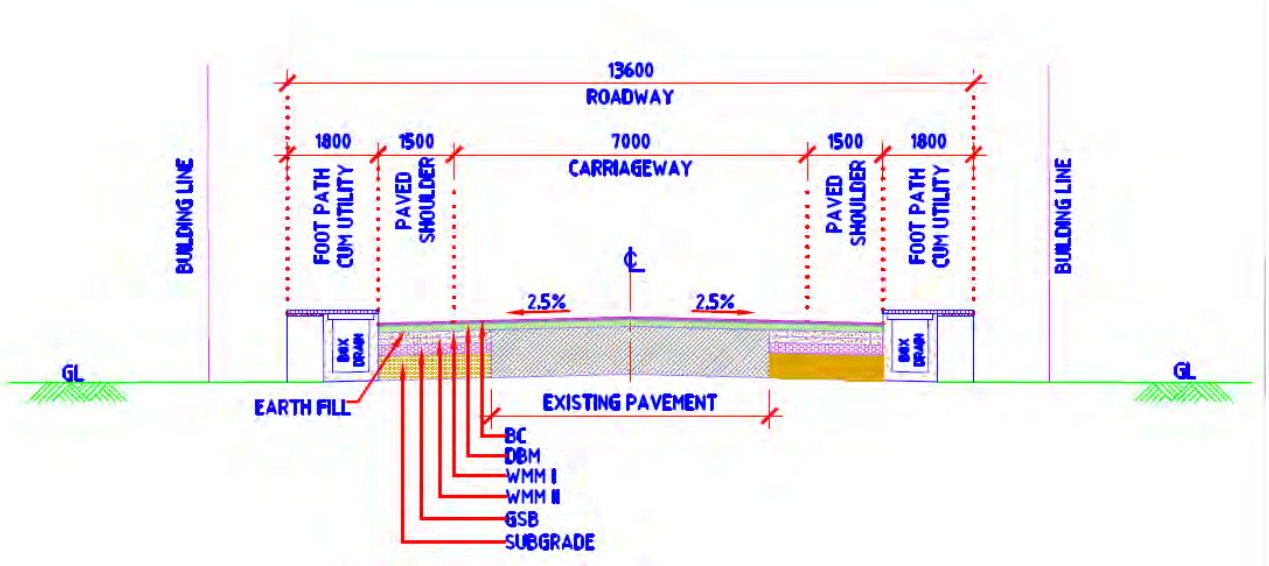

Figure 4-2: Typical cross section for widening of existing road (TCS-2)

4.2 Horizontal Alignment

General principles followed for designing the horizontal alignment are:

i) Alignment shall be designed in line with the Existing alignment and best fitted within the available ROW.

ii) All horizontal curves requiring super elevation shall consist of circular portion flanked by spiral transitions at both ends.

iii) Reverse curves may be needed in difficult terrain. Sufficient length between two curves shall be provided for introduction of requisite transition curves and required super elevation.

iv) The curves in the same direction separated by short tangents known as broken back curves shall be avoided to the extent possible within the available ROW.

v) Radius of Horizontal Curves:

The radius of horizontal curves shall not be less than ruling minimum values as given in Table-2.5 of IRC: SP: 73-2018 for the specified design speed. Wherever possible higher radii shall be adopted, subject to the availability of PROW

vi) Transition Curves:

As per IRC 73:1980, the length of transition curves will be the maximum value of the following three cases,

Case I: Length calculated as per "Rate of Centrifugal Acceleration", $L=(0.0215V^3)/CR$

Case II: Length Calculated as per "rate of Change of Super elevation", L= Super elevation (%)/100*150*Width of the carriageway.

Case III: As per Table - 17 of IRC 73-1980.

4.3 Cross Slope

Camber

Camber/Unidirectional cross fall shall be provided for each carriageway including paved shoulders in accordance with IRC: SP: 73-2018. The cross-fall for earthen shoulder shall be minimum 0.5% steeper than that of the carriageway. However a minimum of 3% is to be provided in normal sections. The camber details are shown in **Table 4-2**.

Table 4-2 Camber Details

	Description	Camber
1	Carriageway including paved shoulder – Flexible pavement	2.5%
2	Earthen shoulder	3.0%

Super elevation

Super Elevation shall be provided on curves in accordance with IRC 73: 1980. It should be noted that the super elevation should be given up to a certain radius as presented in Table 15 of IRC 73: 1980 as mentioned in **Table 4-3**.

Table 4-3 Radius beyond which super elevation is not required

Camber (%)	Radius (m)	Speed (km/hr)
2.5	750	65
2.5	300	40

On super elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse cross fall of 0.5%.

4.4 Sight Distance

The Intermediate sight distance is the clear distance ahead needed by the driver to bring his vehicle to a stop before meeting a stationary object in his path. These distances are based on perception time and brake reaction times are shown in the **Table 4-4**. The desirable Intermediate sight distance (ISD) is twice of the safe stopping sight distance.

In the design, Intermediate sight distance as shown in **Table 4-4** will be ensured all along the project road.

Intermediate Sight Distance is adopted for the entire length of the corridor to possible extent.

Table 4-4 Sight Distance for Design Speeds

Design Speed (km/h)	Intermediate Sight Distance (m)
65	180
40	90

Source: Table – 2.6 of IRC SP: 73- 2018

For Valley curves, the design is governed by night visibility which is considered in terms of Headlight Sight Distance. It is the distance ahead of the vehicle illuminated by the head light which is within the view of the driver. The headlight sight distance shall be at least equal to the safe stopping sight distance.

4.5 Vertical Alignment

General principles followed for designing the vertical alignment are:

i) The vertical alignment shall be designed as per IRC SP 23: 1993 and IRC 73:1980

ii) Gradients up to the value corresponding to ruling gradient shall be provided in accordance with IRC: SP: 73-2018.

iii) Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile. Desirably, there should be no change in grade within a distance of 150m in case of new carriageway and bypass.

iv) The aspect of efficient drainage shall be taken into consideration while designing vertical profile and cross sections of the highway in accordance with IRC SP 42: 2014 and IRC SP 50: 2013.

v) There shall be coordination between horizontal alignment and vertical profile of the project highway and guidelines in accordance with IRC 73: 1980.

vi) The level of minor bridge shall be worked out with respect to High Flood level and the proposed soffit level shall be cross verified with existing soffit level.

vii) As per IRC: SP: 73-2018 Clause 7.7, If the cushion over the pipe culvert at any point across the road is arrived to be less than 0.6m excluding the road crust, the particular section of the pipe culvert shall be encased with concrete.

viii) The vertical alignment of the widening carriageway, bypass and realignment locations shall be designed as per IRC SP 73:2018.

ix) Sight distance shall be in accordance with provision of IRC SP: 73-2018.

x) The project road is located in Plain terrain. Thus, the vertical alignment of the project road is substantially designed to satisfy design speeds of 40 kmph to 65 kmph

xi) The vertical alignment design of the project road in built up areas i.e. from chainage 0.000 to 2.750 (towns and villages) has followed the existing grade. This is preferred to provide easy road side access to the abutting property and at grade intersections/junctions. While designing the vertical alignment, efforts were made to satisfy the Intermediate Sight Distance.

4.6 Intersections

Junction designs will be carried based on alignment plan as the right of way is acquired accordingly taking reference from IRC:SP:73-2015, IRC:SP:84-2014 and on the basis of IRC SP 41: 1994, 'Guidelines for the Design of At-grade Intersections in Rural and Urban Areas'. Summing up, the intersections will be designed based upon the following parameters.

- Total traffic volume (for major junctions)
- Turning traffic volumes (for major junctions)
- Composition of traffic (for major junctions)
- Number of approach roads and their category
- Width of approach roads
- Angle of approach with main highway
- Surface type
- Site conditions / constraints
- Local importance and demand

4.7 Rehabilitation of Existing Pavement

Visual Inspection survey has been conducted. Riding quality of the existing pavement is in good to fair condition. There are no major pavement distresses observed in the entire stretch. There are some occasional ravelling, fine cracks and patching other than few local undulations on surface. No rutting along the wheel path, which indicates existing pavement is structurally adequate.

4.7.1 Existing Pavement Layer Details

Soil test pit survey was carried to know the existing crust details. Soil collected at 0.75 m and 1.5 m from all these test pit locations and used for different test to get the existing subgrade strength and soil properties.

4.7.2 Design Traffic

Flexible pavement shall be designed for a minimum design period of 15 years, subject to the condition that design traffic shall not be less than 20 msa.

4.7.3 Overlay

Based on visual inspection, we found that existing road is in good to fair condition. We found few local undulations, fine cracks, edge break and shoulder depression. From the trial pit, it is found that existing bitumen layer thickness is around 150 mm. So based on our assessment, we propose crack sealing with sand bitumen slurry mix and 40 mm functional overlay with required profile corrective course.

Table 4-5: Sight Distance for Design Speeds

Section no.	Overlay Thickness (mm)
0.000 to 2.750	40

Hence 40mm BC is proposed over the existing carriageway.

4.7.4 Profile Corrective Course Calculation

If PCC required more than 50 mm other than 40 mm BC as overlay, we proposed to use DBM as PCC, otherwise BC thickness can be increased to maintain proper cross slope.

4.8 Pavement Design for New Construction/ Widening Portion

The new or reconstruction of flexible pavement shall be designed in accordance with IRC:37-2018 for design traffic estimated from traffic surveys. The design life of the proposed pavement shall be 15 years.

4.8.1 Design Traffic

The design traffic for the project corridor in terms of cumulative number of standard axles will be computed for a design life of 15 years based on stage construction.

$$N = \frac{365 \times \left[(1+r)^n - 1\right]}{r} \times A \times D \times F$$

Where,

N: The cumulative number of standard axles in the design period in terms of msa.

r: Annual Growth Rate of commercial vehicles.

n: Design Life in years

A: Initial traffic in the year of completion of construction in terms of the number of commercial vehicles/day

D: Lane Distribution Factor

F: Vehicle Damage Factor

15 years cumulative MSA is taken as design traffic for the project road and as the design traffic along the road after 15 years is 12 MSA. But as per IRC SP: 73-2018, Flexible pavements shall be designed for a minimum design period of 15 years, subject to the

condition that design traffic shall not be less than 20 MSA. Accordingly, 20 MSA is considered for the design of new pavement for widening of road.

Table 4-6: MSA calculations

MSA Calculations (including construction period of 3 years)			
S.NO	**Location of AADT**	**Design Traffic - 15 year**	**Design Traffic - 21 year**
1	Chamravattam Bridge	12	20
2	NH-66	11	17

4.8.2 Growth Rate

Annual growth rates of commercial vehicles adopted for the design is 5%.

4.8.3 Design Period

Pavement design life is the period for which the initial design of pavement crust layers shall be designed. Design life should not be used to refer to the terminal stage of crust beyond which crust becomes unusable. IRC SP: 37-2018 stipulates that the flexible pavement shall be designed for a minimum design period of 15 years.

4.8.4 Lane Distribution Factor

The lane distribution factor (D) is necessary as it directly affects the total equivalent standard axle load applications used in the design. The lane factor specification mentioned in the IRC: 37:2018, the lane distribution factor is adopted as 50% of the total number of commercial vehicles in both the directions for Two-Lane Single Carriageway roads and the same has been followed in the evaluation of million standard axles (MSA).

4.8.5 Vehicle Damage Factor

The Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as equivalent number of standard axles per commercial vehicle.

Vehicle Damage Factors (VDFs) were assessed using the axle load data mainly for the commercial vehicles that contributes significantly to pavement distress for the project road collected during axle load survey conducted in the project stretch for both the directions. Commercial vehicles recorded were Bus (Minibus, 2-Axle), Light Commercial Vehicle (Goods & Passenger), Two-axle Single Unit Commercial Vehicle (2-axle), Three-axle Trucks (Tandem Axle), 4- Axle Tandem and Tridem vehicles, Semi Truck Trailers of Tandem type, Tridem type, Tandem-Tandem type, Tandem-Tridem combination.

Axle load and classified volume count surveys were conducted and the VDF's thus arrived are presented in the following section

Calculation of VDF for different type of axles is shown below:

VDF = ((Axle load in Kg) / 6625)4 For Front axle

VDF	=	((Axle load in Kg) / 8155)4	For Dual wheel axle
VDF	=	((Axle load in Kg) / 15087)4	For Tandem axle
VDF	=	((Axle load in Kg) / 22834)4	For Tridem axle

Axle load survey has been carried and the direction-wise vehicle damage factors (VDF) arrived based on the data analysis.

The axle load surveys were conducted for both the directions, at two locations i.e.

1. Chamravattam Bridge

2. near urban bank at NH-66.

The axle load surveys were done using properly calibrated axle load pads. The axle load data has been collected as per the axle configuration of the vehicles. The number of equivalent standard axles per truck (VDF) was calculated on the basis of results obtained. The axle load survey data collected is analyzed to bring out the Gross Vehicle Weight (GVW) and Single Axle Load (SAL) Distributions by truck type (axle configuration).

Figure 4-3: Sample Photographs of Axle Load Survey

VDF Calculations are presented in **Table 4-7** based on the Axle load and classified volume count surveys conducted during the month of May, 2019.

Table 4-7: VDF factor

Sl. No	Location	Direction		Bus	LCV	2 Axle Truck	3 Axle Truck	Multi Axle Truck
		From	To					
1	Chamravattam bridge	Chamravattam bridge junction	Chamravattam west bridge junction	0.7	0.3	3.0	6.1	7.0
2		Chamravattam west bridge junction	Chamravattam bridge junction	0.4	0.1	1.5	2.2	6.8
3	near urban	Chamravattam bridge junction	Kuttipuram	0.0	0.4	1.8	3.8	4.6

4	bank at NH-66	Kuttipuram	Chamravattam bridge junction	1.8	0.2	2.3	2.4	8.1

4.8.6 Design CBR

Existing subgrade characteristics were tested in the laboratory from the samples collected; Trial pits were carried out at every 500 metre interval, samples were collected. The CBR is established in the Laboratory for the collected samples. 9% CBR value has been examined after the detailed analysis. The detailed investigation results and existing pavement composition are presented in Material Report

Table 4-8: CBR results

Summary of Modified Proctor Test and CBR results							
Sl.No	**Trial Pit No**	**Chainage**	**Soil Classification**	**DEPTH**	**OMC**	**MDD**	**CBR**
				(M)	**%**	**gm/cc**	**%**
1	TRIAL PIT - 01	0+000	Fine sand (SP)	0.75	16.728	1.819	6
2				1.5	16.446	1.823	12
3	TRIAL PIT - 02	0+500		0.75	14.973	1.995	9
4				1.5	13.306	1.883	11
5	TRIAL PIT - 03	1+000		0.75	15.651	1.88	7
6				1.5	12.44	1.908	5
7	TRIAL PIT - 04	1+500	Fine sand (SM)	0.75	11.4	1.932	5
8			Fine sand (SP)	1.5	14.308	1.883	9
9	TRIAL PIT - 05	2+000		0.75	14.3	1.993	8
10			Fine sand (SM)	1.5	13.2	1.868	9
11	TRIAL PIT - 06	2+500		0.75	12.6	1.951	8
12				1.5	13.2	1.868	11
13	TRIAL PIT - 07	5+000		0.75	12.031	1.918	6
14				1.5	13.2	1.868	6

Table 4-9: Pavement Composition for New Construction / Widening

S.NO	Section	Effective CBR (%)	Design Traffic (MSA)	BC (mm)	DBM (mm)	WMM (mm)	GSB (mm)	Subgrade (mm)
1	Widening of Existing Road (1.5 m on both sides) from chainage 0.000 to 2.750	9	20	40	75	250	200	500
2	New construction from chainage 4.660 to 4.800	9	20	40	75	250	200	500

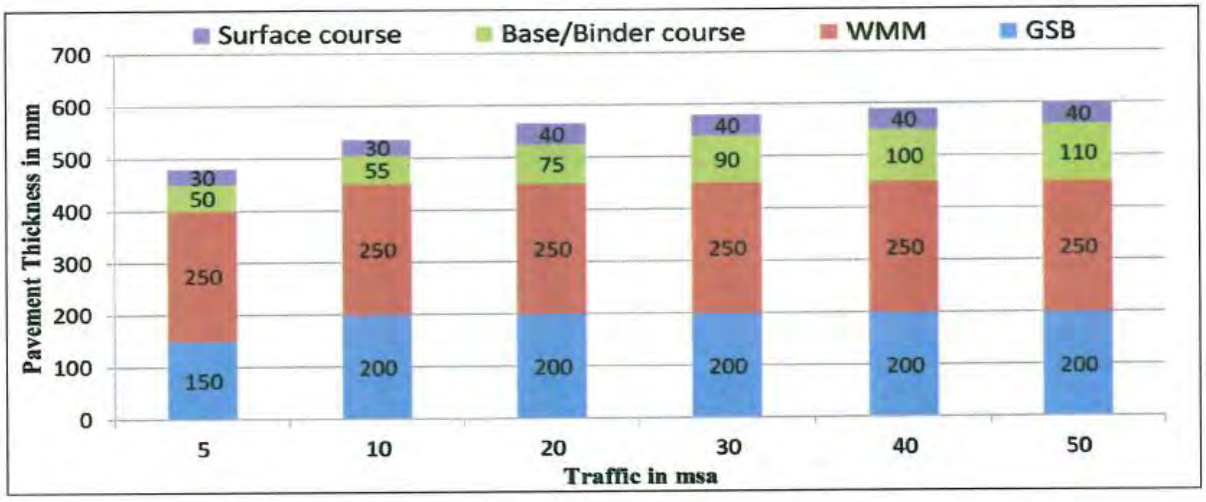

Fig. 12.5 Catalogue for Pavement with Bituminous Surface Course with Granular Base and Sub-base - Effective CBR 9% (Plate-5)

Figure 4-4 : Catalogue for Pavement as per IRC-37, 2018

4.9 Design of Traffic Control and Safety Devices

4.9.1 Road Signs

Traffic control devices, whether used singly or in combination, must contribute to the safe and effective control of traffic and must:

- Be safe and appropriate for the road, its environment or the use of the road; and
- Not dazzle, distract or mislead road users; and
- Convey a clear and consistent message to road users; and
- Be placed so as to be visible to road users, be legible to road users, if of a type that includes written words or symbols; and allow adequate time for the intended response from road users; and

- Comply with the relevant requirements of IRC: 67-2012 and Specifications for Road and Bridge Works – Fifth Revision, and
- Be maintained in good repair.

In addition to the requirements of the IRC and Specifications for Road and Bridge Works, some general principles for using signs are described in IRC:SP:44-1996 Code to Highway safety. Traffic signs should:

- be coordinated with the geometric road layout so that they are conspicuous in both day and night-time conditions, and not used to 'solve problems caused by poor and confusing road geometry'
- be installed according to design guides and warrants (however, a device should not necessarily be installed simply because a guide or warrant is met – engineering judgement must still be applied when deciding the most appropriate traffic sign, or alternative measure)
- be properly located and of adequate size so that road users can read and act on the message
- Provide adequate advance warning of hazard or decision points, notwithstanding that the hazard or decision point itself should be adequately delineated.

The traffic sign face details and the specifications are designed as per the codal provisions of IRC: 67:2012. The siting and location of Road signs on the project facility are to improve the safety of road users including pedestrians who are vulnerable to the motorised traffic.

4.9.2 Road Markings

Road Markings are an important means of traffic control on roads. In some cases, the road markings are used to supplement general traffic regulations, or regulations and warnings given by signs and signals. In other cases, markings can be used without supplement by other devices.

The principal advantage of road markings is that they convey guidance or information to the road user without diverting attention from the roadway. In bad weather conditions, this may be of vital importance to road safety. Road markings should therefore be given special attention with respect to both application and maintenance.

Uniformity in design and application of the markings are important factors. Each marking shall convey the same meaning independent of where it is applied. A paved road without any markings is difficult for drivers to use in a proper way, especially in darkness and when there is a wide carriageway. As far as road safety is concerned, it is therefore important to apply road markings as soon as possible after a new overlay is done. For the same reason, it is important to maintain the function of the markings by keeping them clean from sand and dirt, and to renew worn markings.

The longitudinal markings and the road alignment should always be in harmony with each other. Road markings and the specifications on the project facility are carried as per the codal provisions of IRC: 35-2015 and Specifications for Road and Bridge Works. Road markings design are not only limited to lane markings, edge markings, centre line of the project facility but also to mark bus stops, , cross roads at major junctions, direction arrows and pedestrian crossings.

4.9.3 Traffic Safety Devices

Traffic Safety devices are required to improve safety on proposed facilities.

Road Studs – Provided for the entire length of project corridor as per the spacing mentioned in the IRC 35-2015.

4.10 Roadside Drainage

4.10.1 Introduction

A good drainage system is vital for the safety and longer life of any pavement structure. This is more relevant in the case of any development proposed in an area. Proper drainage of proposed developments is basic requirement for maintaining the structural soundness and functional efficiency of a proposed structure. Proposed development surface must be protected from any ingress of water. For this purpose, the following conditions have to be ensured.

- Saving the pavement structure from stagnation of water.
- Efficient dispersal and disposal of water.
- Quick disposal of sub-surface water away from the pavement.
- Interception of the surface runoff.
- Keeping the water flow duration on the paved surface to a minimum.

Cross slope / Transverse gradient of proposed development facilities is also necessary for quick surface runoff disposal from the surface. If existing drain is in good condition, the same will be cleaned and used.

4.10.2 Design Standards

The design of drains is carried out in accordance with the following codes:

- IRC: SP: 42 – 2014, “Guidelines on Road Drainage”.
- IRC: SP: 50 – 2013, “Guidelines on Urban Drainage”.
- IRC: SP: 84 – 2014, “Manual of Specifications and Standards for Four Laning of highways through Public Private Partnership”.
- IRC: SP: 73 – 2018, “Manual of Specifications and Standards for Two Laning of Highway with Paved Shoulders through Public Private Partnership”.

4.10.3 Storm Water Drain Design and Design Parameters

- Hydrologic analysis: calculating the total discharge that the system will require to drain off
- Hydraulic design: fixing dimensions and slope of the drain to have adequate capacity to carry the discharge. These two aspects are dealt separately below.

4.10.3.1 Hydrologic Analysis

Hydrologic analysis is an important step prior to the hydraulic design of road drainage system. Such analysis is necessary to determine the magnitude of flow and the duration for which it would last. Rational method is a universally accepted empirical formula relating rainfall to runoff and is applicable for small catchment area not exceeding 50 square kilometres. The parameters to derive the runoff by rational method are described below.

4.10.3.2 Design Storm Period

Drainage systems are designed for the rainfall intensity corresponding to design duration and frequency. The frequency of 25 years return period shall be considered for this project as suggested in **sections 6.3.1 of IRC:SP:42-2014**.

As **per section 6.2.1 of IRC: SP: 42-2014** one hour rainfall data for the project stretch is identified by applying the zone specific conversion factor to 24 hour rainfall data for various return periods. **ATLAS of State wise Generalised ISOPLUVIAL (Return Period) Maps of the Southern Peninsula (Part-I) published by India Meteorological Department, September 2007** is referred for 24 hour rainfall intensity of 25 years return period. Project is located in the Kerala shown in Isopluvial map of Figure 4-5**.** The rainfall intensity observed along the project area is presented in **Table 4-10**.

As per **Figure I.1 (Annexure – 1) of IRC: SP: 42-2014**, the project falls in the West Coast Region subzone 5(a) & (b). For this zone the conversion factor to modify 24 hour rainfall to 1 hour rainfall is found to be **0.32** referring **Clause No. 4.2 of The Flood Estimation Report** West Coast Region subzone 5(a) & (b) published by Directorate of Hydrology, 1997. This conversion factor is applied to the 24 hour rainfall value and the design 1 hour rainfall is found out as shown in **Table 4-10**.

Table 4-10 Calculations for 1 hour Rainfall intensity

Project Corridor	24 hour Rainfall intensity (mm)	1 hour Rainfall intensity (mm)
Ponnani junction to Padinjarekara beach	160	51.2

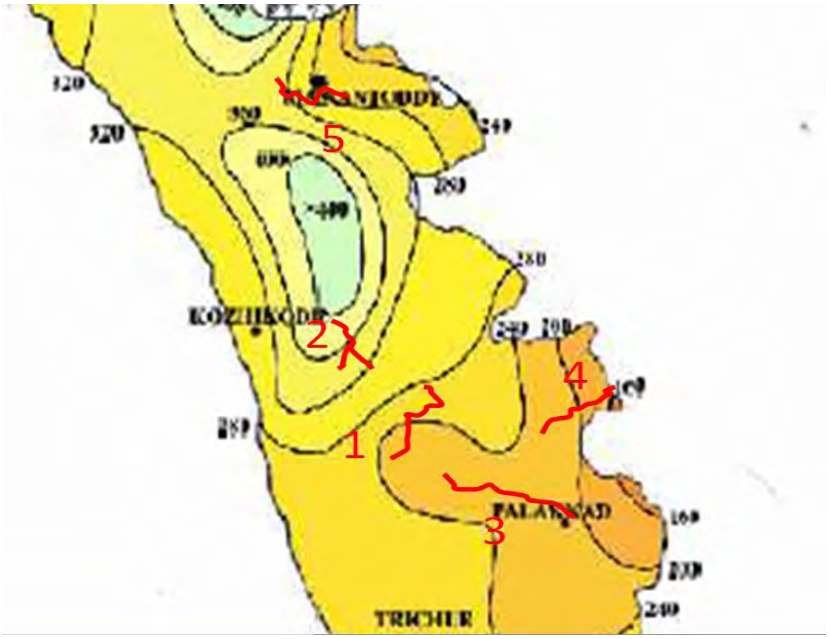

Figure 4-5: 25 years Isopluvial map for Kerala state

4.10.3.3 Peak Runoff

The peak runoff or the peak discharge for the given area is found out by using the following formula as per Section 6.4.2 of IRC: SP: 42:2014

$$Q = 0.028\ Pm\ A\ I_c$$

Where, Q = Design peak runoff rate in cum/sec

Pm = Weighted Coefficient of runoff for catchment characteristics,

A = Catchment area in hectares

I_c = Critical intensity of rainfall in cm per hour for the selected frequency and for duration equal to the time of concentration.

Weighted Runoff coefficient (Pm) of catchment area that consists of different surfaces can be found by the following relationship.

$$Pm = \sum (Pi \times Ai)/\sum Ai,\ (i= 1, 2, 3....)$$

Where, Pi = Runoff coefficient for the surface type of area Ai contributing runoff to drain.

4.10.3.4 Coefficient of Runoff

The coefficient of run-off (P) is the portion of precipitation that makes its way to the drain. Its value depends on a large number of factors such as permeability of the surface, type of ground cover, shape and size of catchment area, the topography, the geology, initial state of wetness and duration of storm. The value of "P" commonly adopted for use in Rational Formula as per Table 6.5 of IRC: SP: 42-2014 are given in

Table 4-11 Coefficient of Runoff

Sl. No.	Description of Surface	Coefficient of Runoff (P)
1	Steep, bare rock and watertight pavement surface (concrete or bitumen)	0.90

4.10.3.5 Area of Runoff Catchment

This area considered for the calculation of storm water runoff is the project right of way.

4.10.3.6 Time of Concentration

Time of concentration (T_c) is the time required for storm water to travel from the hydrological most distant point in the watershed to the point under consideration. The primary component in designing storm water drain is the design storm i.e. rainfall value of specified duration and return period. The storm duration chosen for design purpose is the Time of Concentration.

The time of concentration is the sum of the time taken for surface flow of water (T_o) and the time taken for longitudinal flow of water in drain (T_f). That is

$$T_c = T_o + T_f$$

Time of concentration for surface flow of water (**Section 6.3 of IRC: SP: 50-2013**)

$$T_o = (0.87 \times L^3 / H)^{0.385}$$

Where, T_o = Time of concentration for surface flow of water in hours

L = Distance of critical point to the drain location in km

H = Fall in level from the critical point to the drain level in meters

Time of concentration for longitudinal flow of water in drain,

$$T_f = L_c / V$$

Where, $$V = \frac{1}{n} R^{2/3} S^{1/2}$$

T_f = Time of concentration for longitudinal flow of water in drain in hours

L_c = Length of longitudinal drain in m

V = Mean velocity in m/s

n = Manning's roughness coefficient

R = Hydraulic mean radius (A/P) in m

A = Area of drain section in m^2

P = Wetted Perimeter in m

S = Longitudinal gradient of the drain (m/m)

4.10.3.7 Rainfall Intensity

Once the time of concentration has been fixed, the next step is estimating the rainfall intensity for the given time of concentration. As per **IRC: SP: 42-2014,** the rainfall intensity for shorter durations of small catchments is estimated using the following equation.

$$I_c = F (T+1) / (T (T_c+1))$$

Where, I_c = Intensity of Rainfall within a shorter period of T_c hours within a storm

F = Total Rainfall in storm in cm, falling for storm duration of 'T' hours

T_c = Time of concentration in hours within the storm duration of 'T' hours

Total rainfall for a shorter duration (1 hour) corresponding to 25 year return period is taken as per **Table 4-10.**

4.10.4 Hydraulic Design

Once the quantity of runoff has been determined, the stage is set for the next step of hydraulic design of the drain. The hydraulic capacity of the drain should be checked to ensure that it is capable of handling the expected flows without affecting the nearby developments. For the runoff specified in the section 4.10.3.3**,** suitable type of drain (lined/ Unlined/ Open/ Closed) shall be designed.

4.10.4.1 Drain Design

In engineering practice, the storm water flow is assumed as open channel flow and flow is uniform. The basic relationships are expressed by the Manning's formula. The capacity of the drain is designed in such a way that it can carry the surface runoff generated from the given stretch.

$$Q = \frac{1}{n} A R^{2/3} S^{1/2} \text{ and } V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where, Q = Peak discharge in cum/sec

n = Manning's roughness coefficient

R = Hydraulic mean radius (A/P) in m

S = Longitudinal gradient of the drain in m/m

A = Area of flow cross section in m^2 for wetted perimeter (P) in m

Manning's coefficient (n) depends upon the surface characteristics of longitudinal drain section. The coefficient of regosity for various surfaces is considered as per **Table 6.3 of IRC: SP: 50-2013** and **Table 7.1 of IRC: SP: 42-2014**. Coefficient of regosity shall be considered as follows. For earthen drain coefficient of regosity shall be considered based on the soil characteristics.

- For rectangular concrete box drain the 'n' value is 0.014.

4.10.4.2 Design Section

While deciding the drain section it is not sufficient that they are sufficient to carry the required discharge. As per IRC standards, following guidelines are also required to be kept in view.

Minimum and Maximum Velocities: The velocity values in excess of maximum permissible velocity will cause erosion in the drain, which increases the maintenance cost and also weakens the road structurally. **Table 7.1 of IRC: SP: 42-2014** has given maximum permissible velocities for different drain surfaces and **Clause 6.8.3 of IRC: SP: 50-2013** suggests minimum and maximum velocities to be maintained in different types of drain.

- Box Drain – For Concrete Drain the minimum self-cleansing velocity is **0.75 m/sec** and maximum permissible velocity is **6 m/sec**.

Minimum free board: Minimum free board required as given in the Section **6.8.4 of IRC: SP: 50-2013** are presented in Table 4-12.

Table 4-12 Minimum free board required for different drain width

Drain width	Minimum Free Board required
Less than 300 mm bed width	10 cm
Beyond 300 mm and up to 900 mm bed width	15 cm
Beyond 900 mm and up to 1500 mm bed width	30 cm
For Larger Drains	Up to 90 cm

4.10.4.3 Gradient of drain

It is planned to have the drain bed parallel to the road surface except in the vicinity of outfall locations. For Drains as far as possible longitudinal slope shall not be less than 0.3% for lined drains.

4.11 Road Side Furniture

Road side furniture shall be provided in accordance with Section 9 of IRC SP: 73-2015.

The road signs shall be provided in accordance with IRC 67: 2012. Traffic signs include roadside signs, overhead signs and route marker signs and curb mounted signs along the entire Project Highway and shall be designed as per IRC 67: 2012.

Pavement markings on the project highway shall be in accordance with IRC 35:2015. These markings shall be applied to road centre, edge line, continuity line, stop line, give way lines, diagonal/chevron markings and zebra crossing and at parking areas.

4.12 Summary of Design Standards adopted for Road design, Drainage Design and Project Facilities

The design standards for various Road design and Project Facilities are presented in the **Table 4-13.**

Table 4-13 : Design Standards for Road Design, Drainage Design and Project Facilities

Summary of Design Standards adopted for Road design, Drainage Design and Project Facilities		
S. No	**Items**	**Standards**
1	**Design Speed for Plain Terrain**	
	I. Ruling	65 Kmph
	II. Minimum	40 Kmph
	III. Restricted speed locations	As per site condition
2	**Proposed ROW**	As mentioned in Typical Cross Section
3	**Carriageway**	
	Width per lane	3.5m
	Rate of taper	1 in 15
4	**Paved shoulder**	
	Open country with isolated built up area	1.5m
5	**Horizontal Radius of curvature**	
	Radius beyond which no super elevation is required (65/40 kmph) with 2.5% camber	750m/300m
	Desirable minimum radius (65/50/40 kmph)	400m/150m
6	**Camber/Cross fall**	
	Bituminous concrete surfacing including paved shoulder	2.50%
	Earthen shoulder	3.00%
7	**Super elevation**	

Summary of Design Standards adopted for Road design, Drainage Design and Project Facilities		
S. No	**Items**	**Standards**
	Minimum	2.5%
	Maximum	5%
8	**Intermediate Sight Distance**	
	Desirable Minimum (65/40kmph)	180m/90m
9	**Vertical Alignment**	
	Desirable distance between change in grade (tangent points)	150m
	Minimum length of vertical curve (65/40 kmph)	40m/20m
	Maximum grade change not requiring vertical curve (65/40Kmph)	0.8% & 1.2%
10	**Gradient**	
	Maximum	2.5%
	Minimum	0.30%
• Existing gradient will be followed at built-up locations from chainage 0.000 to 2.750.		
11	**Safety barriers**	
	Recommended barrier will be provided and as specified in IRC SP 73-2018.	
12	**Drainage Design**	
	Design Storm	25 Years Return period
	Rainfall Intensity	Table 4-10
	Runoff Co-efficient	Table 4-11
	Area of Catchment	Project right of way
	Mannings ‘n’ Value	Section 4.10.4.1
	Minimum width of drain	0.3 m
	Free Board	Table 4-12
	Minimum and maximum Velocities	Section 4.10.4.2
	Box Drain	
	Minimum Longitudinal Gradient	0.3 %
	Minimum Velocity	0.75 m/s

Summary of Design Standards adopted for Road design, Drainage Design and Project Facilities		
S. No	**Items**	**Standards**
	Maximum Velocity	6 m/s
	Maximum Kerb Inlet spacing	30 m
	Chute Drain	15 m interval

5 Codes/Specification

References Codes used in the design of highway and drainage are as mentioned in **Table 5-1.**

Table 5-1: List of Codes and Specifications

S. No.	Description	Design code/standard	
1	Geometric Designs & standards	(i)	IRC:38:1988 Guidelines for design of horizontal curves
		(ii)	IRC:SP-23:1993 – Vertical curves for Highways
		(iii)	IRC:73:1980 Geometric Design Standards for Rural (Non-Urban) Highways
2	Design of Pavement	(i)	IRC:37:2018 – Guidelines for Design of Flexible Pavement
		(ii)	IRC:115:2014 – Guidelines for strengthening of flexible pavements
3	Junctions / Intersections / Interchanges	(i)	IRC:92:1985 - Guidelines for Design of Interchanges
		(ii)	IRC:93:1985 – Guidelines on Design & Installation of Road Traffic signals
		(iii)	IRC:SP-41:1994 – Design of At grade junctions
		(iv)	Type designs for intersections on NH by MORTH
4	Kilometre stones, 200m stones and boundary pillar	(i)	IRC:8-1980 – Type Design for Highway kilometre stones
		(ii)	IRC:26:1967 -Type design for 200m stones

S. No.	Description	Design code/standard	
		(iii)	IRC:25:1967 -Type design for boundary stones
5	Traffic Signs	(i)	IRC:31:1969 – Route marker signs for state routes
		(ii)	IRC:67:2012 – Code of practice for road signs
6	Road Markings	(i)	IRC: 35:2015 – Code of practice for road markings.
7	Drainage	(i)	IRC:SP:42:2014 – Guidelines on Road Drainage
		(ii)	IRC:SP-50:2013 – Guidelines on urban drainage
8	Safety Measures	(i)	IRC:103:2012 – Guidelines for pedestrian facilities
		(ii)	IRC:SP-44 – Highway Safety Code
		(iii)	IRC:SP-55:2014 – Guidelines on traffic Management in work zones
9	Manual and Specifications	(i)	IRC SP-73:2018 Manual of Specifications and Standards for Two Laning of Highway with Paved Shoulders through Public Private Partnership.
		(ii)	Ministry of Road Transport & Highways (MoRT&H) specifications and circulars – Fifth edition: 2013.

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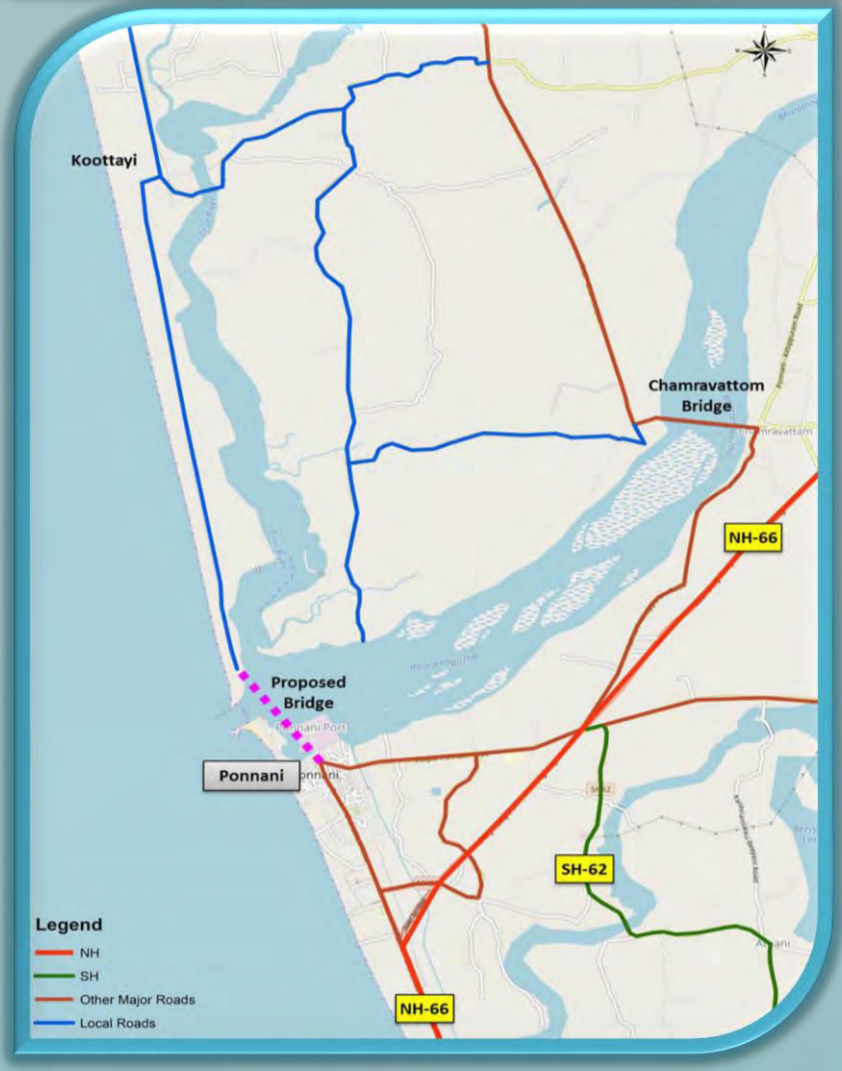
Roads and Bridges Development Corporation of Kerala Limited (RBDCK)

Kerala Infrastructure Investment Fund Board (KIIFB)

Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches



Detailed Project Report
(Volume-III: Materials Report)
March 2020

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L&T Infrastructure Engineering Ltd.

Client:	**Roads and Bridges Development Corporation of Kerala Limited (RBDCK)** (A Government of Kerala Undertaking)		
Project:	Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches in the State of Kerala	**Project No.:** C1193601	
Title:	Detailed Project Report(Volume-III Material Report)	**Document No.:** RP010	**Rev.:** 0

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Notes:

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Revision Details:

0	12/03/2020	First submission	HMS		NCB		KGN	
Rev.	**Date**	**Details**	**Init.**	**Sign.**	**Init.**	**Sign.**	**Init.**	**Sign.**
			Prepared		**Checked**		**Approved**	

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1. Introduction

1.1 Background

Roads and Bridges Development Corporation of Kerala Limited (RBDCK) (the "Client/Authority") has been entrusted with the assignment of **'Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala'**. In this context, the Client has appointed **L&T Infrastructure Engineering (L&TIEL) (the "Consultant")** for carrying out Feasibility Study, to establish the technical, economic and financial viability of the aforesaid project and to prepare Detailed Project Report.

This report pertains to the "Feasibility Study", wherein the various aspects of the project like Alignment options, traffic analysis, alignment plan, typical cross sections, Preliminary environmental and social assessments, Land acquisition/resettlement plans, cost estimates & Economical/Financial analysis are discussed in detail and accordingly conclusions and recommendations are made for the feasibility of the aforesaid project.

A key map showing the location of the project stretch is given in **figure 1.1**.

This report **RP002** presents the Surveys and Investigations carried out for Ponnani project road.

1.2 Objective of the study

The main objective of the Feasibility Study is to study in detail on various options of Alignment, Bridge Types in terms of Structure and Aesthetics, Road and Bridge Cross sections to cater the present and projected Traffic, connectivity of the proposed alignment with adjoining road networks keeping in view of Environmentally and Socially viable and sustainable, enhancement of Tourism potential by conducting detailed analysis / investigation / survey. The consultant will present the most feasible options for Alignment, Bridge location and Type, Road and Bridge cross section and various amenities to enhance Tourism potential to RBDCK.

1.3 Structure of the Report

Engineering Survey and Investigation Report presents the following chapters / aspects for development of the project

- Introduction chapter presents the Project background and scope of the project
- Project description chapter briefly describes the location of the project stretch, existing project features and the need for the development of the project.
- Field exploration and Laboratory testing
- Analysis of Modified Proctor and Compaction test and CBR results

1.4 Project Description

The Project Starts at the Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) and ends at Padinjarekara beach. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock. The project is a part of Coastal Highway and the proposed alignment will be

linking the two points; on southern side the Ponnani Junction (NH66 Bypass) and Northern side Padinjarekkara-Kuttayi Road. At present the two sides of the river is connected by Jenkar services in the day time. The road connectivity between the two banks is via Chamravattom Bridge which takes around 20Km. Hence the proposed Bridge will be the life line of the Ponnani Beach and its surrounding area. This road will act as a parallel road to NH 66 and reduces the travelling distance from Ernakulam to Kozhikode around 30 Km.

A reconnaissance survey was carried out along the project road to appreciate them and to finalise the locations of field surveys and investigations. The project appreciation of the project road is given below.

1.5 Project Location

The proposed road starts at Chemmannar and passes through Kuthumkal- PHC Junction- Kurangupara- 40 Acre Junction- Bison Valley and it ends at Gap Road with a total length of 18.86 Km. The stretches from Kuthumkal to PHC Junction (8.0 Km) and from Kurangupara to 40 Acre Junction (3.1 Km) is excluded in the scope.The project alignment and the major towns/ villages along the project road is presented below.

Figure 1-1: Key map of Project Road

The Project road starts from Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) which follows the existing PWD road up to the cross junction of Ponnani main road and then turns towards the ferry terminal, afterwards follows the proposed structure and crossing the Bharathupuzha River through an Iconic bridge of 250 m obligatory span and then parallel path to existing road up to proposed km 4.70 and then merge with existing PWD road. The project

alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock.

The total length of alignment is **4.8 km** in which about **2.75 km** passes through existing PWD road.

Based on the inventory survey, the project road is divided into the following three sections:

S.No	Section	Chainage
1	Ponnani Junction – Ponnani Court	(0/000 Km – 2/750 Km)
2	Structure portion	(2/785 Km – 4/800 Km)

Table 1-1 Sections of Project road

It can be noted that Ponnani junction – before structure starts section has a length of 2.75 km which is about 50% of the total length of alignment.

2. Scope of the Services

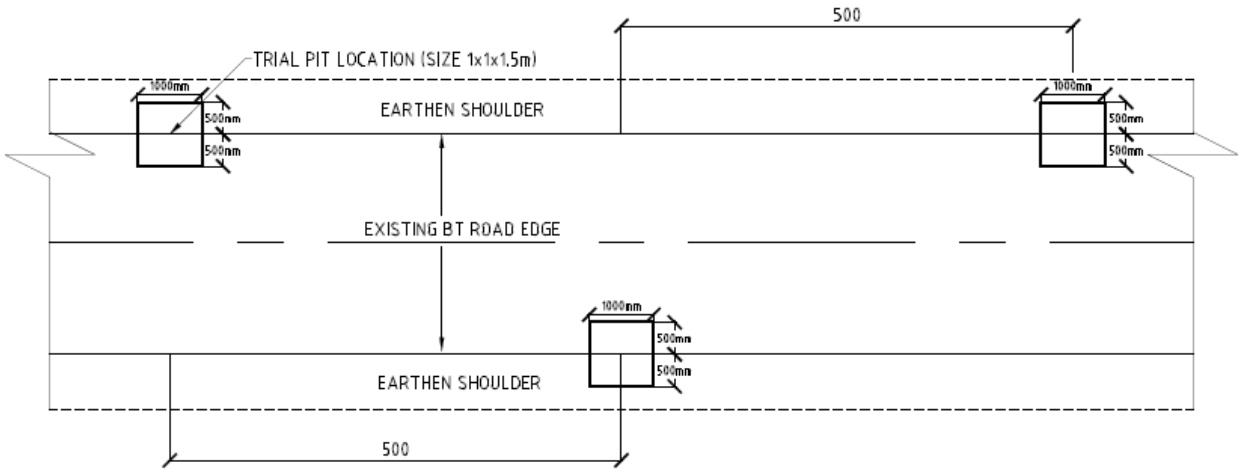
The scope of services for the current assignment includes the following tasks:

1. Trial Pit has been conducted for 7 locations in staggered basis. Trial pit dimension are 1mx1m. Soil samples are collected at 0.75m and 1.5m depth.
2. To determine the subgrade strength and subsoil characteristics of road using trial pits at every 500 metre on staggered basis has been conducted Also dry density at subgrade level and analysis of existing granular base and sub base samples.
3. Investigation includes the sieve size analysis of all trial pits, determination of the MDD and OMC of 14 samples from 7 trial pits.
4. Testing of borrow and quarry material for earth work, pavement and embankment construction for approaches.
5. Design of pavement for reconstruction using IRC 37-2018 and overlay design using IRC 115-2014, for the projected traffic for 15 years.

Soil investigation is required to evolve various soil parameters at the proposed project location in order to carry out engineering analysis. Broad objectives of the investigations are as follows.

- To obtain general information on the character and genesis of soil.
- To assess the sequence and extent of each soil stratum in the region likely to be affected by the proposed work.
- To evaluate nature of each stratum and engineering property of soil, this may affect design and mode of construction.
- To assess engineering parameters for design

Trial Pits location			
Sl.No	**Chainage**	**Side**	**Pit No**
1	0+000	RHS	1
2	0+500	LHS	2
3	1+000	RHS	3
4	1+500	LHS	4
5	2+000	RHS	5
6	2+500	LHS	6
7	5+000	RHS	7



Trial Pit Layout Plan

3. Field exploration and Laboratory testing

3.1 FIELD EXPLORATION AND METHODOLOGY

A test pit of 1.0 x1.0 x 1.5 m was excavated at an interval of 500 meter staggered on LHS & RHS. Soil samples were collected at 0.75m depth and at 1.5m depth in sufficient quantities. Relevant laboratory tests on soil samples were carried out in accordance with Indian Standards.

3.2 ANALYSIS OF VARIOUS LABORATORY TESTS

Disturbed samples (SPT Samples) obtained from specified sampler were tested for the following index properties as well as strength properties to classify the strata to various soil group as per unified soil classification IS: 1498-1970 and IS: 2720.

3.2.1 Moisture Content {IS: 2720 (Part II) - 1973}

The natural moisture content of all the soil samples brought from the site was determined as

prescribed in IS: 2720. For many soils, the water content will be an extremely important index used for establishing the relationship between the way a soil behaves and its properties. The consistency of a fine-grained soil largely depends on its water content. The water content is also used in expressing the phase relationships of air, water, and solids in a given volume of soil.

3.2.2 Grain Size Distribution {IS: 2720 (Part IV) - 1985}

Both sieve analysis and Hydrometer analysis were conducted on different samples and the findings are tabulated. Since particle diameters typically span many orders of magnitude for natural sediments, in order to conveniently describe wide ranging data sets, the base to logarithmic (phi) scale was used to represent grain size information for sediment distribution. A tabular classification of grain sizes in terms of units and other commonly used measurement scales is included for purposes of comparison.

3.2.3 Specific Gravity {IS: 2720 (Part III)- 1980}

The specific gravity of soil particles was determined by using pycnometer or density bottle. Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at the same stated temperature. The specific gravity of a soil is used in the phase relationship of air, water, and solids in a given volume of the soil.

3.2.4 Modified proctor test (IS: 2720 (PART 8) -1983)

Modified proctor test conducted in the laboratory to determine the amount of compaction and water content required in the field. The tests provide a relationship between the water content and the dry density.

3.2.5 California bearing ratio (IS: 2720 (PART 16) -1987)

CBR test was conducted on the soaked soil sample. From the load-penetration curve the bearing ratio for penetration of 2.50mm and 5.00m was calculated. The mould with the soil was soaked in water for 4 days after which the sample is to be tested. The test was conducted as per IS 2720 (Part XVI). The load to the plunger was applied so that the rate of penetration remains constant at 1.25mm/min.

4. Details of Grain Size analysis and Atterbergs limits

The details of Grain size analysis and atterberg limits are presented in Table below

TYPE OF BORING: ROTARY DRILLING 150mm DIA					DEPTH IN METRE: 0.75m and 1.50m								
Sl.No	Trial Pit No	DEPTH	SOIL DESCRIPTION	I.S CLASIFI CATION	GRAIN SIZE ANALYSIS				Atterbergs Limit (%)				SPECIFIC GRAVITY
		(M)			GRAVE L%	SAND %	SILT %	CLAY%	N M C	LL	PL	PI	
1	TRIAL PIT - 01	0.75	BROWNISH FINE SAND	SP	0	96	4	0	10	No Limit	No Plasticity	-	2.66
2		1.5	BROWNISH FINE SAND	SP	0	96	4	0	12	No Limit	No Plasticity	-	2.66
3	TRIAL PIT - 02	0.75	BROWNISH FINE SAND	SP	0	95	5	0	15	No Limit	No Plasticity	-	2.66
4		1.5	BROWNISH FINE SAND	SP	0	95	5	0	15	No Limit	No Plasticity	-	2.66
5	TRIAL PIT - 03	0.75	GREYESH BROWN FINE SAND	SP	0	97	3	0	15	No Limit	No Plasticity	-	2.67
6		1.5	DARK BROWN FINE SAND	SP	0	93	7	0	17	No Limit	No Plasticity	-	2.65
7	TRIAL PIT - 04	0.75	GREYESH BROWN FINE SAND	SM	0	88	12	0	7	No Limit	No Plasticity	-	2.65
8		1.5	BROWNISH FINE SAND	SP	0	94	6	0	13	No Limit	No Plasticity	-	2.66
9	TRIAL PIT - 05	0.75	DARK BROW MEDIUM TO FINE	SP	0	98	2	0	9	No Limit	No Plasticity	-	2.67
10		1.5	DARK BROW MEDIUM TO FINE	SM	0	84	16	0	16	No Limit	No Plasticity	-	2.64
11	TRIAL PIT - 06	0.75	REDDISH BROW MEDIUM TO FINE	SP	0	96	4	0	9	No Limit	No Plasticity	-	2.66
12		1.5	DARK BROW MEDIUM TO FINE	SP	0	94	6	0	17	No Limit	No Plasticity	-	2.66
13	TRIAL PIT - 07	0.75	BROWNISH FINE SAND	SP	0	98	2	0	4	No Limit	No Plasticity	-	2.67
14		1.5	BROWNISH FINE SAND	SP	0	97	3	0	5	No Limit	No Plasticity	-	2.67

5. Summary of Modified Proctor Test and CBR Results:

Summary of Modified Proctor Test and CBR results							
Sl.No	Trial Pit No	Chainage	Soil Classification	DEPTH	OMC	MDD	CBR
				(M)	%	gm/cc	%
1	TRIAL PIT - 01	0+000	Fine sand (SP)	0.75	16.728	1.819	6
2				1.5	16.446	1.823	12
3	TRIAL PIT - 02	0+500		0.75	14.973	1.995	9
4				1.5	13.306	1.883	11
5	TRIAL PIT - 03	1+000		0.75	15.651	1.88	7
6				1.5	12.44	1.908	5
7	TRIAL PIT - 04	1+500	Fine sand (SM)	0.75	11.4	1.932	5
8			Fine sand (SP)	1.5	14.308	1.883	9
9	TRIAL PIT - 05	2+000		0.75	14.3	1.993	8
10			Fine sand (SM)	1.5	13.2	1.868	9
11	TRIAL PIT - 06	2+500		0.75	12.6	1.951	8
12				1.5	13.2	1.868	11
13	TRIAL PIT - 07	5+000		0.75	12.031	1.918	6
14				1.5	13.2	1.868	6

6. Details of Existing Pavement:

Sl. NO	TRIAL PIT NUMBER	CHAINAGE	THICKNESS (mm)	
			BC+DBM	WMM+GSB
1	Trial pit 1	0+000	150	450
2	Trial pit 2	0+500	220	230
3	Trial pit 3	1+000	130	270
4	Trial pit 4	1+500	100	200
5	Trial pit 5	2+000	250	150
6	Trial pit 6	2+500	150	160
7	Trial pit 7	5+000	40	360

Trial pit -1 at chainage 0+000

Trial Pit--2 at chainage 0+500

Trial pit- 3 at chainage 1+000

Trial pit -4 at chainage 1+500

Trial pit- 5 at chainage 2+000

Trial pit- 6 at chainage 2+500

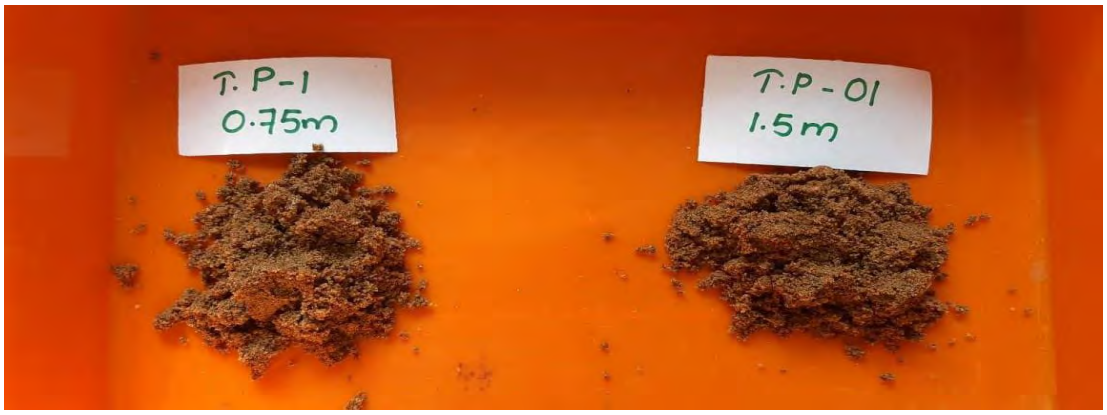
Trial pit- 7 at chainage 5+000

7. Analysis of Modified Proctor test and CBR results

7.1 Modified Proctor Test and CBR results at Trial Pit No: 1

Location: Ponnani Junction, Malappuram

Chainage: 0/000



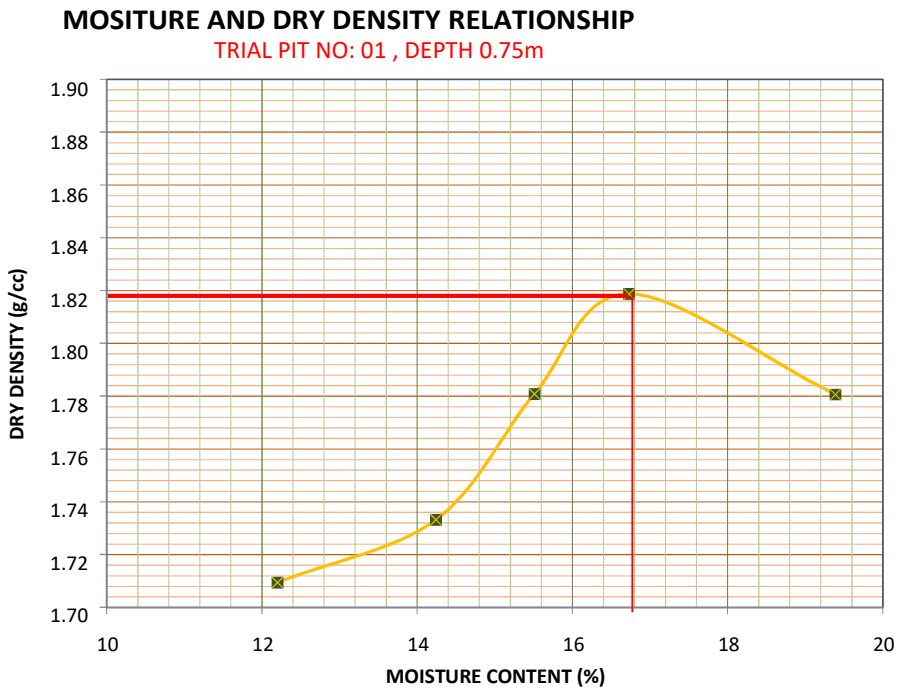
Modified Proctor Test at Chainage-0/000 (0.75 m depth)																		TRIAL PIT NUMBER	1
																		DEPTH, m	0.75
LOCATION	Ponnani Junction, Malappuram				CHAINAGE	0/000												SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR																		
SL No	DETERMINATION OF DENSITY	12%			15%			18%			21%			24%					
1	WT OF MOULD (gm)	3642			3642			3642			3642			3642					
2	WT OF MOULD+ COMPACTED SOIL (gm)	5560			5622			5699			5765			5770					
3	WT OF COMPACTED SOIL (gm)	1918			1980			2057			2123			2128					
4	VOLUME (cc)	1000			1000			1000			1000			1001					
5	BULK DENSITY (W/V)(g/cc)	1.918			1.980			2.057			2.123			2.126					
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM			
7	CONTAINER NO																		
8	WT OF CONTAINER, M1 (gm)	71	66.5	72.7	47.3	69	65	66.3	72.6	69	66.3	68.1	62.4	62	58	63			
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	164.8	178.8	145.9	135.1	163.9	157.5	146	144.6	160.7	178.9	153.3	158	178.9	153.3	155.3			
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	155.6	166.4	137.3	124	151.9	146.3	135.3	135	148.3	162.3	141	144.8	160.1	138	140			
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	10.875	12.412	13.313	14.472	14.475	13.776	15.507	15.385	15.637	17.292	16.872	16.019	19.164	19.125	19.870			
12	AVERAGE WATER CONTENT (%)	12.200			14.241			15.510			16.728			19.386					
13	DRY DENSITY (g/cc)	1.709			1.733			1.781			1.819			1.781					
	OPTIMUM MOISTURE CONTENT, OMC %	16.728			MAXIMUM DRY DENSITY,MDD (g/cc)						1.819								

MDD OUPUT VALUES

		DATE	08.11.2019
LOCATION	Ponnani Junction, Malappuram (CH: 0/00)	**TRIAL PIT NO.**	1
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION	Dynamic Heavy Compaction		

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	96	4	0

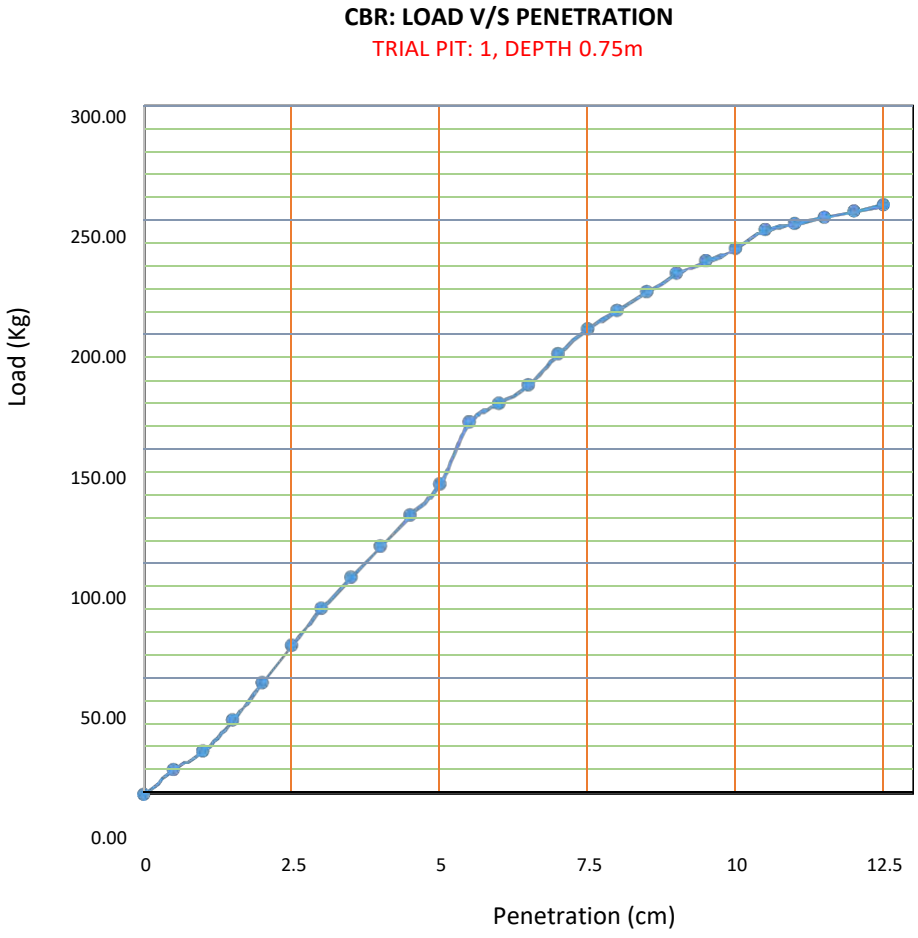
OMC TEST SPECIMEN DETAILS	
Bulk Dry Density, MDD (g/cc)	2.037
Optimum Moisture Content (%)	16.730
Maximum Dry Density, MDD (g/cc)	1.819

CBR OUPUT VALUES

		DATE	15.11.2019
LOCATION	Ponnani Junction, Malappuram	**TRIAL PIT NO.**	1
TEST	CBR Test	**DEPTH**	0.75m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	
Optimum Moisture Content, OMC	16.73%	**Maximum Dry Density, MDD (g/cc)**	1.819

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	64.8
Load at 5mm penetration, Kg	135
CBR at 2.5mm penetration	4
CBR at 5mm penetration	6
Recommended CBR value	**6**

Modified Proctor Test at Chainage-0/000 (1.5 m depth)				TRIAL PIT NUMBER	1
				DEPTH, m	1.5
LOCATION	Ponnani Junction, Malappuram	CHAINAGE	0/00	SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR				

SL No	DETERMINATION OF DENSITY	9%	12%	15%	18%	21%
1	WT OF MOULD (gm)	3642	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5491	5586	5681	5765	5793
3	WT OF COMPACTED SOIL (gm)	1849	1944	2039	2123	2151
4	VOLUME (cc)	1000	1000	1000	1000	1000
5	BULK DENSITY (W/V)(g/cc)	1.849	1.944	2.039	2.123	2.151

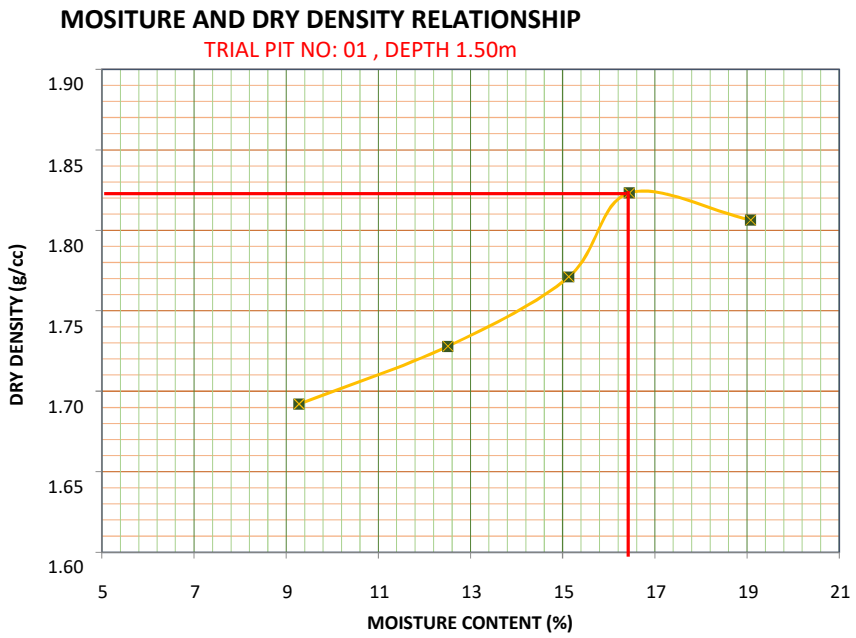
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM
7	CONTAINER NO															
8	WT OF CONTAINER, M1 (gm)	65.2	65.5	67	70.4	64.2	72.9	68	67.8	62.3	66.5	65.9	64.6	48.3	53.32	54.25
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	132.9	151.4	135.4	151.4	164.1	189.6	209.9	192.9	171.6	224.9	139.5	189.6	150.9	179.7	164.9
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	127.09	144.13	129.64	142.39	152.96	176.68	189.53	176.95	158.16	199.64	129.16	174.23	131.38	158.4	151.76
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	9.388	9.246	9.195	12.516	12.551	12.449	16.761	14.613	14.020	18.973	16.345	14.020	23.495	20.270	13.476
12	AVERAGE WATER CONTENT (%)	9.276			12.505			15.132			16.446			19.080		
13	**DRY DENSITY (g/cc)**	**1.692**			**1.728**			**1.771**			**1.823**			**1.806**		
	OPTIMUM MOISTURE CONTENT, OMC %	**16.446**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.823**					

MDD OUPUT VALUES

		DATE	09.11.2019
LOCATION	Ponnani Junction, Malappuram (CH: 0/00)	**TRIAL PIT NO.**	1
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	96	4	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.042	
Optimum Moisture Content (%)			16.446	
Maximum Dry Density, MDD (g/cc)			1.823	

CBR OUPUT VALUES

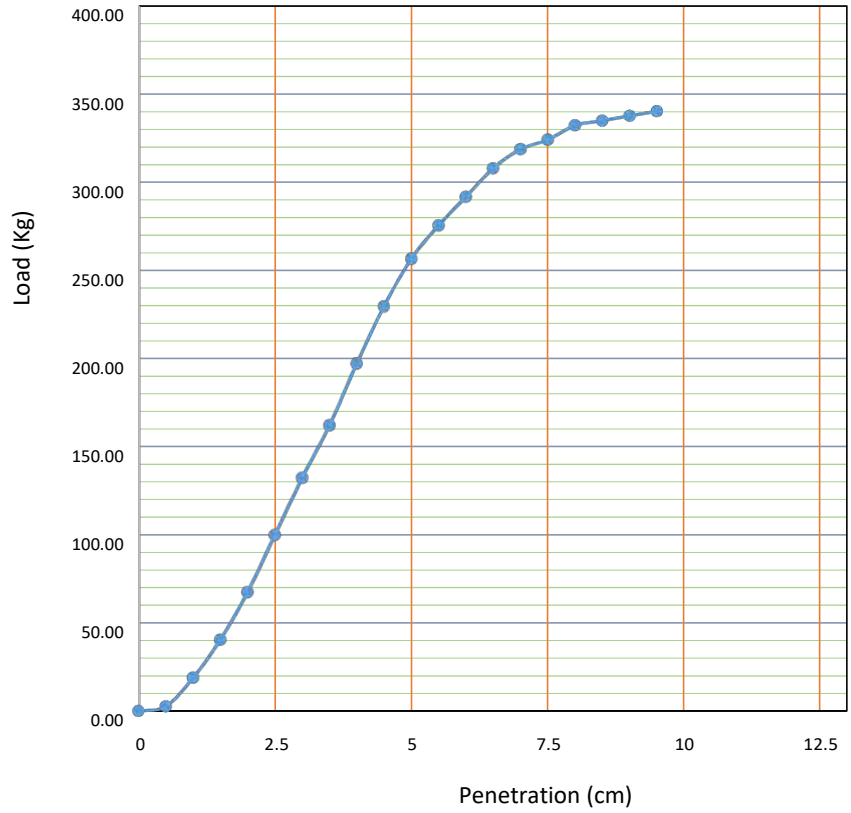
		DATE	09.11.2019
LOCATION	Ponnani Junction, Malappuram	**TRIAL PIT NO.**	1
TEST	Modified CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 1, DEPTH 1.50m

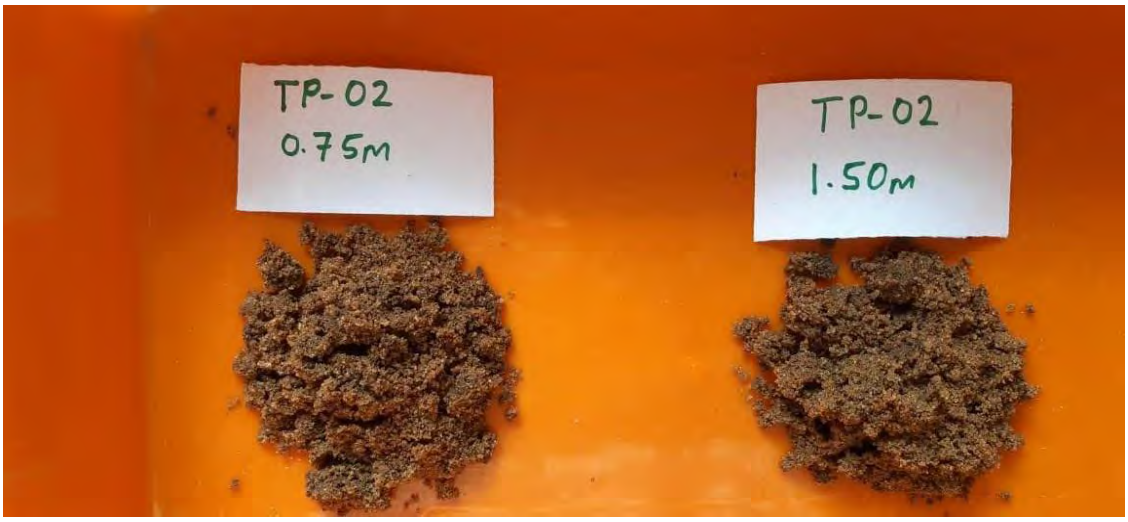


CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	99.9
Load at 5mm penetration, Kg	256.5
CBR at 2.5mm penetration	7
CBR at 5mm penetration	12
Recommended CBR value	**12**

7.2 Modified Proctor Test and CBR results at Trial Pit No: 2

Location: Ponnani, Malappuram

Chainage: 0/500



Modified Proctor Test at Chainage-0/500 (0.75 m depth)				**TRIAL PIT NUMBER**	2
				DEPTH, m	0.75
LOCATION	Ponnani, Malappuram	CHAINAGE	0/500	**SOIL CLASSIFICATION**	FINE SAND (SP)
TEST	MODIFIED PROCTOR				

SL No	**DETERMINATION OF DENSITY**	**6%**	**9%**	**12%**	**15%**	**18%**	**21%**
1	WT OF MOULD (gm)	3642	3642	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5565	5649	5743	5936	5894	5894
3	WT OF COMPACTED SOIL (gm)	1923	2007	2101	2294	2252	2252
4	VOLUME (cc)	1000	1000	1000	1000	1001	1002
5	BULK DENSITY (W/V)(g/cc)	1.923	2.007	2.101	2.294	2.250	2.248

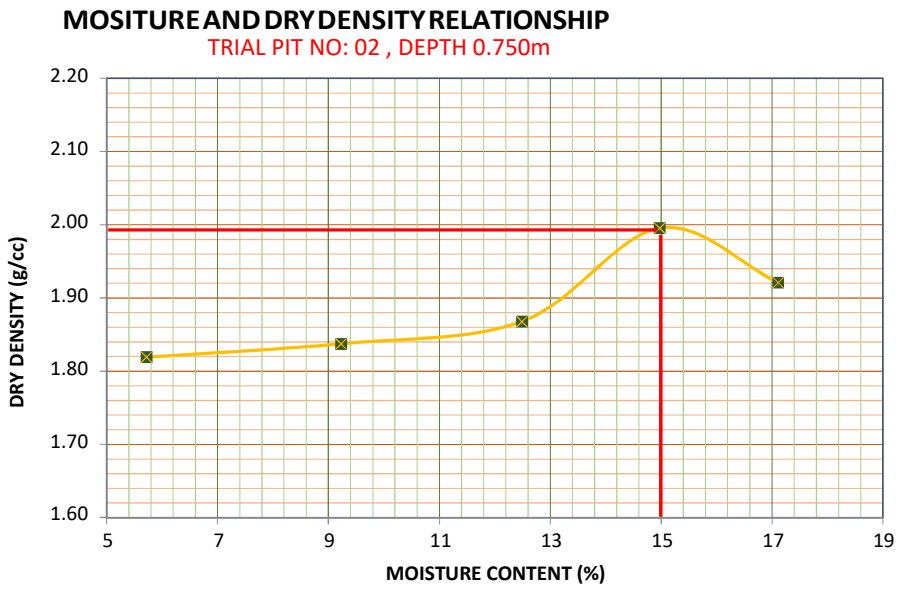
	WATER CONTENT DETERMINATION	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**
7	CONTAINER NO																		
8	WT OF CONTAINER, M1 (gm)	71.8	60.9	69.7	68.2	64.4	64.1	66	67.9	66.2	65.8	66.1	60.2	70.4	65.5	62	68.2	62.8	74.6
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	182.9	176.2	194.5	194.5	182.7	160.4	178.2	193	199.1	207.3	179.9	148.8	206.4	191.1	185.6	278.1	200.6	182
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	176.9	169.9	187.8	184.1	172.9	151.9	165.2	179.1	185	186.1	165.8	138.5	182	173.7	171	238.4	178.5	167.5
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	5.709	5.780	5.673	8.973	9.032	9.681	13.105	12.500	11.869	17.623	14.142	13.155	21.864	16.081	13.394	23.325	19.101	15.608
12	AVERAGE WATER CONTENT (%)	5.721			9.229			12.491			14.973			17.113			19.345		
13	**DRY DENSITY (g/cc)**	**1.819**			**1.837**			**1.868**			**1.995**			**1.921**			**1.883**		
	OPTIMUM MOISTURE CONTENT, OMC %	**14.973**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.995**								

MDD OUPUT VALUES

		DATE	06.11.2019
LOCATION	Ponnani Malappuram (CH: 0/500)	**TRIAL PIT NO.**	2
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	95	5	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.234	
Optimum Moisture Content (%)			14.973	
Maximum Dry Density, MDD (g/cc)			1.995	

CBR OUPUT VALUES

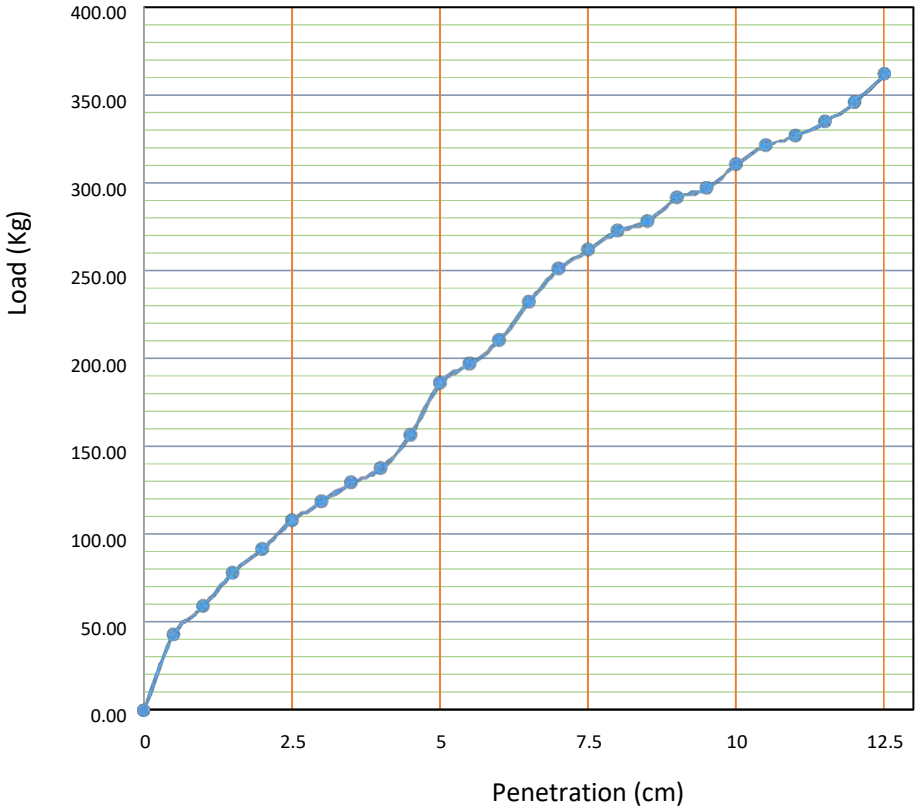
		DATE	11.11.2019
LOCATION	Ponnani , Malappuram	**TRIAL PIT NO.**	2
TEST	CBR Test	**DEPTH**	0.750m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 2, DEPTH 0.75m



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	108
Load at 5mm penetration, Kg	186.3
CBR at 2.5mm penetration	7
CBR at 5mm penetration	9
Recommended CBR value	**9**

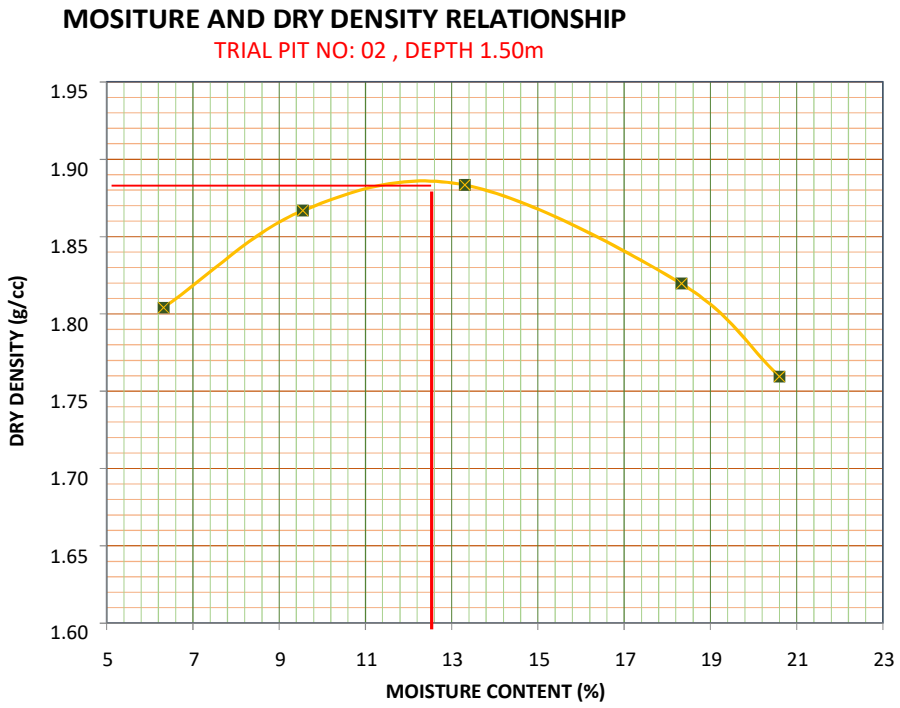
Modified Proctor Test at Chainage-0/500 (1.5 m depth)																		TRIAL PIT NUMBER	2
																		DEPTH, m	1.5
LOCATION	Near MES college, Ponnani , Malappuram				CHAINAGE		0/500											SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR																		
SL No	DETERMINATION OF DENSITY	6%			9%			12%			15%			18%					
1	WT OF MOULD (gm)	3642			3642			3642			3642			3642					
2	WT OF MOULD+ COMPACTED SOIL (gm)	5560			5687			5776			5795			5764					
3	WT OF COMPACTED SOIL (gm)	1918			2045			2134			2153			2122					
4	VOLUME (cc)	1000			1000			1000			1000			1000					
5	BULK DENSITY (W/V)(g/cc)	1.918			2.045			2.134			2.153			2.122					
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM			
7	CONTAINER NO																		
8	WT OF CONTAINER, M1 (gm)	58	60.4	72.5	68.2	66.3	68.5	60.9	64.2	65.7	71.2	71.4	62.4	48.3	53.32	54.25			
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	138.4	182.6	209.7	183.3	189	193.2	180.8	217.9	192.6	205.7	210.4	165.1	150.9	179.7	164.9			
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	133.59	175.34	201.6	173.12	178.19	182.61	164.76	201.11	178.79	185	189	149	131.38	158.4	148			
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	6.363	6.316	6.274	9.703	9.661	9.281	15.444	12.264	12.212	18.190	18.197	18.591	23.495	20.270	18.027			
12	AVERAGE WATER CONTENT (%)	6.318			9.548			13.306			18.326			20.597					
13	DRY DENSITY (g/cc)	1.804			1.867			1.883			1.820			1.760					
	OPTIMUM MOISTURE CONTENT, OMC %	13.306			MAXIMUM DRY DENSITY, MDD (g/cc)						1.883								

MDD OUPUT VALUES

		DATE	01.11.2019
LOCATION	Ponnani Junction, Malappuram (CH: 0/500)	**TRIAL PIT NO.**	2
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	95	5	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.109	
Optimum Moisture Content (%)			13.306	
Maximum Dry Density, MDD (g/cc)			1.883	

CBR OUPUT VALUES

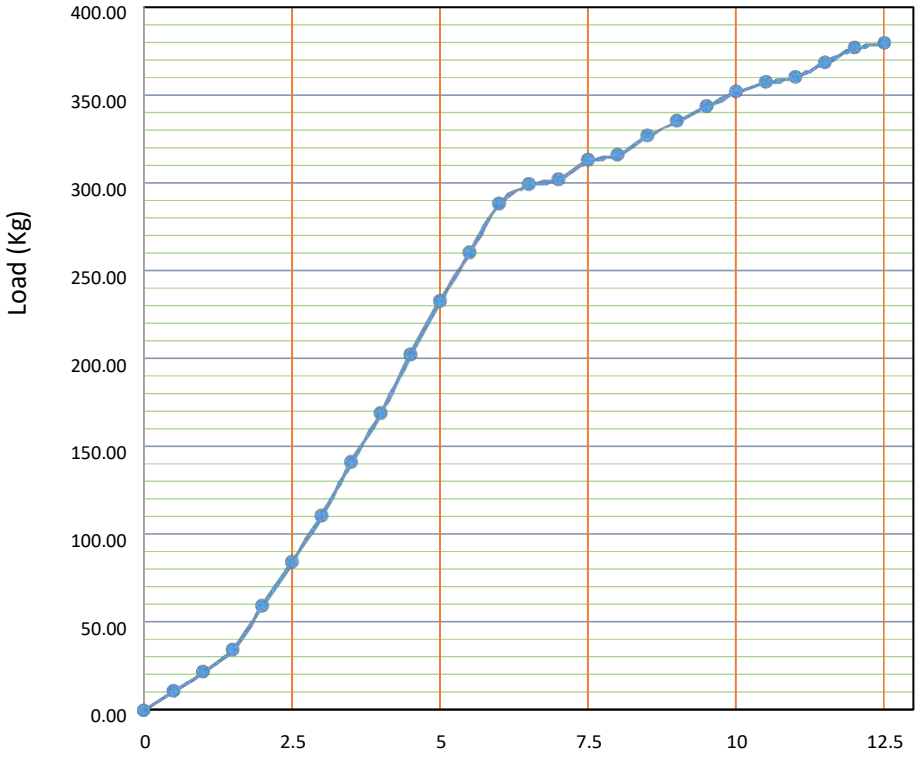
		DATE	07.11.2019
LOCATION	Near MES college ,Ponnani, Malappuram	**TRIAL PIT NO.**	2
TEST	Modified CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 1, DEPTH 1.50m

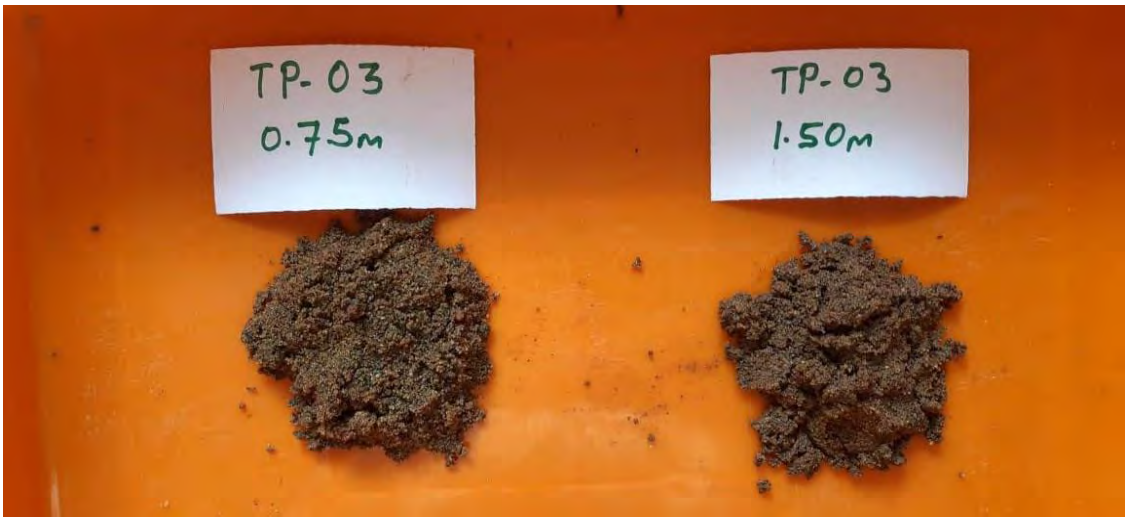


CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	84.485
Load at 5mm penetration, Kg	232.68
CBR at 2.5mm penetration	6
CBR at 5mm penetration	11
Recommended CBR value	**11**

7.3 Modified Proctor Test and CBR results at Trial Pit No: 3

Location: Ponnani, Malappuram

Chainage: 1/000



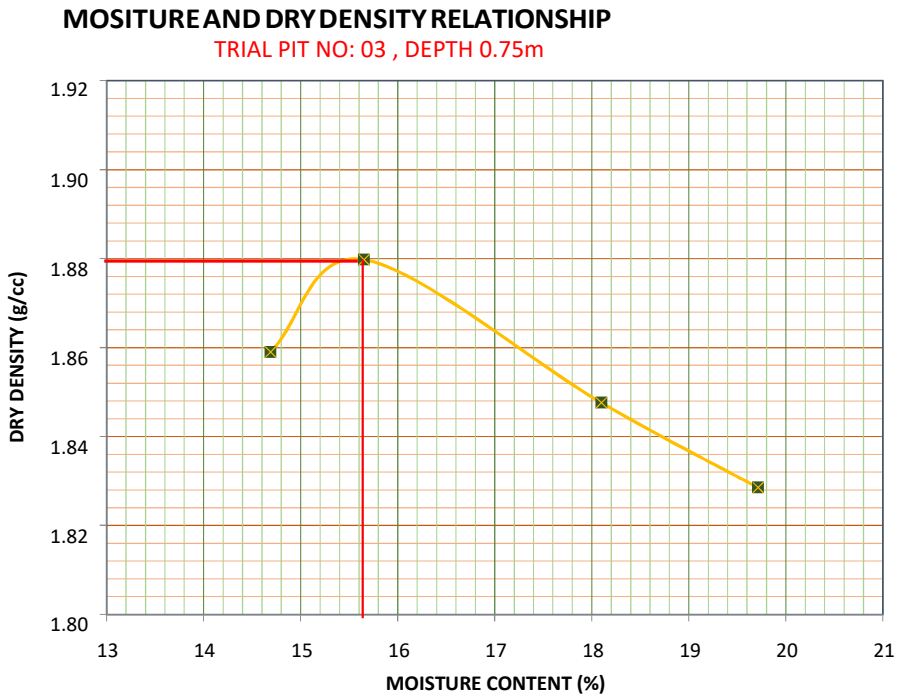
Modified Proctor Test at Chainage-1/000 (0.75 m depth)													TRIAL PIT NUMBER	3
													DEPTH, m	0.75
LOCATION	Near TB Hospital , Ponnani Malappuram			CHAINAGE		1/000							SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR													
SL No	DETERMINATION OF DENSITY	15%			18%			21%			24%			
1	WT OF MOULD (gm)	3642			3642			3642			3642			
2	WT OF MOULD+ COMPACTED SOIL (gm)	5774			5816			5824			5831			
3	WT OF COMPACTED SOIL (gm)	2132			2174			2182			2189			
4	VOLUME (cc)	1000			1000			1000			1000			
5	BULK DENSITY (W/V)(g/cc)	2.132			2.174			2.182			2.189			
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	
7	CONTAINER NO													
8	WT OF CONTAINER, M1 (gm)	65.2	72.3	67.6	73.2	66.7	64.1	68.1	72.1	67.2	65.5	65.3	70.2	
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	155.3	182.4	156.7	195.9	170.8	146.7	200.7	175	199.2	214.9	222.7	224.1	
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	142.8	168.5	146.1	178.5	156.3	136.4	178.7	159	181	188	198	200	
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	16.108	14.449	13.503	16.524	16.183	14.246	19.892	18.412	15.993	21.959	18.613	18.567	
12	AVERAGE WATER CONTENT (%)	14.687			15.651			18.099			19.713			
13	DRY DENSITY (g/cc)	1.859			1.880			1.848			1.829			
	OPTIMUM MOISTURE CONTENT, OMC %	15.651			MAXIMUM DRY DENSITY, MDD (g/cc)						1.880			

MDD OUPUT VALUES

		DATE	07.11.2019
LOCATION	Ponnani Junction, Malappuram (CH: 0/1000)	**TRIAL PIT NO.**	3
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



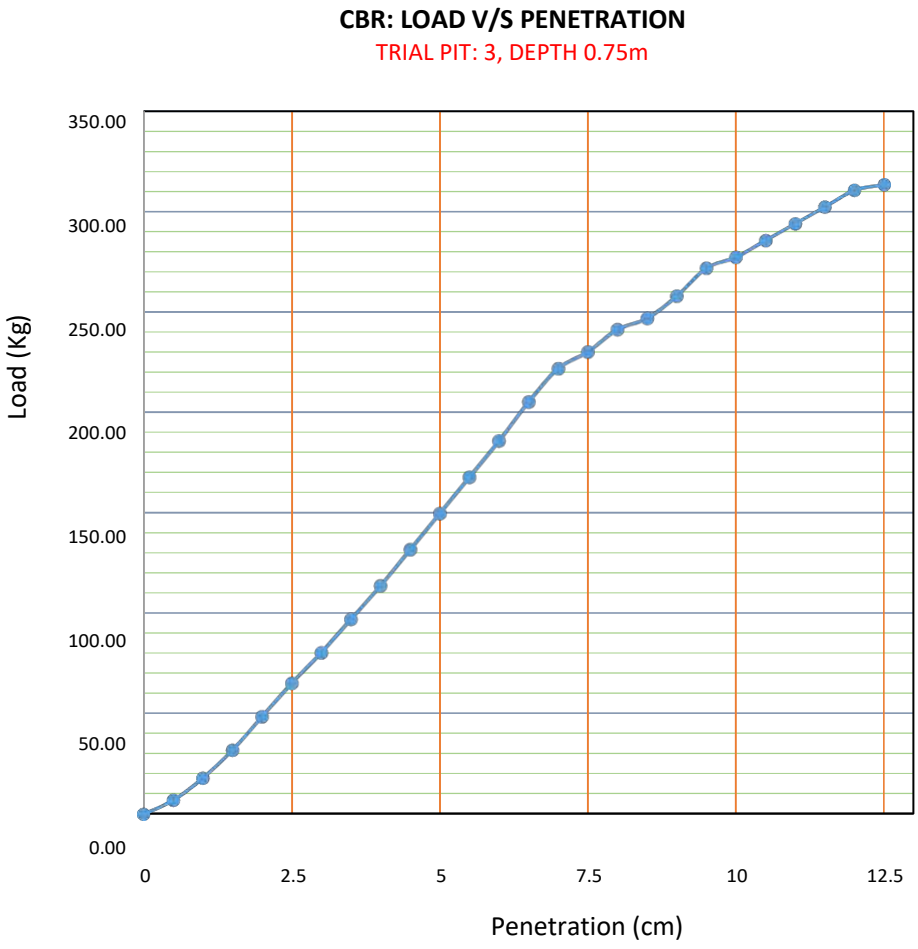
SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	97	3	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.106	
Optimum Moisture Content (%)			15.651	
Maximum Dry Density, MDD (g/cc)			1.880	

CBR OUPUT VALUES

		DATE	14.11.2019
LOCATION	Near TB Hospital , Ponnani Malappuram	**TRIAL PIT NO.**	3
TEST	Modified CBR Test	**DEPTH**	0.75m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	65.095
Load at 5mm penetration, Kg	149.58
CBR at 2.5mm penetration	4
CBR at 5mm penetration	7
Recommended CBR value	**7**

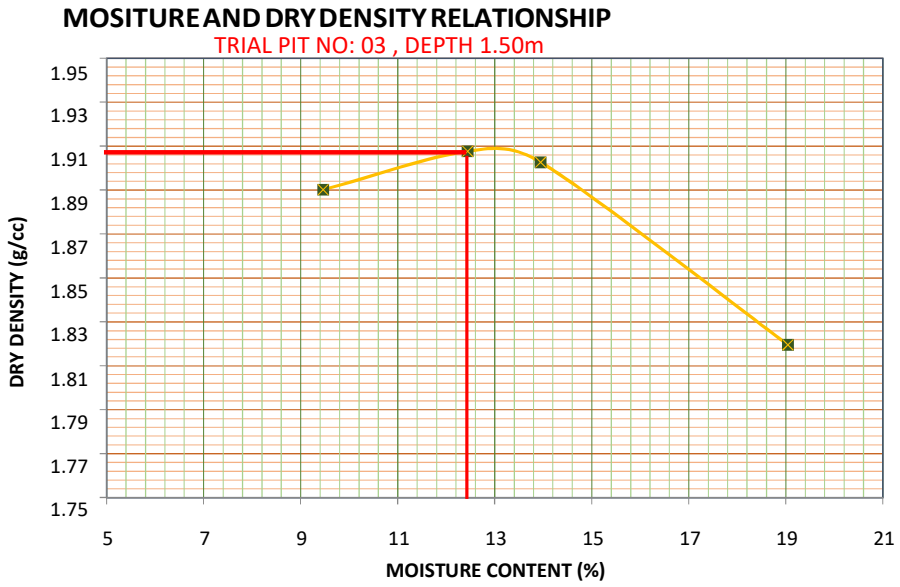
Modified Proctor Test at Chainage-1/000 (1.5 m depth)														TRIAL PIT NUMBER	3
														DEPTH, m	1.5
LOCATION	Near TB hospital, Ponnani , Malappuram			CHAINAGE		1/000								SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR														
SL No	DETERMINATION OF DENSITY	9%			12%			15%			18%				
1	WT OF MOULD (gm)	3642			3642			3642			3642				
2	WT OF MOULD+ COMPACTED SOIL (gm)	5711			5787			5810			5808				
3	WT OF COMPACTED SOIL (gm)	2069			2145			2168			2166				
4	VOLUME (cc)	1000			1000			1000			1000				
5	BULK DENSITY (W/V)(g/cc)	2.069			2.145			2.168			2.166				
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM		
7	CONTAINER NO														
8	WT OF CONTAINER, M1 (gm)	64.4	64.4	65.5	67.2	70.1	70	72.2	70.9	62.3	74	61	64.2		
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	154.4	188.9	163.4	151.9	166.2	151.4	174.2	193.6	178	198.7	155.5	183.8		
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	147.6	175.4	156.1	141.8	156.4	142.4	161.3	178.6	164.3	177	140.7	166		
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	8.173	12.162	8.057	13.539	11.356	12.431	14.478	13.928	13.431	21.068	18.570	17.485		
12	AVERAGE WATER CONTENT (%)	9.464			12.442			13.946			19.041				
13	DRY DENSITY (g/cc)	1.890			1.908			1.903			1.820				
	OPTIMUM MOISTURE CONTENT, OMC %	12.440			MAXIMUM DRY DENSITY, MDD (g/cc)						1.908				

MDD OUPUT VALUES

		DATE	08.11.2019
LOCATION	Near TB hospital, Ponnani , Malappuram(CH: 1000)	**TRIAL PIT NO.**	3
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	97	3	0

OMC TEST SPECIMEN DETAILS	
Bulk Dry Density, MDD (g/cc)	2.137
Optimum Moisture Content (%)	12.422
Maximum Dry Density, MDD (g/cc)	1.908

CBR OUPUT VALUES

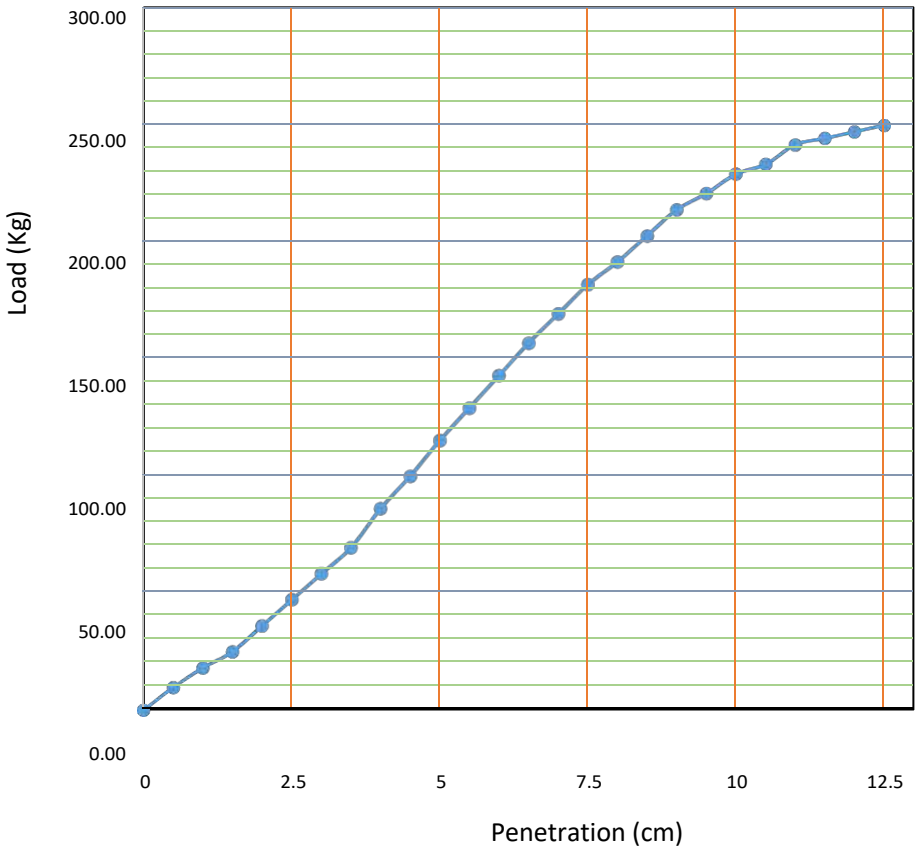
		DATE	07.11.2019
LOCATION	Near TB hospital, Ponnani , Malappuram	**TRIAL PIT NO.**	3
TEST	CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 3, DEPTH 1.50m

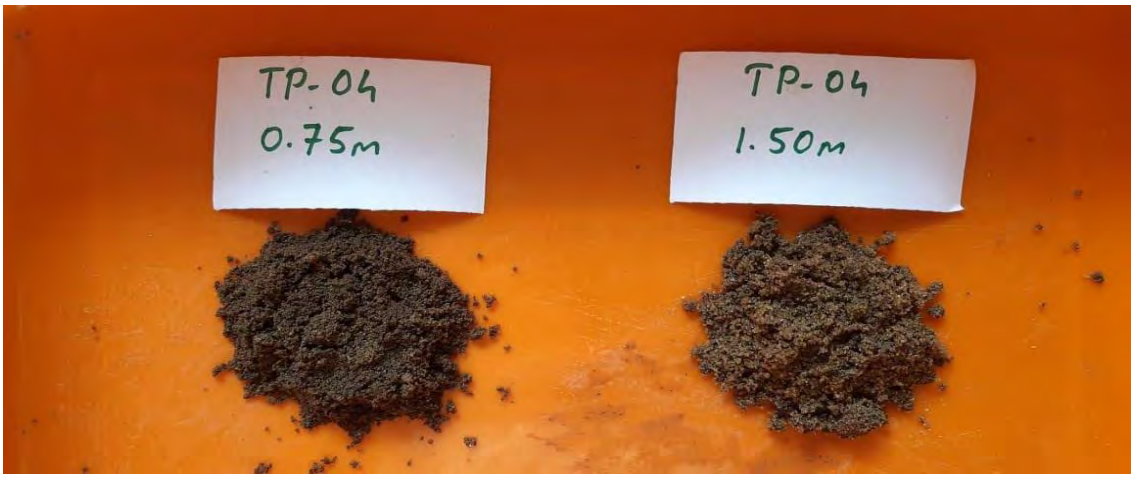


CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	47.09
Load at 5mm penetration, Kg	114.955
CBR at 2.5mm penetration	3
CBR at 5mm penetration	5
Recommended CBR value	**5**

7.4 . Modified Proctor Test and CBR results at Trial Pit No: 4

Location: Ponnani, Malappuram

Chainage: 1/500



Modified Proctor Test at Chainage-1/000 (1.5 m depth)				TRIAL PIT NUMBER	4
				DEPTH, m	0.75
LOCATION	Near Rzwana Tea Stall , Ponnani Malappuram	CHAINAGE	0/1500	SOIL CLASSIFICATION	FINE SAND (SM)
TEST	MODIFIED PROCTOR				

SL No	DETERMINATION OF DENSITY	9%	12%	15%	18%
1	WT OF MOULD (gm)	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5681	5776	5816	5814
3	WT OF COMPACTED SOIL (gm)	2039	2134	2174	2172
4	VOLUME (cc)	1000	1000	1000	1000
5	BULK DENSITY (W/V)(g/cc)	2.039	2.134	2.174	2.172

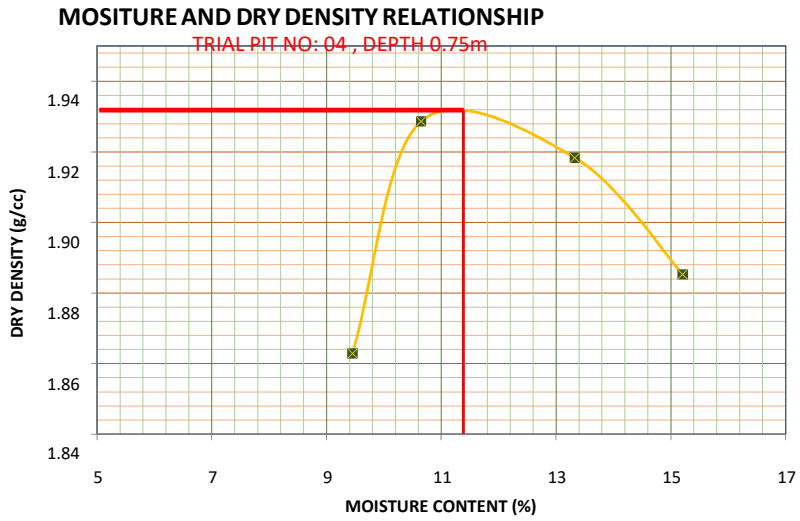
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM
7	CONTAINER NO												
8	WT OF CONTAINER, M1 (gm)	65.2	58.1	70.9	71	68.3	65.9	69.4	60.5	65.5	58.2	63.6	70.1
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	167.2	169.1	205.9	165.7	142	169.7	211.8	211.4	154.6	201.5	193	190.9
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	158.63	159.45	194.01	156.3	135	159.9	193.1	193.8	145.3	178.9	176.7	177.5
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	9.173	9.521	9.658	11.020	10.495	10.426	15.117	13.203	11.654	18.724	14.412	12.477
12	AVERAGE WATER CONTENT (%)	9.451			10.647			13.325			15.204		
13	**DRY DENSITY (g/cc)**	**1.863**			**1.929**			**1.918**			**1.885**		
	OPTIMUM MOISTURE CONTENT, OMC %	**11.400**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.932**		

MDD OUPUT VALUES

		DATE	09.11.2019
LOCATION	Near Rzwana Tea Stall, Ponnani Junction (CH: 0/1500)	**TRIAL PIT NO.**	4
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SM)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SM	0	88	12	0

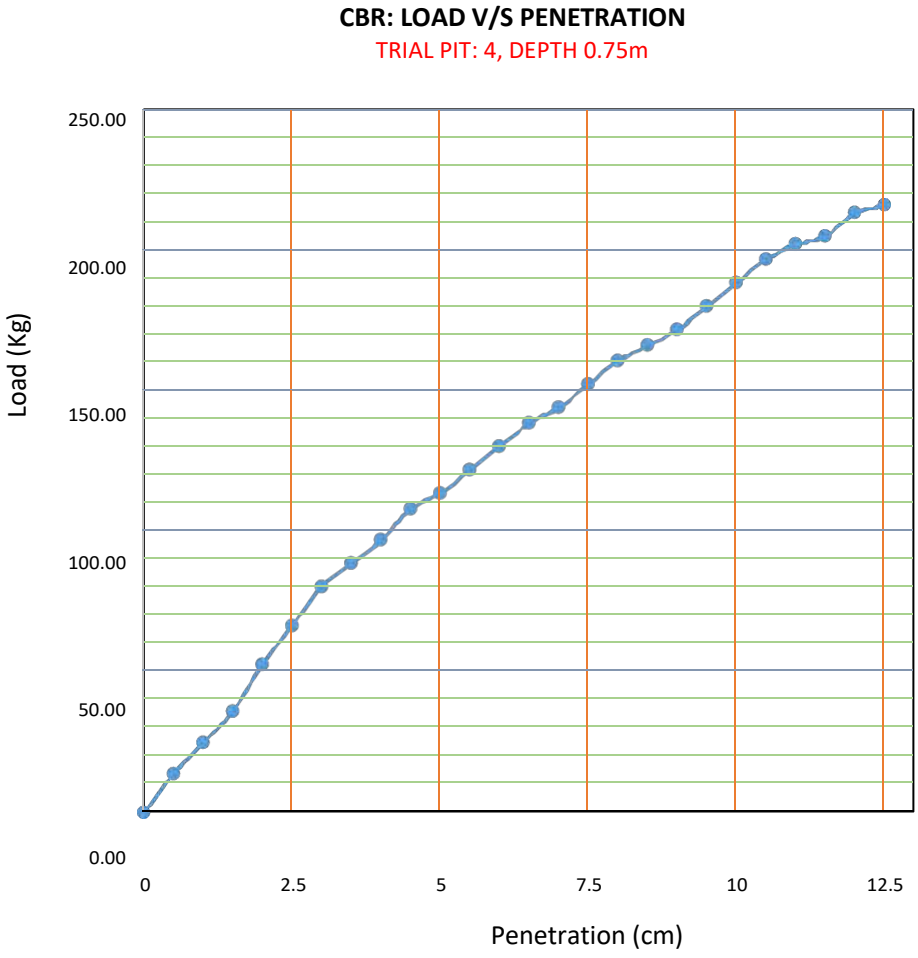
OMC TEST SPECIMEN DETAILS	
Bulk Dry Density, MDD (g/cc)	2.164
Optimum Moisture Content (%)	11.400
Maximum Dry Density, MDD (g/cc)	1.932

CBR OUPUT VALUES

		DATE	14.11.2019
LOCATION	Near Rzwana Tea Stall, Ponnani Malappuram	**TRIAL PIT NO.**	4
TEST	Modified CBR Test	**DEPTH**	0.75m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	66.48
Load at 5mm penetration, Kg	113.57
CBR at 2.5mm penetration	4
CBR at 5mm penetration	5
Recommended CBR value	**5**

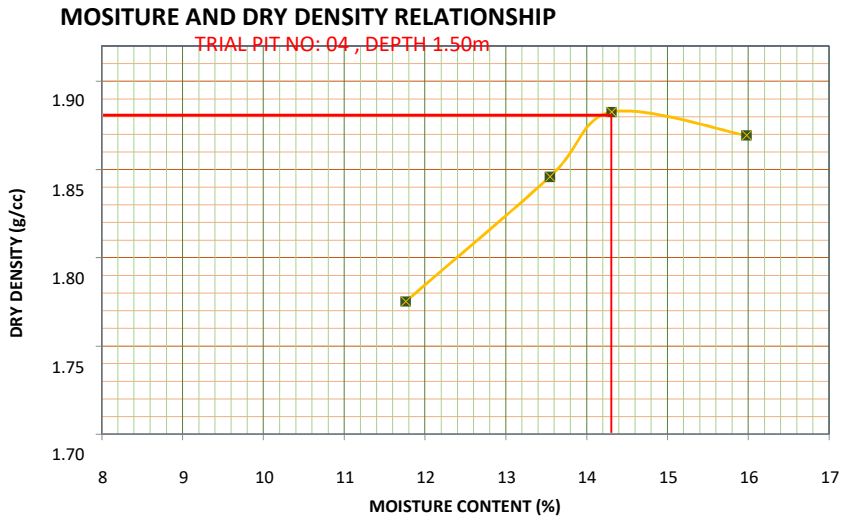
Modified Proctor Test at Chainage-1/500 (1.5 m depth)													TRIAL PIT NUMBER	4
													DEPTH, m	1.5
LOCATION	Near Rizuwana tea stall , Ponnani Malappuram			CHAINAGE		1/500							SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR													
SL No	DETERMINATION OF DENSITY	12%			15%			18%			21%			
1	WT OF MOULD (gm)	3642			3642			3642			3642			
2	WT OF MOULD+ COMPACTED SOIL (gm)	5626			5738			5794			5810			
3	WT OF COMPACTED SOIL (gm)	1984			2096			2152			2168			
4	VOLUME (cc)	1000			1000			1000			1000			
5	BULK DENSITY (W/V)(g/cc)	1.984			2.096			2.152			2.168			
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	
7	CONTAINER NO													
8	WT OF CONTAINER, M1 (gm)	60.5	66.7	68.8	67.8	68.1	66.3	65.6	72.7	74.9	67.4	65.8	62.5	
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	159.1	156.7	189.1	164.4	173.9	179.9	168	221.9	168.3	197.8	180.1	161.8	
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	149.19	147.13	176.01	152.14	161.24	167.27	155.54	202.69	156.62	179.9	163.84	148.52	
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	11.174	11.899	12.210	14.536	13.592	12.509	13.854	14.778	14.293	15.911	16.585	15.438	
12	AVERAGE WATER CONTENT (%)	11.761			13.546			14.308			15.978			
13	DRY DENSITY (g/cc)	1.775			1.846			1.883			1.869			
	OPTIMUM MOISTURE CONTENT, OMC %	14.308			MAXIMUM DRY DENSITY, MDD (g/cc)						1.883			

MDD OUPUT VALUES

		DATE	07.11.2019
LOCATION	Near Rizuwana tea stall , Ponnani Malappuram (CH: 0/1500)	**TRIAL PIT NO.**	4
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION	Dynamic Heavy Compaction		

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	94	6	0

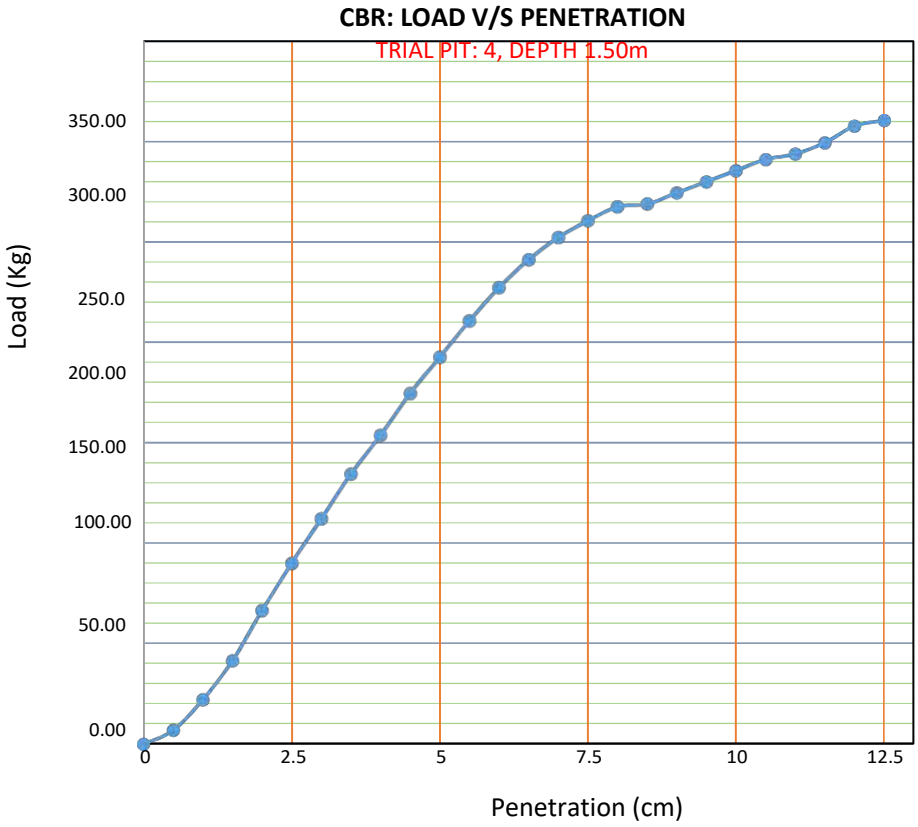
OMC TEST SPECIMEN DETAILS	
Bulk Dry Density, MDD (g/cc)	2.109
Optimum Moisture Content (%)	14.308
Maximum Dry Density, MDD (g/cc)	1.883

CBR OUPUT VALUES

		DATE	11.11.2019
LOCATION	Near Rizuwana tea stall , Ponnani Malappuram	**TRIAL PIT NO.**	4
TEST	Modified CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

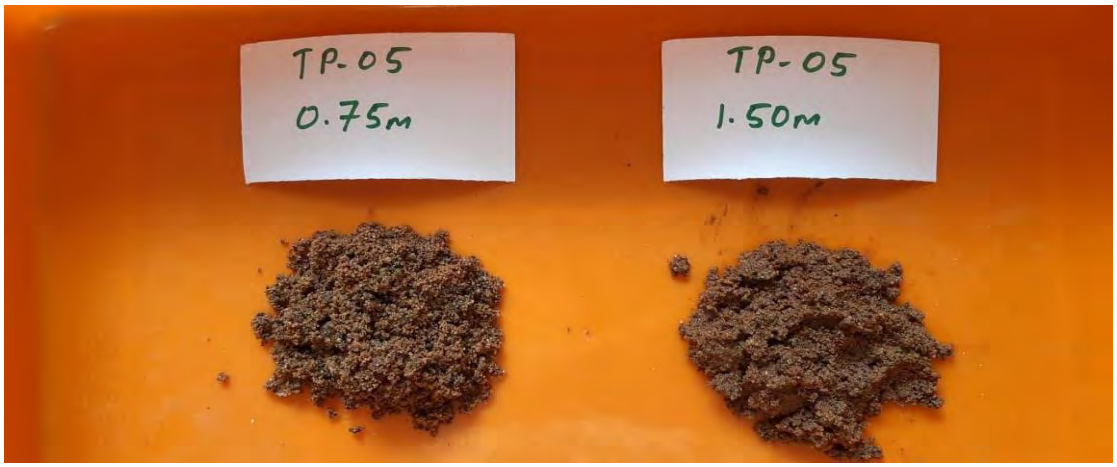


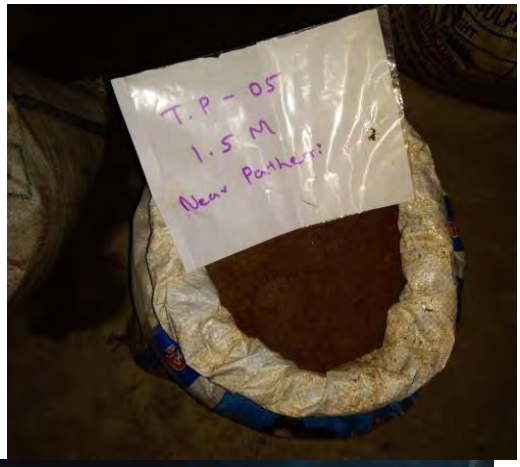
CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	90.025
Load at 5mm penetration, Kg	192.515
CBR at 2.5mm penetration	6
CBR at 5mm penetration	9
Recommended CBR value	**9**

7.5 Modified Proctor Test and CBR results at Trial Pit No: 5

Location: Ponnani, Malappuram

Chainage: 2/000





Modified Proctor Test at Chainage-2/000 (0.75 m depth)				TRIAL PIT NUMBER	5
				DEPTH, m	0.75
LOCATION	Ponnani Malappuram	CHAINAGE	2/000	SOIL CLASSIFICATION	FINE SAND (SP)
TEST	MODIFIED PROCTOR				

SL No	DETERMINATION OF DENSITY	12%	15%	18%	21%
1	WT OF MOULD (gm)	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5751	5865	5936	5894
3	WT OF COMPACTED SOIL (gm)	2109	2223	2294	2252
4	VOLUME (cc)	1000	1000	1000	1000
5	BULK DENSITY (W/V)(g/cc)	2.109	2.223	2.294	2.252

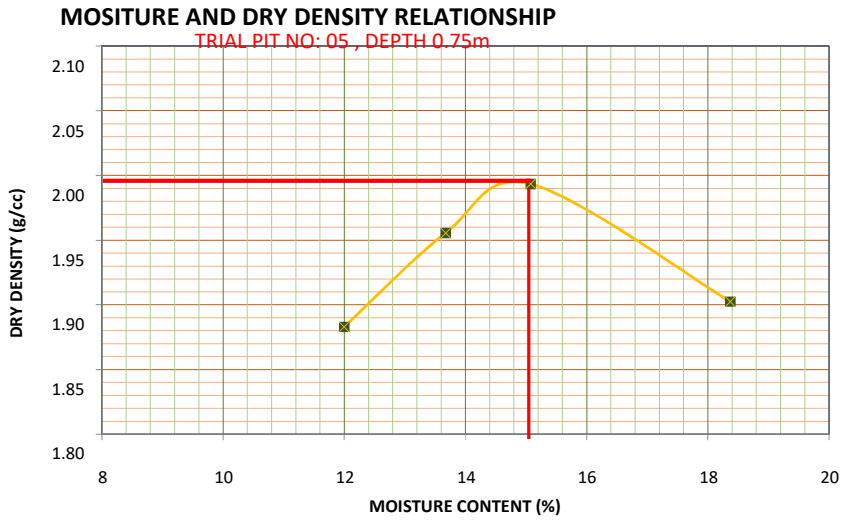
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM
7	CONTAINER NO												
8	WT OF CONTAINER, M1 (gm)	63	70.18	65.8	70.3	65.5	66.1	68.6	67.9	63.6	68.4	69.1	65.5
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	159.8	208.7	205.5	191	201.5	147.1	164.3	131	157.5	143.9	175.7	163.8
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	149.28	193.82	190.8	175.71	184.67	138.17	150	123.64	145.64	130.59	159.22	150.67
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	12.193	12.035	11.760	14.505	14.123	12.391	17.568	13.204	14.456	21.402	18.287	15.416
12	AVERAGE WATER CONTENT (%)	11.996			13.673			15.076			18.368		
13	DRY DENSITY (g/cc)	1.883			1.956			1.993			1.903		
	OPTIMUM MOISTURE CONTENT, OMC %	14.300			MAXIMUM DRY DENSITY, MDD (g/cc)						1.993		

MDD OUPUT VALUES

		DATE	07.11.2019
LOCATION	Ponnani Malappuram (CH: 0/2000)	**TRIAL PIT NO.**	5
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION	Dynamic Heavy Compaction		

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SP)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SP	0	98	2	0

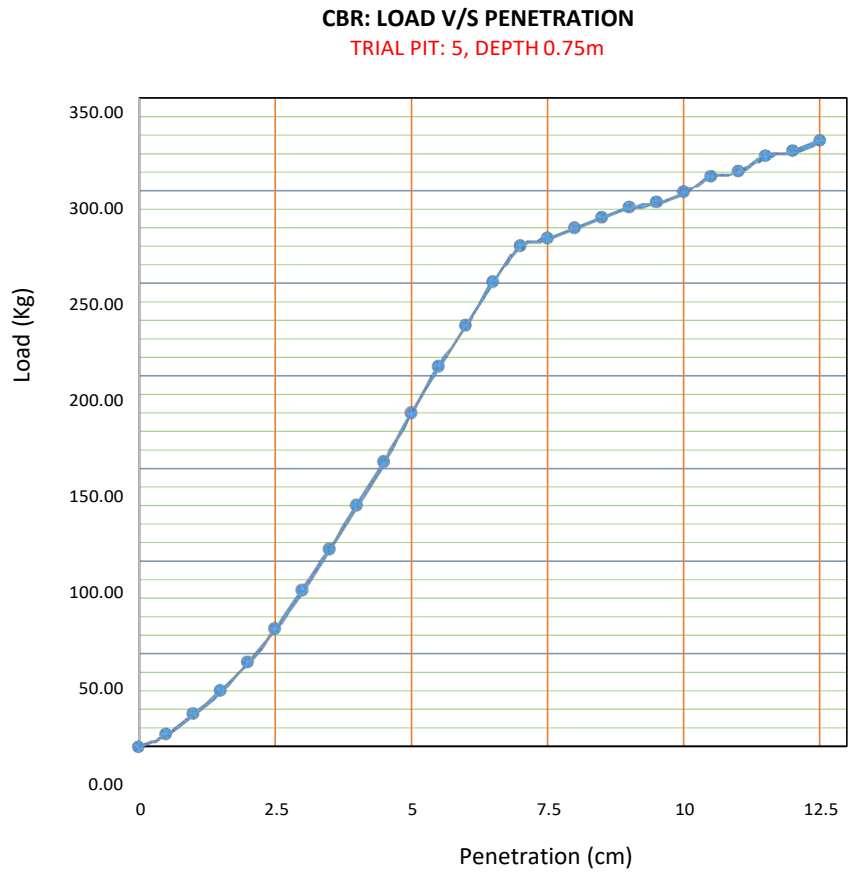
OMC TEST SPECIMEN DETAILS	
Bulk Dry Density, MDD (g/cc)	2.109
Optimum Moisture Content (%)	14.300
Maximum Dry Density, MDD (g/cc)	1.993

CBR OUPUT VALUES

		DATE	13.11.2019
LOCATION	Ponnani Malappuram	**TRIAL PIT NO.**	5
TEST	Modified CBR Test	**DEPTH**	0.75m
CONDITION OF SPECIMEN AT TEST	Remoulded Soaked		
TYPE OF COMPACTION	Dynamic Heavy Compaction		

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	63.71
Load at 5mm penetration, Kg	180.05
CBR at 2.5mm penetration	4
CBR at 5mm penetration	8
Recommended CBR value	**8**

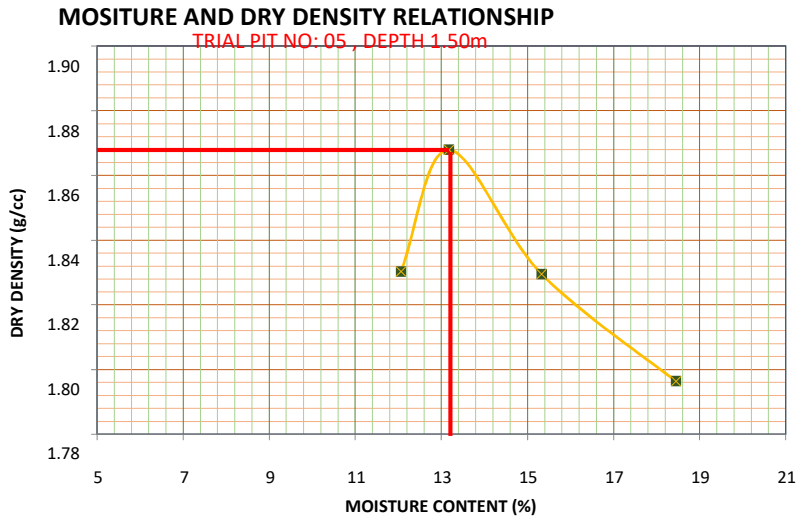
Modified Proctor Test at Chainage-2/000 (1.5 m depth)												TRIAL PIT NUMBER		5
												DEPTH, m		1.5
LOCATION	Ponnani Malappuram				CHAINAGE		2/000					SOIL CLASSIFICATION		FINE SAND (SM)
TEST	MODIFIED PROCTOR													
SL No	DETERMINATION OF DENSITY	12%			15%			18%			21%			
1	WT OF MOULD (gm)	3642			3642			3642			3642			
2	WT OF MOULD+ COMPACTED SOIL (gm)	5693			5756			5752			5772			
3	WT OF COMPACTED SOIL (gm)	2051			2114			2110			2130			
4	VOLUME (cc)	1000			1000			1000			1001			
5	BULK DENSITY (W/V)(g/cc)	2.051			2.114			2.110			2.128			
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	
7	CONTAINER NO													
8	WT OF CONTAINER, M1 (gm)	71.3	64.3	68.5	64.8	65.6	69.2	65.4	55.1	60.8	65.8	60.35	67.25	
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	154.7	157.7	150.8	157.4	170.1	169.4	156.7	150.7	190.4	158	153	169	
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	145.9	147.5	141.9	146.4	157.4	158.5	142	139.1	175.5	142.1	139.1	154.32	
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	11.796	12.260	12.125	13.480	13.834	12.206	19.191	13.810	12.990	20.839	17.651	16.860	
12	AVERAGE WATER CONTENT (%)	12.060			13.174			15.330			18.450			
13	DRY DENSITY (g/cc)	1.830			1.868			1.830			1.796			
	OPTIMUM MOISTURE CONTENT, OMC %	13.200			MAXIMUM DRY DENSITY, MDD (g/cc)						1.868			

MDD OUPUT VALUES

		DATE	08.11.2019
LOCATION	Ponnani (CH: 0/2000)	**TRIAL PIT NO.**	5
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SM)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SM	0	84	16	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)		2.092		
Optimum Moisture Content (%)		13.200		
Maximum Dry Density, MDD (g/cc)		1.868		

CBR OUPUT VALUES

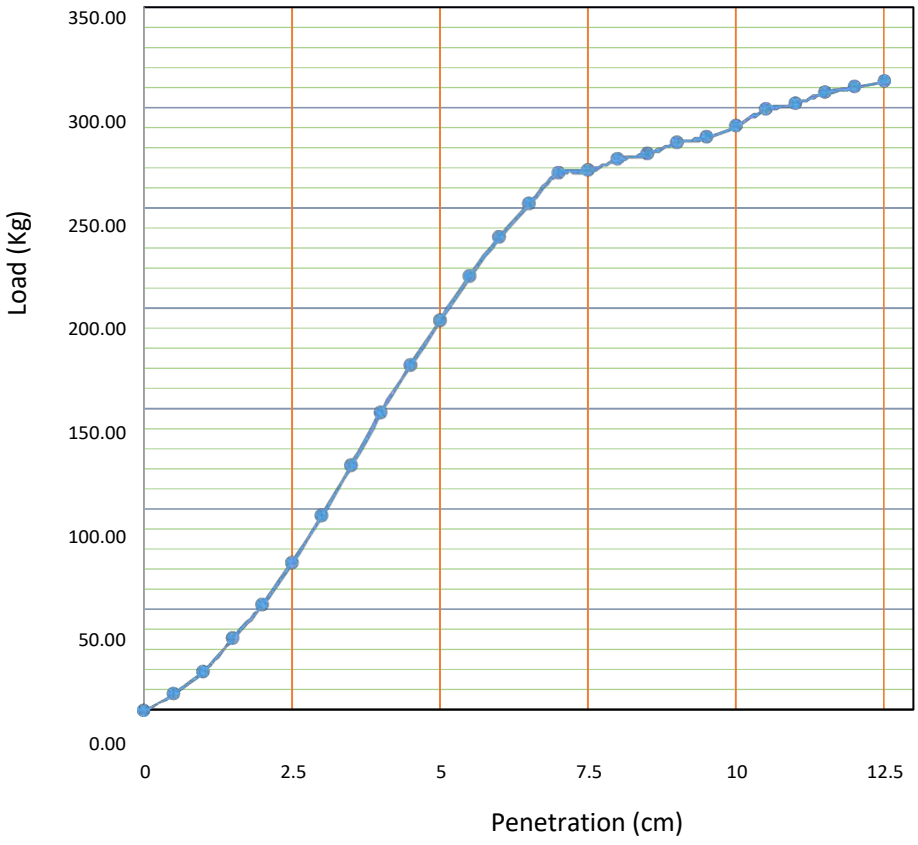
		DATE	16.11.2019
LOCATION	Ponnani Malappuram (CH 2000)	**TRIAL PIT NO.**	5
TEST	Modified CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 5, DEPTH 1.50m

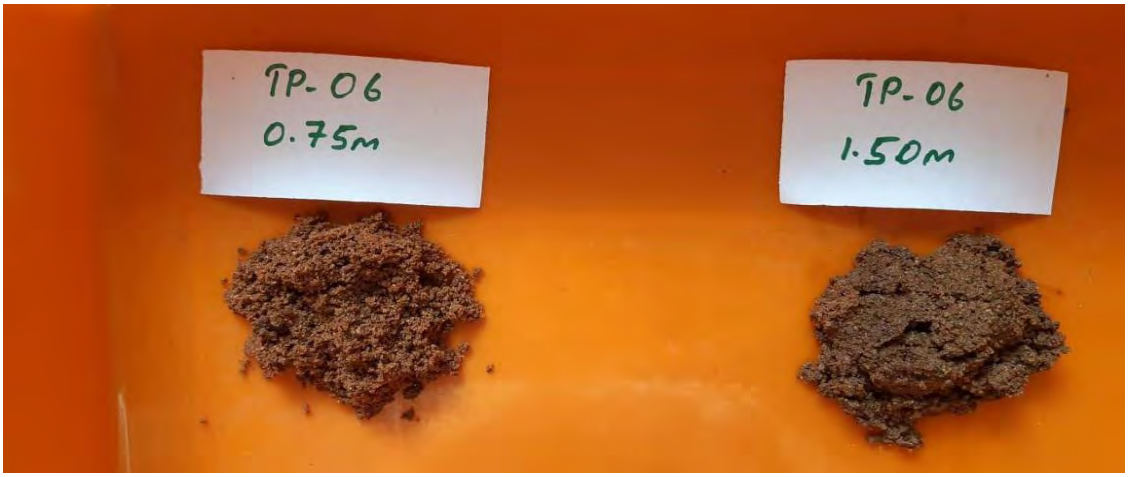


CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	73.405
Load at 5mm penetration, Kg	193.9
CBR at 2.5mm penetration	5
CBR at 5mm penetration	9
Recommended CBR value	**9**

7.6 Modified Proctor Test and CBR results at Trial Pit No: 6

Location: Ponnani, Malappuram

Chainage: 2/500



Modified Proctor Test at Chainage-2/500 (0.75 m depth)				**TRIAL PIT NUMBER**	6
				DEPTH, m	0.75
LOCATION	Ponnani Malappuram	CHAINAGE	2/500	**SOIL CLASSIFICATION**	FINE SAND (SM)
TEST	MODIFIED PROCTOR				

SL No	**DETERMINATION OF DENSITY**	**3%**	**6%**	**9%**	**12%**	**15%**
1	WT OF MOULD (gm)	3642	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5476	5595	5650	5840	5830
3	WT OF COMPACTED SOIL (gm)	1834	1953	2008	2198	2188
4	VOLUME (cc)	1000	1000	1000	1001	1002
5	BULK DENSITY (W/V)(g/cc)	1.834	1.953	2.008	2.196	2.184

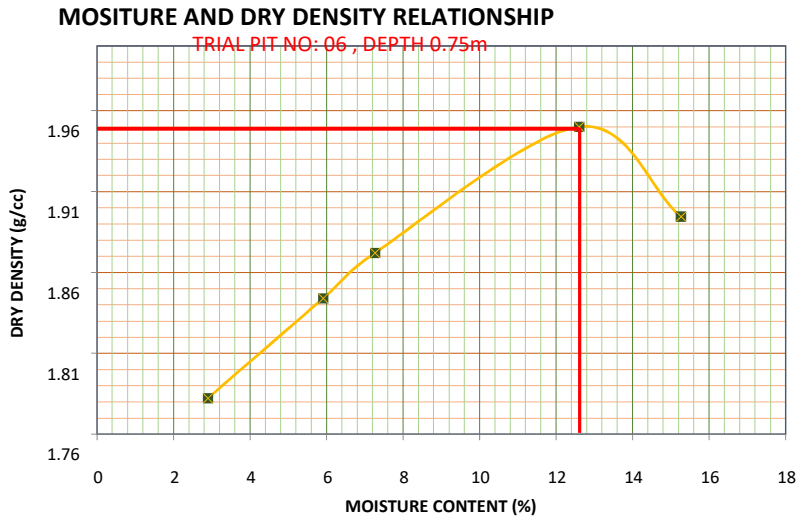
	WATER CONTENT DETERMINATION	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**
7	CONTAINER NO															
8	WT OF CONTAINER, M1 (gm)	65.7	65.5	74.9	67.2	77.3	73.1	85.9	62.5	74	67	67.2	70.1	72.3	67.7	63.2
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	168.1	180.3	199.7	226.6	252.9	193.1	247.5	218.7	221.3	293.5	191.3	226.3	255.4	220.6	247.6
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	165.11	177.14	196.23	217.7	242.89	186.55	233.82	205.56	216.52	268.06	177.56	208.71	228.03	201.45	225.12
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	3.008	2.831	2.860	5.914	6.045	5.773	9.248	9.185	3.354	12.653	12.450	12.690	17.575	14.318	13.883
12	AVERAGE WATER CONTENT (%)	2.899			5.911			7.262			12.598			15.259		
13	**DRY DENSITY (g/cc)**	**1.782**			**1.844**			**1.872**			**1.950**			**1.895**		
	OPTIMUM MOISTURE CONTENT, OMC %	**12.600**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.951**					

MDD OUPUT VALUES

		DATE	01.11.2019
LOCATION	Ponnani (CH: 0/2500)	**TRIAL PIT NO.**	6
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SM)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SM	0	96	4	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.185	
Optimum Moisture Content (%)			12.600	
Maximum Dry Density, MDD (g/cc)			1.951	

CBR OUPUT VALUES

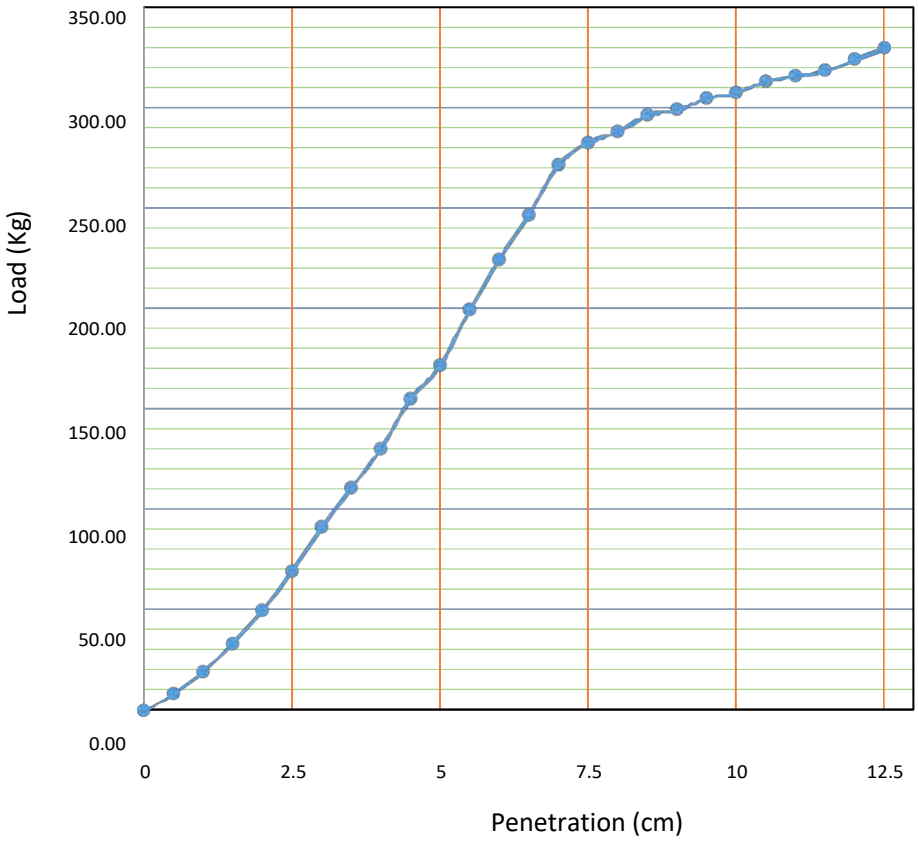
		DATE	05.11.2019
LOCATION	Ponnani Malappuram (CH 2500)	**TRIAL PIT NO.**	6
TEST	Modified CBR Test	**DEPTH**	0.75m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 6, DEPTH 0.75m



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	69.25
Load at 5mm penetration, Kg	171.74
CBR at 2.5mm penetration	5
CBR at 5mm penetration	8
Recommended CBR value	**8**

Modified Proctor Test at Chainage-2/500 (1.5 m depth)				TRIAL PIT NUMBER	6
				DEPTH, m	1.5
LOCATION	Ponnani Malappuram	CHAINAGE	2/500	SOIL CLASSIFICATION	FINE SAND (SM)
TEST	MODIFIED PROCTOR				

SL No	DETERMINATION OF DENSITY	6%	9%	12%	15%	18%
1	WT OF MOULD (gm)	3642	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5485	5557	5650	5766	5757
3	WT OF COMPACTED SOIL (gm)	1843	1915	2008	2124	2115
4	VOLUME (cc)	1000	1000	1000	1001	1000
5	BULK DENSITY (W/V)(g/cc)	1.843	1.915	2.008	2.122	2.1150

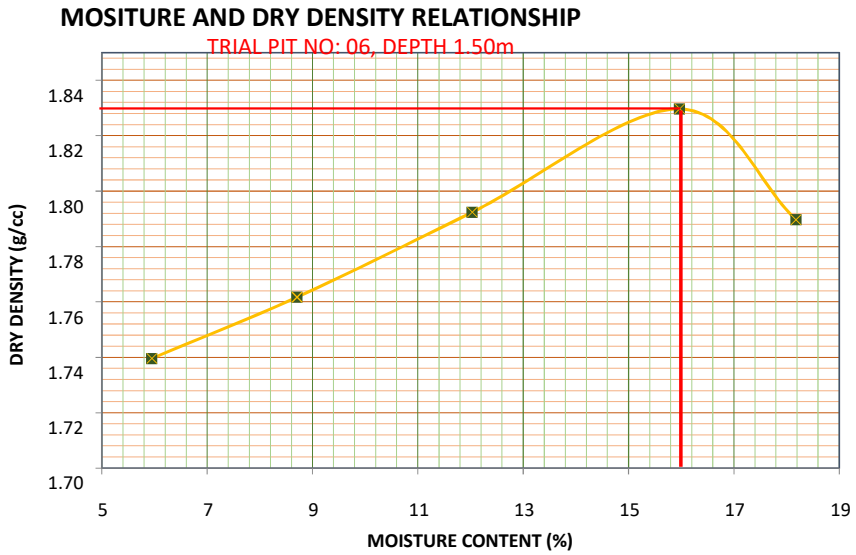
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM
7	CONTAINER NO															
8	WT OF CONTAINER, M1 (gm)	63.3	72.5	68.1	65.6	65.7	70.2	68.9	65.9	70.8	67.1	73.1	66	67.7	63.1	68.9
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	183.4	208.3	220.01	233.4	188.5	158.8	215.7	220	209.4	178.3	225.1	195.5	202.4	183.8	167.8
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	176.78	200.56	211.46	220.01	178.59	151.74	199.95	203.53	194.43	160.99	204.18	180.08	177.19	166.55	155.02
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	5.834	6.044	5.964	8.672	8.778	8.658	12.018	11.967	12.109	18.436	15.960	13.517	23.025	16.675	14.840
12	AVERAGE WATER CONTENT (%)	5.947			8.703			12.031			15.971			18.180		
13	**DRY DENSITY (g/cc)**	**1.740**			**1.762**			**1.792**			**1.830**			**1.790**		
	OPTIMUM MOISTURE CONTENT, OMC %	**13.200**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.868**					

MDD OUPUT VALUES

		DATE	06.11.2019
LOCATION	Ponnani (CH: 0/2500)	**TRIAL PIT NO.**	6
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SM)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SM	0	84	16	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.092	
Optimum Moisture Content (%)			13.200	
Maximum Dry Density, MDD (g/cc)			1.868	

CBR OUPUT VALUES

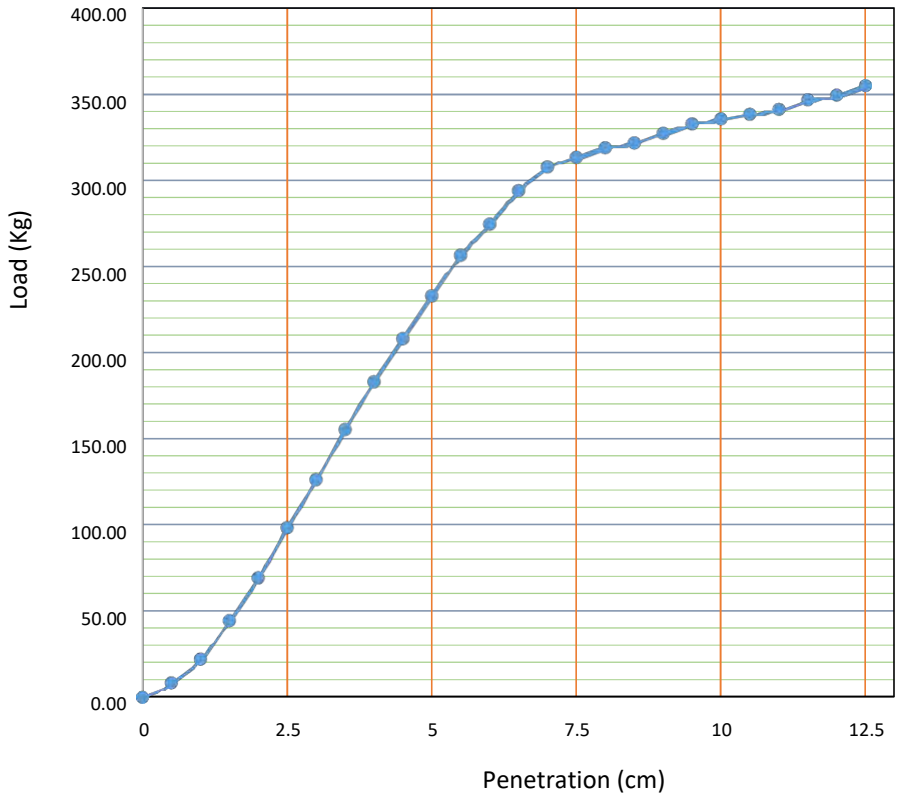
		DATE	07.11.2019
LOCATION	Ponnani Malappuram (CH 2500)	**TRIAL PIT NO.**	6
TEST	Modified CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 6, DEPTH 1.50m

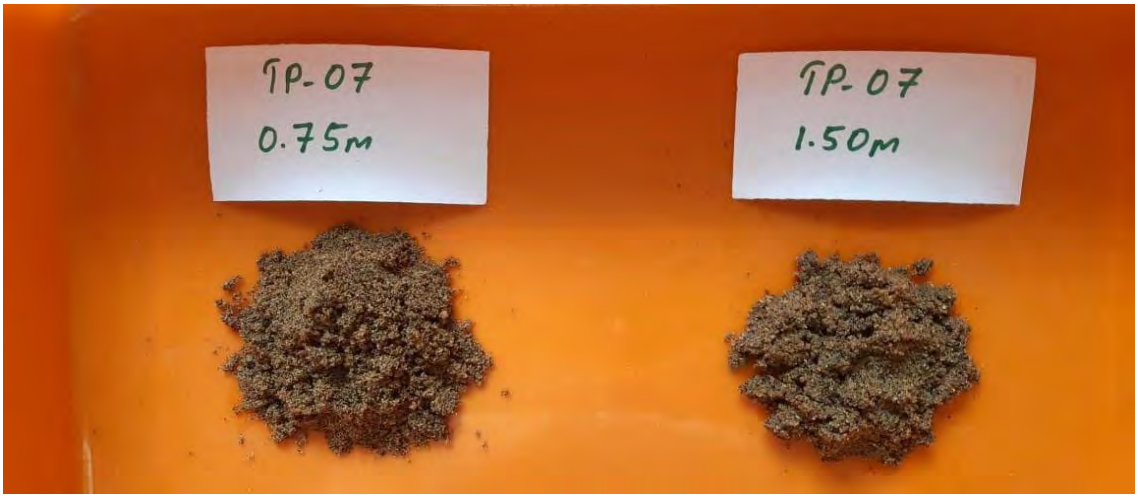


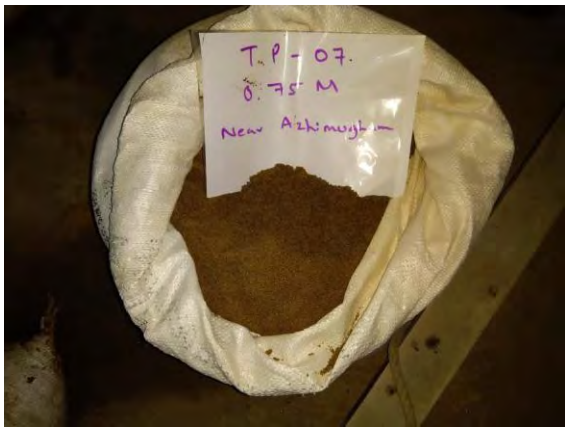
CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	98.335
Load at 5mm penetration, Kg	232.68
CBR at 2.5mm penetration	7
CBR at 5mm penetration	11
Recommended CBR value	**11**

7.7 Modified Proctor Test and CBR results at Trial Pit No: 7

Location: Ponnani, Malappuram

Chainage: 5/000

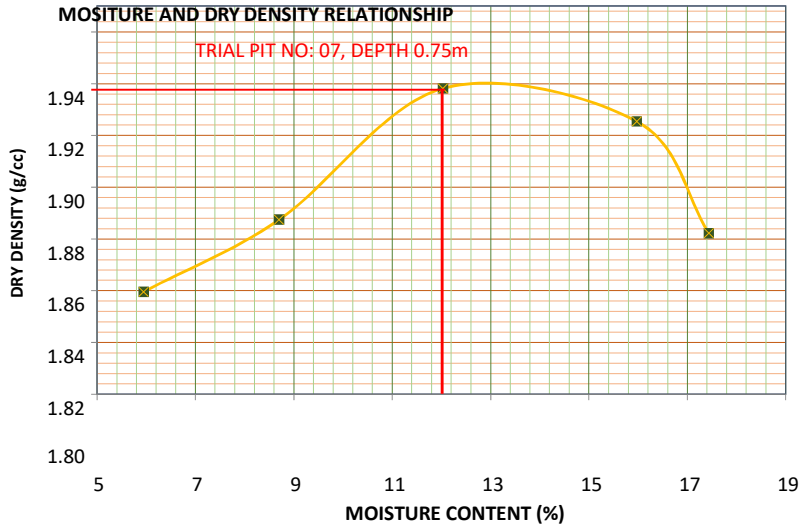




Modified Proctor Test at Chainage-5/000 (0.75 m depth)				TRIAL PIT NUMBER	7
				DEPTH, m	0.75
LOCATION	Ponnani Malappuram	CHAINAGE	5/000	SOIL CLASSIFICATION	FINE SAND (SM)
TEST	MODIFIED PROCTOR				

SL No	DETERMINATION OF DENSITY	9%			12%			15%			18%			21%		
1	WT OF MOULD (gm)	3642			3642			3642			3642			3642		
2	WT OF MOULD+ COMPACTED SOIL (gm)	5591			5672			5791			5854			5829		
3	WT OF COMPACTED SOIL (gm)	1949			2030			2149			2212			2187		
4	VOLUME (cc)	1000			1000			1000			1001			1000		
5	BULK DENSITY (W/V)(g/cc)	1.949			2.030			2.149			2.210			2.1870		
	WATER CONTENT DETERMINATION	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**	**TOP**	**MID**	**BOTTOM**
7	CONTAINER NO															
8	WT OF CONTAINER, M1 (gm)	63.3	72.5	68.1	65.6	65.7	70.2	68.9	65.9	70.8	67.1	73.1	66	65.9	65.7	70.7
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	183.4	208.3	220.01	233.4	188.5	158.8	215.7	220	209.4	178.3	225.1	195.5	227	265.7	183.6
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	176.78	200.56	211.46	220.01	178.59	151.74	199.95	203.53	194.43	160.99	204.18	180.08	203.56	235	167.07
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	5.834	6.044	5.964	8.672	8.778	8.658	12.018	11.967	12.109	18.436	15.960	13.517	17.027	18.133	17.153
12	AVERAGE WATER CONTENT (%)	5.947			8.703			12.031			15.971			17.438		
13	**DRY DENSITY (g/cc)**	**1.840**			**1.867**			**1.918**			**1.905**			**1.862**		
	OPTIMUM MOISTURE CONTENT, OMC %	**12.031**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.918**					

MDD OUPUT VALUES			
		DATE	06.11.2019
LOCATION	Ponnani (CH: 0/5000)	**TRIAL PIT NO.**	7
TEST	Modified Compaction Test	**DEPTH, m**	0.75
TYPE OF COMPACTION		Dynamic Heavy Compaction	
SAMPLE 1			
MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))			



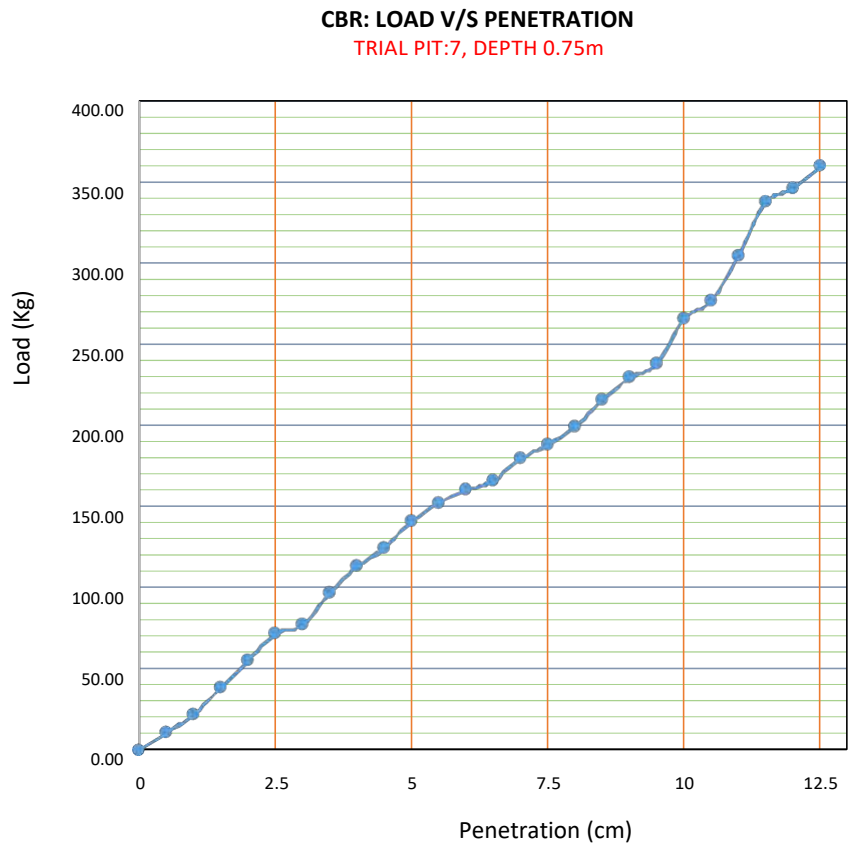
SOIL SAMPLE DETAILS		FINE SAND (SM)		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SM	0	98	2	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.148	
Optimum Moisture Content (%)			12.031	
Maximum Dry Density, MDD (g/cc)			1.918	

CBR OUPUT VALUES

		DATE	11.11.2019
LOCATION	Ponnani Malappuram (CH 2500)	**TRIAL PIT NO.**	7
TEST	Modified CBR Test	**DEPTH**	0.75m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	72.02
Load at 5mm penetration, Kg	141.27
CBR at 2.5mm penetration	5
CBR at 5mm penetration	6
Recommended CBR value	**6**

Modified Proctor Test at Chainage-5/000 (1.5 m depth)				TRIAL PIT NUMBER	7
				DEPTH, m	1.5
LOCATION	Ponnani Malappuram	CHAINAGE	5/000	SOIL CLASSIFICATION	FINE SAND (SM)
TEST	MODIFIED PROCTOR				

SL No	DETERMINATION OF DENSITY	9%	12%	15%	18%	21%
1	WT OF MOULD (gm)	3642	3642	3642	3642	3642
2	WT OF MOULD+ COMPACTED SOIL (gm)	5534	5610	5685	5768	5774
3	WT OF COMPACTED SOIL (gm)	1892	1968	2043	2126	2132
4	VOLUME (cc)	1000	1000	1000	1001	1002
5	BULK DENSITY (W/V)(g/cc)	1.892	1.968	2.043	2.124	2.128

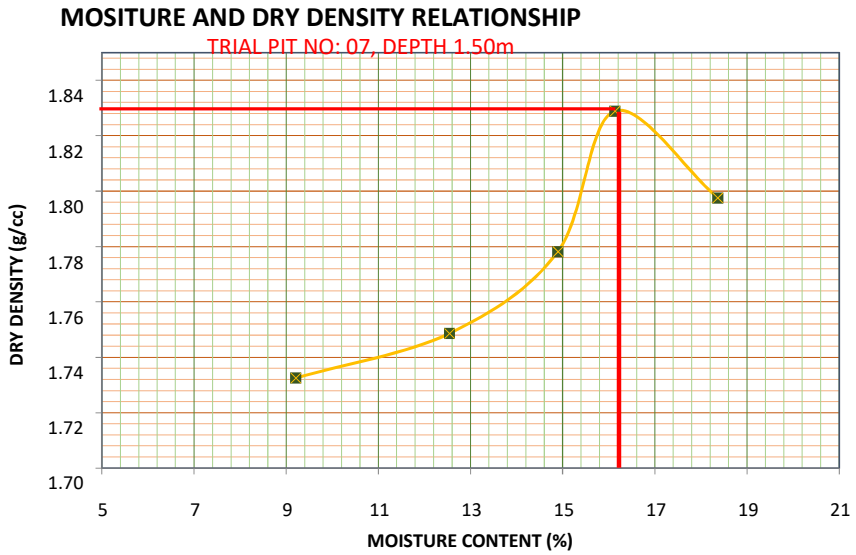
	WATER CONTENT DETERMINATION	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM	TOP	MID	BOTTOM
7	CONTAINER NO															
8	WT OF CONTAINER, M1 (gm)	59.4	69.4	65.5	65.7	62.5	60.4	72.5	66.7	69	60.4	68.3	67.9	67.3	65.8	65.7
9	WT OF CONTAINER+MOIST SOIL, M2 (gm)	162.5	192.7	214.3	187.8	192.3	196.3	176	175.8	190.1	190.3	209.3	210.4	204.6	187.4	197
10	WT OF CONTAINER+DRY SOIL, M3 (gm)	153.9	182.46	201.44	174.63	177.6	180.91	162.22	161.74	174.73	172.51	188.94	191.12	182	168.45	177.98
11	WATER CONTENT ((M2-M3)/(M3-M1))*100 %	9.101	9.057	9.460	12.090	12.772	12.771	15.359	14.794	14.537	15.868	16.877	15.647	19.704	18.461	16.940
12	AVERAGE WATER CONTENT (%)	9.206			12.544			14.897			16.131			18.368		
13	**DRY DENSITY (g/cc)**	**1.733**			**1.749**			**1.778**			**1.829**			**1.798**		
	OPTIMUM MOISTURE CONTENT, OMC %	**13.200**			**MAXIMUM DRY DENSITY, MDD (g/cc)**						**1.868**					

MDD OUPUT VALUES

		DATE	06.11.2019
LOCATION	Ponnani (CH: 0/5000)	**TRIAL PIT NO.**	7
TEST	Modified Compaction Test	**DEPTH, m**	1.5
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

MODIFIED COMPACTION TEST (REF :(IS 2720-PART 08))



SOIL SAMPLE DETAILS		**FINE SAND (SM)**		
SOIL CLASSIFICATION	GRAVEL	SAND	SILT	CLAY
SM	0	84	16	0
OMC TEST SPECIMEN DETAILS				
Bulk Dry Density, MDD (g/cc)			2.092	
Optimum Moisture Content (%)			13.200	
Maximum Dry Density, MDD (g/cc)			1.868	

CBR OUPUT VALUES

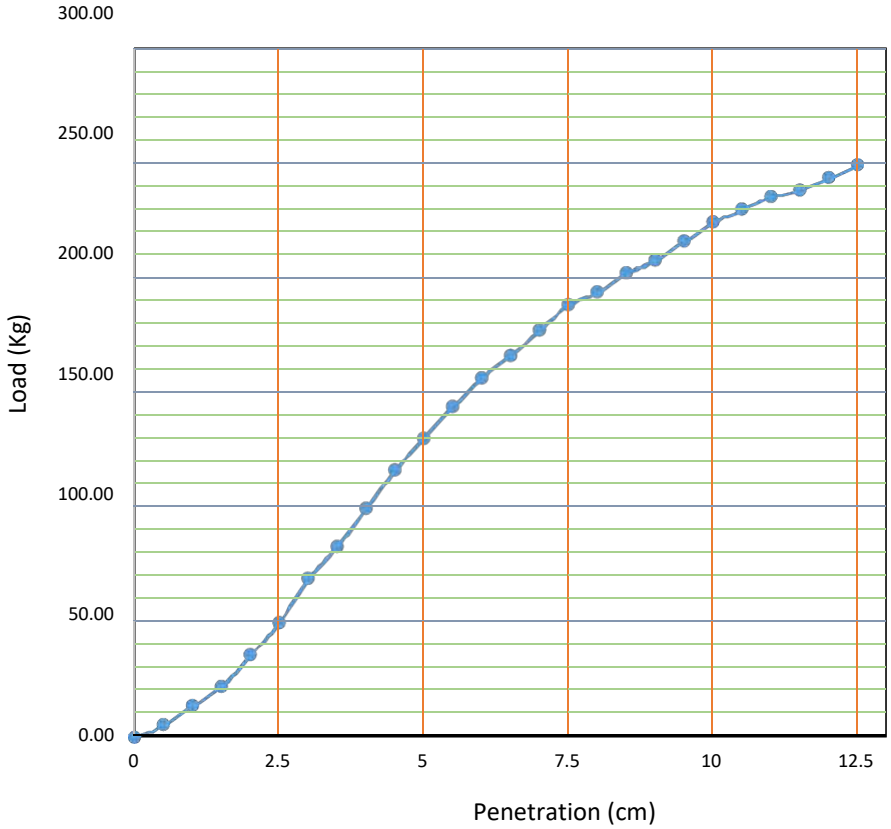
		DATE	12.11.2019
LOCATION	Ponnani Malappuram (CH 5000)	**TRIAL PIT NO.**	7
TEST	Modified CBR Test	**DEPTH**	1.50m
CONDITION OF SPECIMEN AT TEST		Remoulded Soaked	
TYPE OF COMPACTION		Dynamic Heavy Compaction	

SAMPLE 1

GRAPH BETWEEN LOAD V/S PENETRATION (REF :(IS2720-PART16))

CBR: LOAD V/S PENETRATION

TRIAL PIT: 7, DEPTH 1.50m



CBR TEST SPECIMEN DETAILS	
Load at 2.5mm penetration, Kg	49.86
Load at 5mm penetration, Kg	130.19
CBR at 2.5mm penetration	3
CBR at 5mm penetration	6
Recommended CBR value	**6**

8. Sources of Materials:

8.1 Aggregate Sources

Feasible aggregate resources available along the project road are found at Vengara Malappuram at private stone crushing units located at an offset distance of about 40 Km from the project road.

Sl.No	Location	Distance from Project road
1	Vengara, Malappuram	40 km

8.2 Sand Sources

Sand material resources available for the project road are from the Bharathappuzha river. it is noted during the site visit that the sand material from this location are available in plenty.

Sl.No	Location	Distance from Project road
1	Bharathappuzha river	03 km

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Roads and Bridges Development Corporation of Kerala Limited (RBDCK)

Kerala Infrastructure Investment Fund Board (KIIFB)

Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches

Detailed Project Report

(Volume-IV: Environmental Impact Assessment (EIA)including Environmental Management Plan (EMP) & Resettlement Action Plan (RAP))

March 2020

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L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

Client:	**Roads and Bridges Development Corporation of Kerala Limited (RBDCK)** (A Government of Kerala Undertaking)		
Project:	Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/ Suspension Bridge across Ponnani Estuary with Approaches	**Project No.:** C1193601	
Title:	Detailed Project Report – Volume IV (EIA/EMP and RAP)	**Document No.:** RP010	**Rev.:** 0

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File path: I:\bridges\2019\c1193601 - dpr-ponnani cable stayed br\working\reports\vp 009 - detailed project report\volume-iv (environmental impact assesment)\vol iv - eia, emp, rap report - 12.03.2020.docx

Notes:

1. This EIA/EMP and RAP Report is presented as Volume IV of the Detailed Project Report (DPR) for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches

Revision Details:

0	12.03.2020	1st Submission	RLB		RBV		KGN		
Rev.	**Date**	**Details**	**Init.**	**Sign.**	**Init.**	**Sign.**	**Init.**	**Sign.**	
			Prepared		**Checked**		**Approved**		

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1 Introduction

1.1 Background

As part of the Detailed Project Report (DPR) preparation for the construction of a bridge across Ponnani Estuary at the approach, the Environmental Impact Assessment (EIA) report has been prepared and presented in Volume IV of the project DPR for the Construction of Cable Stayed Superstructure for Road Bridge across Ponnani Estuary at the Approach. The other reports prepared for the DPR are listed below:

- Volume 1: Main Report
- Volume 2: Design Report
- Volume 3: Material Report
- **Volume 4: Environmental Assessment and Management Plan (EMP) and Resettlement Action Plan (RAP)**
- Volume 5: Traffic Analysis
- Volume 6: Rail Analysis
- Volume 7: Cost Estimate
- Volume 8: Bridge Management
- Volume 9: Drawings

1.2 Introduction

Road and Road Development Corporation of Kerala Limited (RDC) has entrusted Consultancy Services for preparation of Feasibility Study Detailed Project Report for the Construction of Cable Stayed Superstructure for Road Bridge across Ponnani Estuary in the State of Kerala. In this connection, the Consultant appointed L&T Infrastructure Engineering Limited (LNTIEL) to undertake the feasibility study and preparation of Detailed Project Report for the Construction of a Superstructure for Road Bridge across Ponnani Estuary in Malappuram District, Kerala and to prepare the Detailed Project Report.

Such development projects are usually carried out to improve the connectivity and to reduce the travel time. The project can also be implemented in order to provide appropriate transportation facility. The design of road bridges is governed by standards and guidelines which are mainly concerned with safety, economy and convenience.

A project of this magnitude is bound to have an impact on a number of environmental components during the construction and operation phases. Opportunities for the project to enhance the environment and any day to day maintenance requirements or opportunity or the need to add learning to the Any development project will have impacts on the environment during the construction phase and operation phase. The project will also have impacts on the socio economic environment and the study area will be considered as the area within a radius of 10 km from the project site. Any development project will have impacts on the environmental components considered

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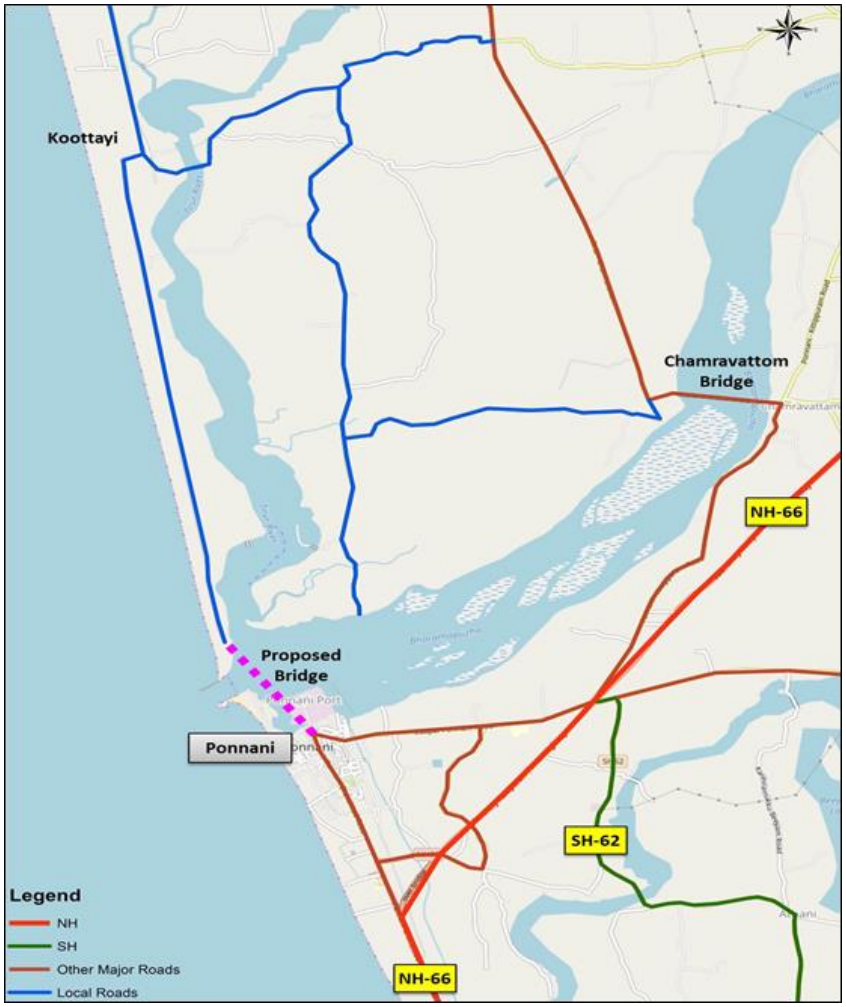

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1	The Environmental (Protection) Act. 1986, and the Environmental (Protection) Rules, 1987-2002 (various amendments)	Umbrella Act. Protection and Improvement of the environment.	All environmental notifications, rules and schedules are issued under the act (not triggered for current project)	MoEF&CC, State Department of Environment & Forest, CPCB and SPCB
2	The Water (Prevention & Control of Pollution) Act,1974	Central and State Pollution Control Board to establish/ enforce water quality and effluent standards, monitor water quality, prosecute offenders, issue licenses for construction/ operation of certain facilities.	Consent required for not polluting ground and surface water during project construction and its operation	State Pollution Control Board
3	Coastal Regulation Zone (CRZ) Notification, 2011/2019	To restrict development activities and act as primary regulation for conservation and protection of India's coastline and protection of coastal livelihoods	Obtaining CRZ Clearance as proposed development attracts the CRZ Notification.	State Coastal Zone Management Authority/CZMA, MoEF&CC
4	Air (Prevention and Control of Pollution) Act, 1981 & 1987 (amendment)	To control air pollution by controlling emission and air pollutants according to prescribed standards	Construction machineries and vehicles to confirm to the standards for construction	State Pollution Control Board
5	Noise Pollution	Noise pollution regulation and	Construction	State Pollution

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	(Regulation And Control) Act, 1990 Noise Pollution (Regulation and Control) Rules 2000 Noise Pollution (Regulation and Control) (Amendment) Rules 2010	controls	machineries and vehicles to confirm to the standards for construction	Control Board
7	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016	Protection to the general public against improper handling and disposal of hazardous wastes	Proposed development will likely involve management of hazardous wastes	State Pollution Control Board
8	The Motor Vehicle Act. 1988	Empowers State Transport Authority to enforce standards for vehicular pollution. From August 1997 the "Pollution Under Control Certificate is issued to reduce vehicular emissions.	All vehicles used for construction will need to comply with the provisions of this act.	State Motor Vehicles Department
9	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Protection against chemical accident while handling hazardous chemicals	Handling of hazardous (flammable, toxic and explosive) chemicals during road construction	District & Local Crisis Group headed by the DM and SDM

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1.	CRZ Clearance	KCZMA/ MoEF&CC	Proposed development attracts provisions of the CRZ Notification	Pre-Construction	Proponent/ Contractor
2.	Tree felling permission	State Department of Environment and Forest/ DFO/PWD	Felling of trees (will be needed in proposed development)	Pre-construction	Proponent/ Contractor
3.	NOC and Consents Under Air, Water, EP Acts & Noise rules of SPCB	State Pollution Control Board	For establishing construction related plants	Construction (Prior to work initiation)	Proponent/ Contractor
4.	Permission to store Hazardous Materials	State Pollution Control Board	Storage and Transportation of	Construction (Prior to work	Proponent/ Contractor

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5.	PUC certificate for use of vehicles for construction	State Pollution Control Board	For all construction vehicles	Construction (Prior to work initiation)	Proponent/ Contractor
6.	NOC for water extraction for construction/allied works	Ground Water Authority	Groundwater extraction	Construction (Prior to work initiation)	Proponent/ Contractor

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1.5.1 Structure of EIA Report

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T[illegible] propo[illegible]d d[illegible]op[illegible]n[illegible] or Con[illegible]r[illegible]on o[illegible]a Ca[illegible] S[illegible]ay[illegible]d S[illegible]p[illegible]on [illegible]rd[illegible] a[illegible]ro[illegible] Ponnan[illegible]ary [illegible] Approa[illegible] T[illegible] pro[illegible] a par[illegible]o[illegible] Coa[illegible]a[illegible] ay [illegible]r[illegible]n [illegible] propo[illegible]d a[illegible]n[illegible]n[illegible] [illegible]n[illegible] [illegible] [illegible]o po[illegible]on [illegible]o[illegible]rn [illegible]d [illegible] Ponnan[illegible]n[illegible]on [illegible]N[illegible] [illegible]ypa[illegible] and Nor[illegible]rn [illegible]d Pad[illegible]ar[illegible]ara[illegible] ay Road T[illegible] pro[illegible] [illegible]ar[illegible] a [illegible] Ponnan [illegible]n[illegible]on [illegible] [illegible]n Pa[illegible]ad Ponnan Road and Pan[illegible]o[illegible] anya[illegible]ar[illegible] [illegible] ay o[illegible]N[illegible] and [illegible]nd a Pad[illegible]ar[illegible]ara [illegible]a[illegible] T[illegible] pro[illegible] a[illegible]n[illegible]n[illegible] ro[illegible] Ma[illegible]app[illegible]ra[illegible] Ponnan [illegible]ar[illegible]o[illegible]r Ponnan [illegible]a[illegible] Road Ponnan E[illegible]ary [illegible]o[illegible] o[illegible] [illegible]ara[illegible]ap[illegible]a R[illegible]r and Pad[illegible]ar[illegible]ara do[illegible]

2.2 Road Connectivity

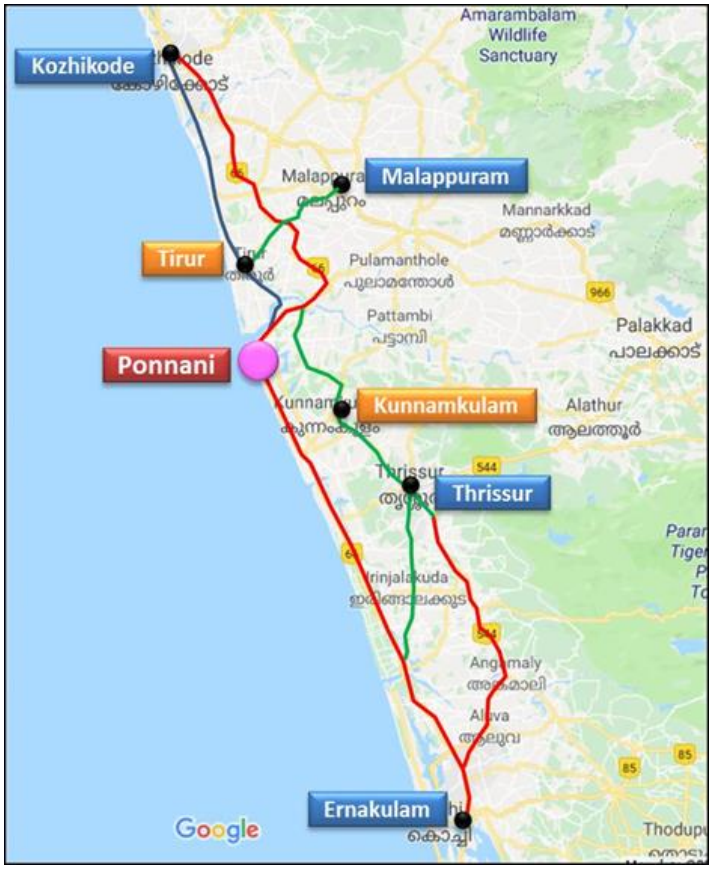
Ponnan[illegible]o[illegible]n [illegible] o[illegible]a[illegible]d a[illegible]on[illegible] [illegible] Na[illegible]ona[illegible] [illegible] ay N[illegible] [illegible] a[illegible] conn[illegible] anya[illegible]ar[illegible] Ta[illegible] Nad[illegible] and Pan[illegible]n Ma[illegible]ara[illegible]ra N[illegible] conn[illegible] Ponnan[illegible] [illegible]a[illegible] pa[illegible] [illegible] Erna[illegible]a[illegible] A app[illegible]a[illegible] T[illegible]r[illegible]anan[illegible]ap[illegible]ra[illegible] [illegible] [illegible] [illegible]o[illegible] and [illegible]o[illegible]od[illegible] [illegible]ann[illegible]r Man[illegible]a[illegible]r [illegible] [illegible] Nor[illegible] N[illegible] [illegible] pr[illegible]do[illegible]nan[illegible]y [illegible]o [illegible]n[illegible] road [illegible] [illegible] pro[illegible] [illegible]n[illegible] ar[illegible]a Con[illegible]d[illegible]ra[illegible] pa[illegible]n[illegible]r [illegible] and [illegible]ood[illegible] [illegible]o[illegible] [illegible]n[illegible]ar[illegible]o[illegible]r[illegible]d a[illegible]on[illegible] [illegible] road[illegible]

S[illegible] conn[illegible] G[illegible]r[illegible]ay[illegible]r [illegible] Ponnan[illegible]a[illegible] [illegible]nd[illegible]ada[illegible] [illegible]n[illegible]on A[illegible]on[illegible] [illegible] pa[illegible]n[illegible]r [illegible] ra[illegible] [illegible] road [illegible] o[illegible]r[illegible]d [illegible]o [illegible]arry [illegible]ood[illegible] [illegible] [illegible]o[illegible]ro[illegible] ar[illegible]a[illegible] [illegible] G[illegible]r[illegible]ay[illegible]r[illegible] [illegible]nna[illegible] [illegible]a[illegible] and T[illegible]r[illegible]r[illegible] [illegible] T[illegible] road [illegible]o pr[illegible]do[illegible]nan[illegible]y [illegible]o [illegible]n[illegible] [illegible]on[illegible] [illegible] ra[illegible]n[illegible]

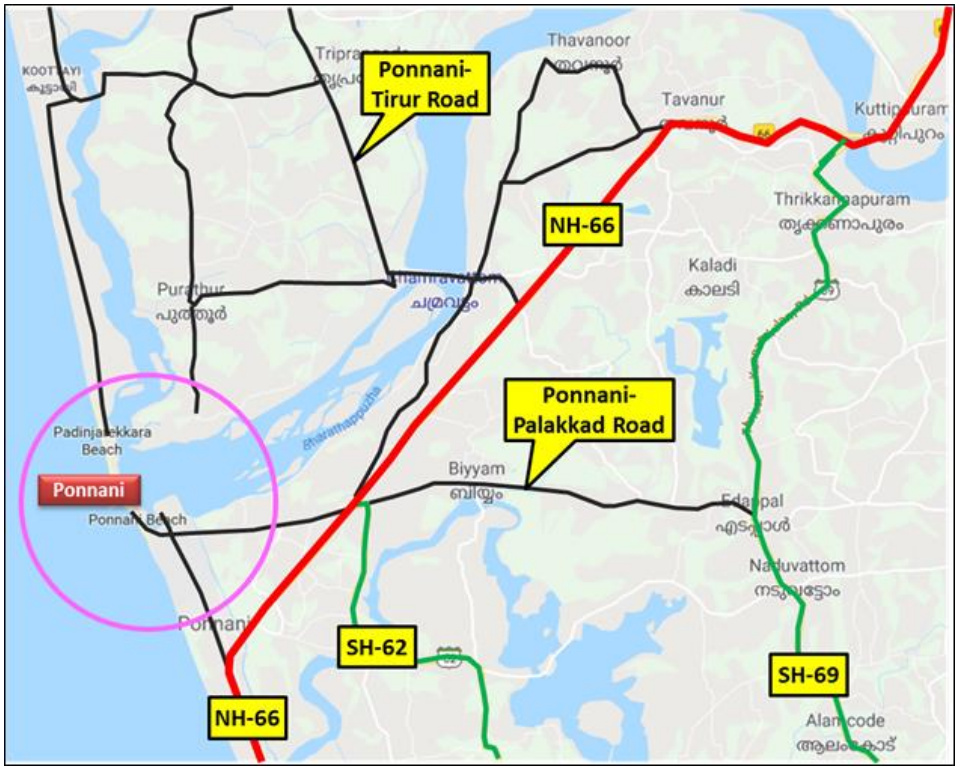
Pa[illegible]ad Ponnan Road conn[illegible] Ponnan[illegible] [illegible] ar[illegible]a[illegible] [illegible] a Edappa[illegible] Pa[illegible]a[illegible] [illegible] Pa[illegible]ad [illegible] T[illegible] road [illegible] [illegible] S[illegible] [illegible] a Edappa[illegible] T[illegible] road [illegible]d[illegible] [illegible] pr[illegible]do[illegible]nan[illegible]y [illegible]n[illegible]r[illegible]d[illegible]a[illegible] and [illegible]ar[illegible] [illegible] [illegible]n [illegible]n[illegible] [illegible]n and [illegible]o [illegible]n[illegible] a[illegible]ar[illegible]o[illegible] [illegible] [illegible]on[illegible]

Ponnan[illegible] T[illegible]r road conn[illegible] Ponnan[illegible] [illegible] nor[illegible] [illegible]d[illegible] o[illegible] [illegible]ara[illegible]ap[illegible]a R[illegible]r a[illegible]on[illegible] [illegible] C[illegible]a[illegible]ra[illegible]a[illegible]o [illegible]rd[illegible] T[illegible] road [illegible] pr[illegible]do[illegible]nan[illegible]y o[illegible]n[illegible]r[illegible]d[illegible]a[illegible] [illegible]an[illegible] [illegible]on[illegible]ra[illegible]on[illegible] A[illegible] pr[illegible]n[illegible] C[illegible]a[illegible]ra[illegible]a[illegible]o [illegible]rd[illegible] [illegible] [illegible] [illegible]or[illegible] conn[illegible]ly [illegible] n Ponnan[illegible] and o[illegible]r n[illegible]ar[illegible]y ar[illegible]a[illegible] [illegible]a[illegible] [illegible]ay[illegible] T[illegible]r[illegible] Tan[illegible]r[illegible] Parappanan[illegible]ad[illegible]

F[illegible]**r**[illegible] [illegible]-[illegible] and **F**[illegible]**r**[illegible] [illegible]-[illegible] [illegible]o[illegible] [illegible] r[illegible]ona[illegible] [illegible]n[illegible] and [illegible]a[illegible]or road[illegible] [illegible]a[illegible] conn[illegible] Ponnan[illegible] [illegible] o[illegible]r par[illegible] o[illegible] [illegible] [illegible]a[illegible] **E**[illegible] [illegible]-[illegible] [illegible]o[illegible] [illegible]o[illegible] [illegible] o[illegible] [illegible] [illegible]n[illegible] road n[illegible]or[illegible] [illegible]a[illegible]r[illegible]n [illegible] Pro[illegible] Ar[illegible]a[illegible]



F□□r□ □-□□R□□□□□□S□□□□□□ □□P□□□□□□T□□ □



F□□r□ □-□□M□□□r R□□d□ □□ Pr□□□□□□l□□□□□□□ Ar□□

□□ □□□ ***near C□ □unctio□n***

□□ □□□ ***near □na□□adi***

S□ □□□ near □a□a□u □uncti□n

□a□a□□ad□□□nnani R□ad near □□ □uncti□n

□□***nnani□Tirur R□ad near C□a□ ra□att□□***

C□a□ ra□att□□ □ridge

E□□□□□□□-□ E□□□□□□□ R□□d N□□□ □r□ □□ Pr□□□□□Ar□□

2.3 Road Characteristics in the project influence area

T□□ □a□or road□ and □□□r □arr□a□□□ay □□d□□ d□a□□ □□□□n □□□□ pro□□□□n□□□n□□ ar□a ar□ pr□□□n□□d □n **T□□□□ □-□□**

Table 2 -1: **C**a**rr**iagew**a**y W □d**t**h o**f** **M**ajo **r** **R**oa **d**s in **Pr**oject **I**nflueence **Ar**□□

S. N□.	**Name** of th**e** R□**ad**	**□arria□e□ a□ □e□ai□s** *
1	National Highway (NH-66)	2L-2W-UD
2	Palakkad- Ponnani Road	1.5L-2W-UD
3	Ponnani- Tirur Road	1.5L-2W-UD
4	SH-62 (Guruvayur- Althara- Ponnani Road)	2L-2W-UD
5	Koottayi- Padinjarekkara Road	1.5L-2W-UD
6	Mangalam- Koottayi Road	1.5L-2W-UD
7	Alathiyur- Purathur Road	1.5L-2W-UD
8	Purathur- Chamravattom Road	1.5L-2W-UD
9	Ponnani Beach Road	1L-2W-UD
10	Chanthappadi- NH Link	1.5L-2W-UD

** L – Lanes, W – Way, UD- Undivided, D- Divided (Eg: 1.5L-2W-UD means Intermediate lane, two-way, undivided road)*

Apar□ ro□ N□-66 and S□-62, all road sect□ns in the pro□□□□ influ□nce ar□a ar□ pr□do□nan□y o□ inte□r□ d□a□□ an□ c□nfigu□a□on. H□weve□, it is □o be no□□d that the□e ar□ □ar□o□□ sec□on□ whe□ the road sect□ns sh□ink □o sing□e an□ □□dth.

T□e Pa□a□□ad□Ponnan□Road is □□ry narro□ n□ar □oda□□ppad□ J□n□□on. Fu□the□ the b□d□□ on Pa□a□□ad- Ponnan□Road a□ross Cano□Cana□is o□single an□ □on□□□ra□on. T□e □oo□ay□ R□□□a□or cum □□d□e a□on□ Man□a□a□- □oo□ay□road is a□o of single an□ □on□□□ra□on. **E**xhibit 2 -□ sh□ows □ome o□the □xisting road n□□□or□ fea□u□es in the□ Pro□□□□Ar□a.

Koo ***tta□i***- □***adin□are□□ara R□ad***

Manga□am- □□□***tta□i R□ad***

A□***at□i□ur***- □***urat□ur R□ad***

P***urat□ur- C□a□ ra□att***om ***R□ad***

□□□tta□i Regu□at□r cu□ □ridge

□ridge acr□ss Can□i Cana□

□□nnani □eac□ R□ad

C□ant□a□□adi□□□ Lin□

E□□□□□□□-□ E□□□□□□□ R□□d N□□□ □r□ □□ Pr□□□□□Ar□□

2.4 Ponnani Harbour

Ponnan□ □□ on□ o□ □□□ □a□or □□□□n□ □ar□o□r□ □n □□ra□a□ □□□□ □□□□n□ a□□□□□□□□□ □□□□ □ □□□an□□□d □oa□□ ar□ □□n□□d □n Ponnan□□ T□□ □□o□□a□□ □□□□ □rad□n□ and a□□□□on□n□ a□□□□□□□□ o□□□r n□ar □□□ Ponnan□□□a□□ and □ro□ □□□r□ □□□□ □an□por□□d □o □ar□o□□ o□□□r par□□ o□□□□ □a□□ □n □ood□□a□□o□□LCV□ and LMV□ pr□do□ □nan□y□T□□□□ □ood□ □ra□□□p□y □ro□□□ □□□ Ponnan□□□a□□ Road □o r□a□□ □□□□r r□□p□□□□□ d□□□na□on□□M□n□ a□□ o□□□ □n□o□□□o a□□□ r□□□□ □a□□arry □□□ □□□□□ □o □□□ □ar□□□□ro□ □□□ p□an□ ar□ o□□□r□□d a□on□ □□□□ road□ Ponnan□□ar□o□r □□ □□□ □a□or □a□□□ □□n□ra□or □n □□□ Pro□□□□In□□□n□□ Ar□a□

□ □□□esa□e *Mar□et □rea*

□e□ □□ *De□e□□□ed □ar□□ur*

T□□ n□□ □□□□n□ □ar□o□r d□□□□op□d □y □□□ Go□□rn□ □n□o□□□ra□a □□ □nd□r□□□□□d □n□□ a□□□□□ □ar□□□a□□□□□□□□ o□□□r a□□□□ □□a□□ ar□a □□□r□□r□ro□ d□□□□□□□on □□□ □o□a□p□op□ □□□ □nd□r□ood □a□□□ Go□□rn□ □n□□a□ □an□□on□d a □ar□o por□o □□ d□□□□op□d a□Ponnan□

2.5 Ponnani Ferry Services

Ponnan□ M□n□□pa□□y op□ra□□□ a □□rry □□r□□□□ □□□n□ar□ □□□□□□n Ponnan□ □ar□o□r and Pad□n□ar□□ara □**E**□□□□□□□□-□□□T□□ □□r□□□□ □□ op□ra□ona□ro□ □□□□□ a□ □o □□□□ p□ □T□□ □ar□ d□a□□□o□□□□ □□rry □□r□□□□ ar□ pr□□□n□□d □n **T**□□□□□ □-□□

T□□□□ □-□□**F**□r□ **D**□□□□□□□ □□ **F**□rr□ **S**□r□□□□

S. N□.	Par□i□ □ar	Am□ □n□ (Rs.)
1	One Person	10
2	Two Wheeler with Driver	20
3	Auto-rickshaw with Driver	30
4	Car/ Jeep/ Van with Driver	65

E□□□□□□-□ F□rr□ □□□□□□r□S□r□□□ □□ P□□□□□□

2.6 Project Corridor

Corr□dor □ar□□ fro□ Ponnan□□□n□□on □□□□ □n Pa□a□ad□Ponnan□Road and Pan□□□□o□□□ □anya□□ ar□□ □□□ay o□N□□□ □ □□□ o□o □ □□ □□□□n□P□ D road □p □o □□ fro□□ □n□□on o□Ponnan□ □a□ road and □□n □rn□ □o□ard□ □□ □rry □r□na□ a□r□ard□ □o□o □ □□ propo□d □r□□r□ and □ro□n□ □□ □ara□ap□a R□r fro□□ an I□on□ □rd□□ o□□□ □ o□□a□ory □pan and □□n para□□pa□ □o □□□n□ road □p □o propo□d □□ □□ and □□n □r□□ □□ □□□n□ P□ D road□ T□□ pro□□ a□n□ □n□ fro□□ Ma□app□ra□ □ Ponnan□ □ar□o□r□ Ponnan□ □a□ Road Ponnan□ E□□ary □o□ o□ □ara□ap□a R□r and Pad□□ar□ara do□ T□□ a□n□ □n□ □o□n □ **F□r** □-□ **F□r** □-□ **F□r** □-□ and **F□r** □-□a□d on □□ □r□y□a□r□ o□r□d a□on□ □□ □□□d A□n□ □n□Op□on □ I □ pr□n□d □ **T□** □-□

T□ □-□ **M□r F□r□** □□□ **A□** □□

S. N□.	Fea□res	□esc□ip□i□n
1	Section-1	» Indian Oil Fuel Station » Nishad Palace » Bismi Industries » MES Ponnani College » KSRTC Bus Depot » Kaffieno Cafe » Bombay Hotel » ESAF Bank » TB Ponnani Hospital » Utaqwa Mosque » Civil Station » Ansar Mosque » Ponnani Court » Ferry Terminal » Connectivity to NH-17 at Ch: 0/000 and 2/560. » Boat Parking Area
2	Section-2	» Ponnani Harbour » Ponnani-Purathur Jungar Terminal » Govt. Tourist Park » Tourist Resort

S. N□.	Fea□□res	□esc□rip□i□n
3	Section-3	» Proposing parallel structure to the existing road » Ends at 900 m from situated government park

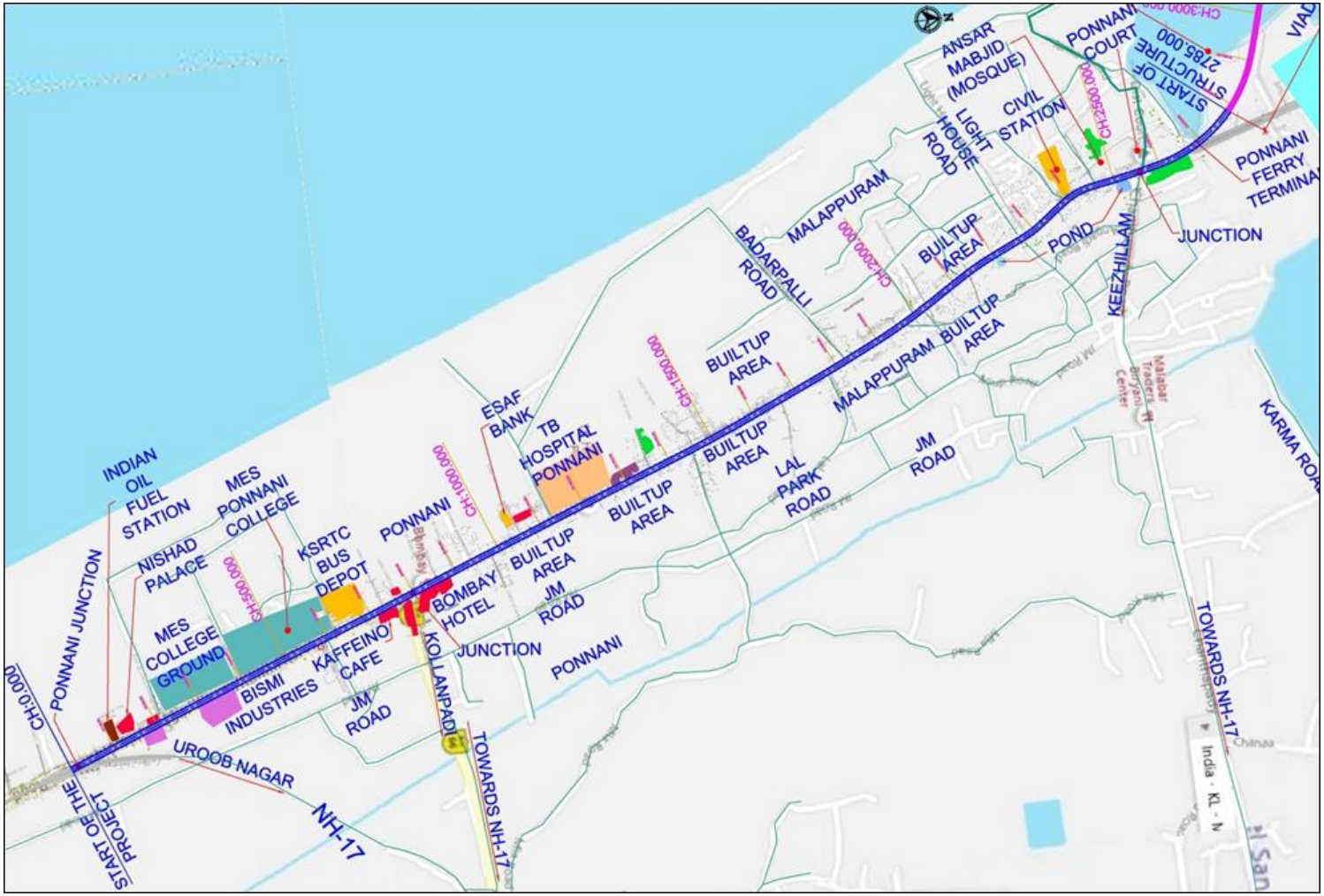
2.7 Section wise Salient Features along Project Alignment

T□□□□ □-□□S□□□□□□ □ □□□ S□□□□□□F□□□r□□ □□□□□ A□□□□ □□□

□esc□rip□i□n	Se□□i□n□I P□nnani □□n□i□n □ P□nnani □□r□ (0 □□ 2□7□5 □m)	Se□□i□n□II S□r□□□re p□r□i□n (2□7□5 □□ 4□450 □m)	Se□□i□n□III Padin□are□□ara □ ea□ □ □□ Pr□□e□□end (4□450 □□ 5□000 □m)
Length of the section	2.78 Km	1.66 Km	0.55 Km
Existing RoW	5 to 10 m	-	7 to 10 m
Lane Configuration	2-lane	2-lane	2-lane
Land Use	Built-up	Harbour & Government land	Built-up
Land Acquisition	Yes	Yes	Yes
Environmental Impact	No	No	No
Critical Location	Yes	No	No
Major Traffic Generation/Attraction	Ferry terminal and local traffic	Tourists	Tourists

ARABIAN SEA
BHARTHAPPUZHA RIVER
PONNANI-BRIDGE ALIGNMENT PLAN - OPTION-1
JUNCTION
GOVERNMENT PARK
BUILTUP AREA
END OF STRUCTURE
PRIVATE TOURIST RESORT
JENKAR TERMINAL (PADINJAREKARA)
VIADUCT STRUCTURE
BRIDGE LOCATION
END OF THE PROJECT
AZHIMUGHAM JUMA MOSQUE
ICE FACTORIES
PONNANI BEACH
BOAT PARKING AREA
PONNANI COURT
ANSAR MABJID (MOSQUE)
CIVIL STATION
LIGHT HOUSE ROAD
START OF STRUCTURE
PONNANI HARBOUR
PONNANI FERRY TERMINAL
MALAPPURAM
BADARPALLI ROAD
POND
KEEZHILAM
KARMA ROAD
ESAF BANK
TB HOSPITAL PONNANI
LAL PARK ROAD
JM ROAD
INDIAN OIL FUEL STATION
MES PONNANI COLLEGE
NISHAD PALACE
KSRTC BUS DEPOT
PONNANI
BOMBAY HOTEL
MES COLLEGE GROUND
KAFFEINO CAFE
BISMI INDUSTRIES
KOLLANPADI
TOWARDS NH-17
PONNANI JUNCTION
UROOB NAGAR
NH-17
START OF THE PROJECT

F□□r□ □-□ Pr□□□□A□□□□ □□□


ANSAR MABJID (MOSQUE)
PONNANI COURT
START OF STRUCTURE
CH:3000.000
2785.000
CH:2500.000
CIVIL STATION
LIGHT HOUSE ROAD
PONNANI FERRY TERMINA
MALAPPURAM
BADARPALLI ROAD
CH:2000.000
BUILTUP AREA
POND
JUNCTION
KEEZHILLAM
MALAPPURAM BUILTUP AREA
CH:1500.000
BUILTUP AREA
ESAF BANK
TB HOSPITAL PONNANI
BUILTUP AREA
LAL PARK ROAD
JM ROAD
KARMA ROA
INDIAN OIL FUEL STATION
MES PONNANI COLLEGE
NISHAD PALACE
KSRTC BUS DEPOT
PONNANI
CH:1000.000
BUILTUP AREA
BOMBAY HOTEL
JM ROAD
CH:500.000
MES COLLEGE GROUND
KAFFEINO CAFE
KOLLANPADI
JUNCTION
PONNANI
PONNANI JUNCTION
CH:0.000
BISMI INDUSTRIES
JM ROAD
TOWARDS NH-17
UROOB NAGAR
START OF THE PROJECT
NH-17
TOWARDS NH-17
India - KL - N

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ARABIAN SEA
JUNCTION
END OF STRUCTURE
4450.000
CH:4500.000
GOVERNMENT PARK
BUILTUP
CH:4000.000
PRIVATE TOURIST RESORT
JENKAR TERMINAL (PADINJAREKARA)
VIADUCT STRUCTURE
CH:3500.000
ICE FACTORIES
BRIDGE LOCATION
PONNANI BEACH
BOAT PARKING AREA
VIADUCT STRUCTURE
CH:3000.000
PONNANI COURT
START OF STRUCTURE
2785.000
CH:2500.000
PONNANI HARBOUR
PONNANI FERRY TERMINAL
BHARTHAPPUZHA RIVER

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END OF STRUCTURE
4450.000
CH:4500.000
BUILTUP AREA
CH:5000.000
AZHIMUGHAN JUMA MOSQUE
END OF THE PROJECT

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2.7.1 Critical Locations: Section 1 of the Alignment

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2.7.2 Critical Locations: Section 2 of Alignment

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2.7.3 Critical Locations- Section 3 of Alignment

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2.8 Cross Section Elements

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L□ a□i□n	T□ S T□pe	□arria□e□ a□ □id□ (m)	Pa□ed S□ □ □der (m)	F□ □pa□ □ m □ rain□ Ear□ en S□ □ □der	T□ a□ □id□ (m)
Ponnani to Padinjarekara beach	Type-1	7 m	1.5 m	1.8 m	13.6 m
	Type-2	7 m	1.8 m	1.8 m	13.6 m
	Type-3	7 m	-	1.8 m	10.6 m

2.9 Type of Pavement and Pavement Composition

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2.10 Project Facilities

2.10.1 Drainage

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2.10.2 Traffic Control and Safety Devices

2.10.2.1 Road Signs

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2.10.2.2 Road Markings

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2.10.2.3 Traffic Safety Devices

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- **R□□d S□□d**□ □ pro□d□d □or □□□ □n□r□ □□n□□□ o□ pro□□□□ □orr□dor a□ p□r □□□□ □pa□n□ □ □n□on□d □n □□□ IRC □□□□□□□□□

2.10.3 Project Facility

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- R□□□ar□a□ □or □o□r□□□□

2.10.4 Road Furniture

- Tra□□□ S□□n□ and Pa□□□ □n□Mar□n□□
- Tra□□□ S□□n□ and pa□□□ □n□□ar□n□□ □□a□□n□□□d□ road□d□ □□□n□□o□□r□□ad □□□n□□□r□ □o□n□d □□□n□ and road □ar□n□□ a□on□ □□□ pro□□□□ □□□□□ay□O□□r□□ad □□□n□ □□a□□□□ □n□a□□d a□□ad o□□a□or □n□r□□□□□on□□ Road □□□d□ □□a□□ □□ pro□d□d □ro□□□o□□ □□□□ □n□□□ o□□□□ pro□□□□ □□□□□□ay□C□□□ron □□□n □oard□ □□a□□□□ pro□d□d a□a□□□or□on□a□ □□r□□□on □□□□r □d□o□□□□ □arra□□□ay□T□□ □□□n □oard□ □□a□□□□ d□□□□n□d a□p□r IRC□ □□□□□□□□□□T□□ pa□□□ □n□□ar□n□□ □□a□□□□ d□□□□n□d a□p□r IRC □□□□□□□□□
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2.10.5 Retaining walls

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2.11 Typical Cross Sections

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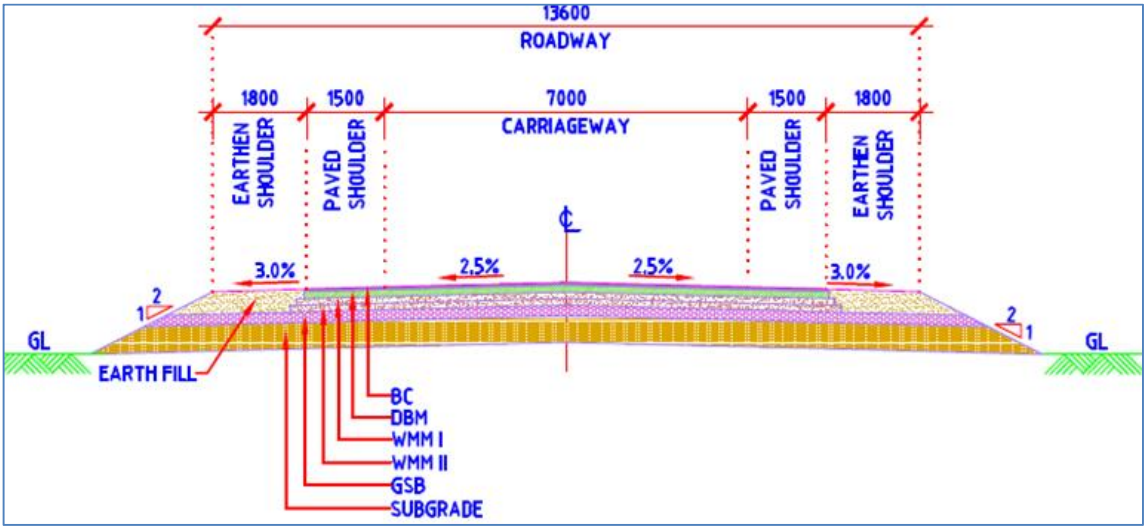
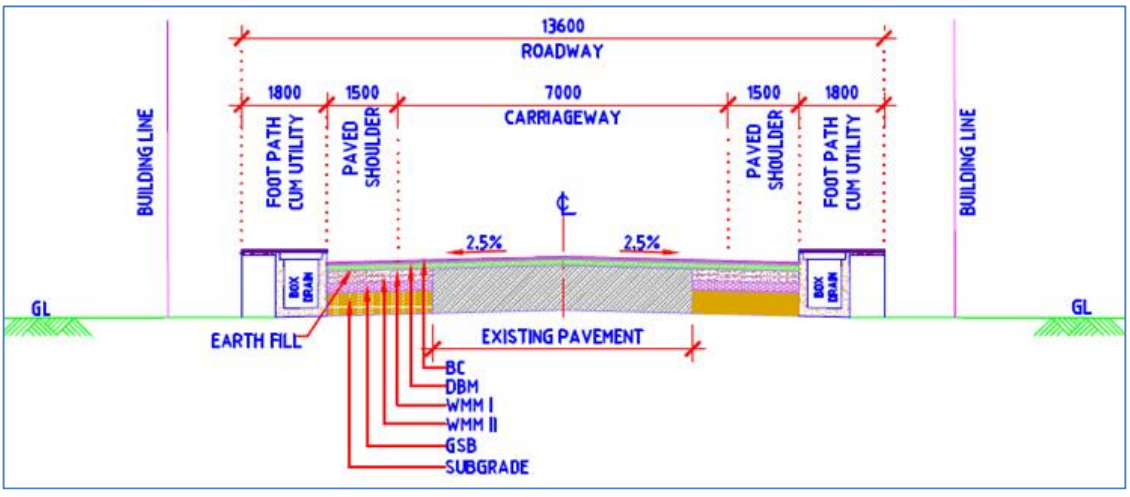
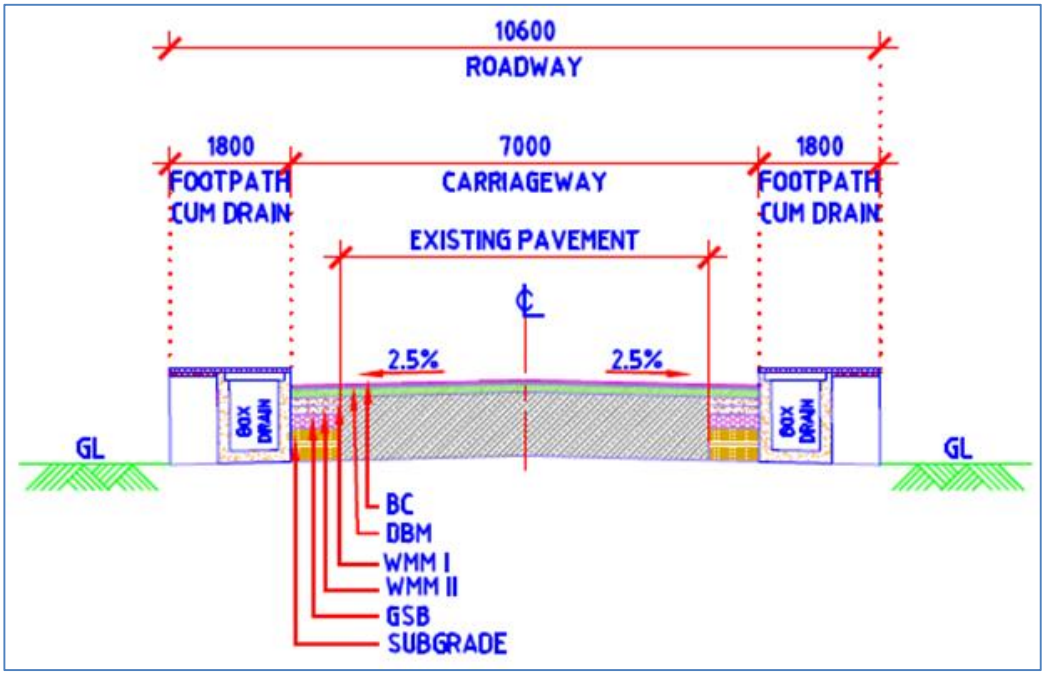
T□□ □yp□a□ro□□ □□□□on□ar□ □□o□n □ro□ **F□□□r□ □-□ □o F□□□r□ □-□□**



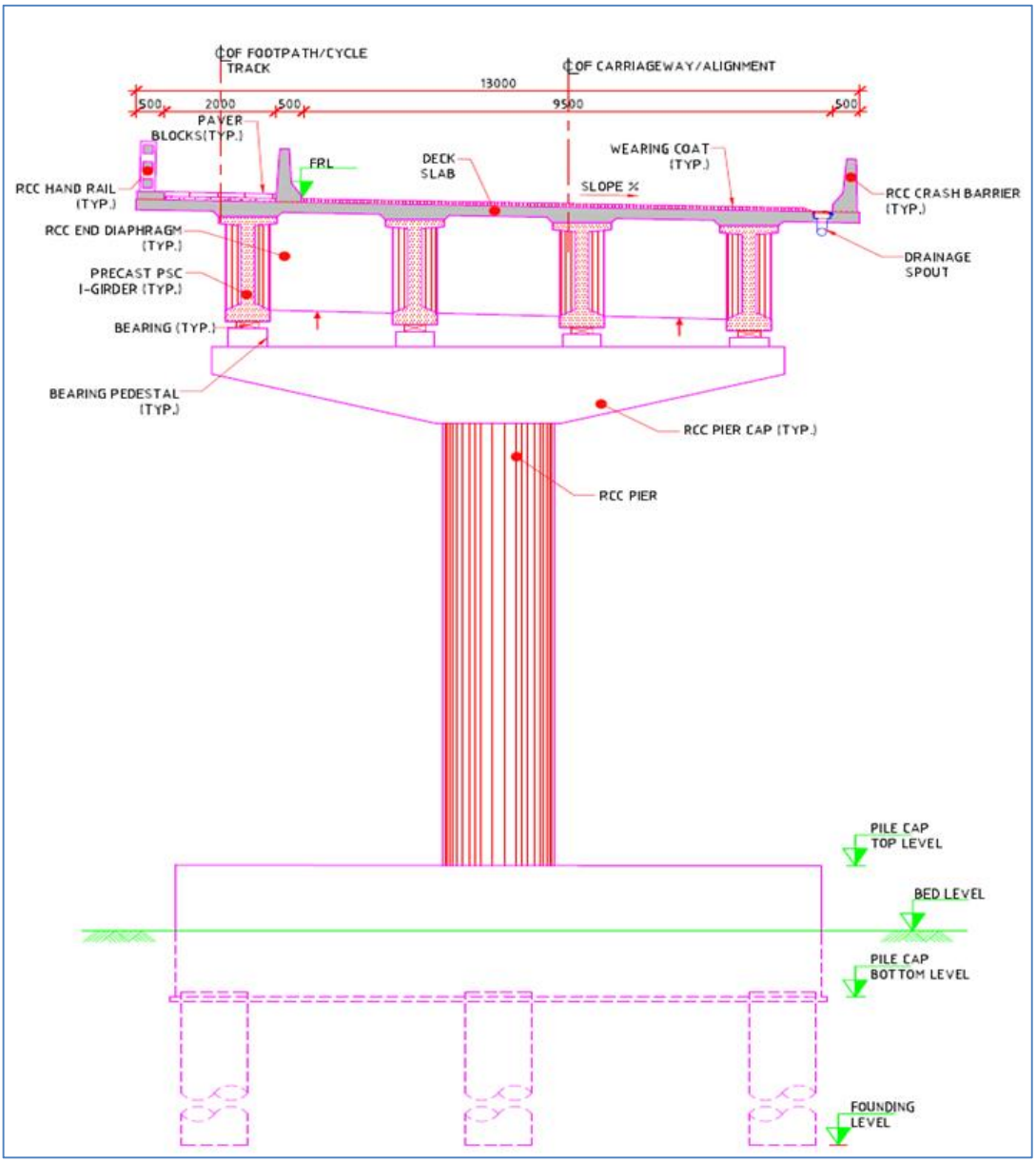
F□□□r□ □-□ T□□□□□□□Cr□□□ S□□□□□□ □□r □□□r□□□□ □□□□r□□□□r□ □TCS-□□



F□□□r□ □-□ T□□□□□□□Cr□□□ S□□□□□□ □□r □ d□□□□□ □□□□□□□□□□ r□□d □TCS-□□



Figu **r**e □-9 **T**ypical **Cr**oss **S**ection fo **r** w □**d**ening of exist ng **r**□□**d** (**TCS-**3)


℄OF FOOTPATH/CYCLE TRACK
℄OF CARRIAGEWAY/ALIGNMENT
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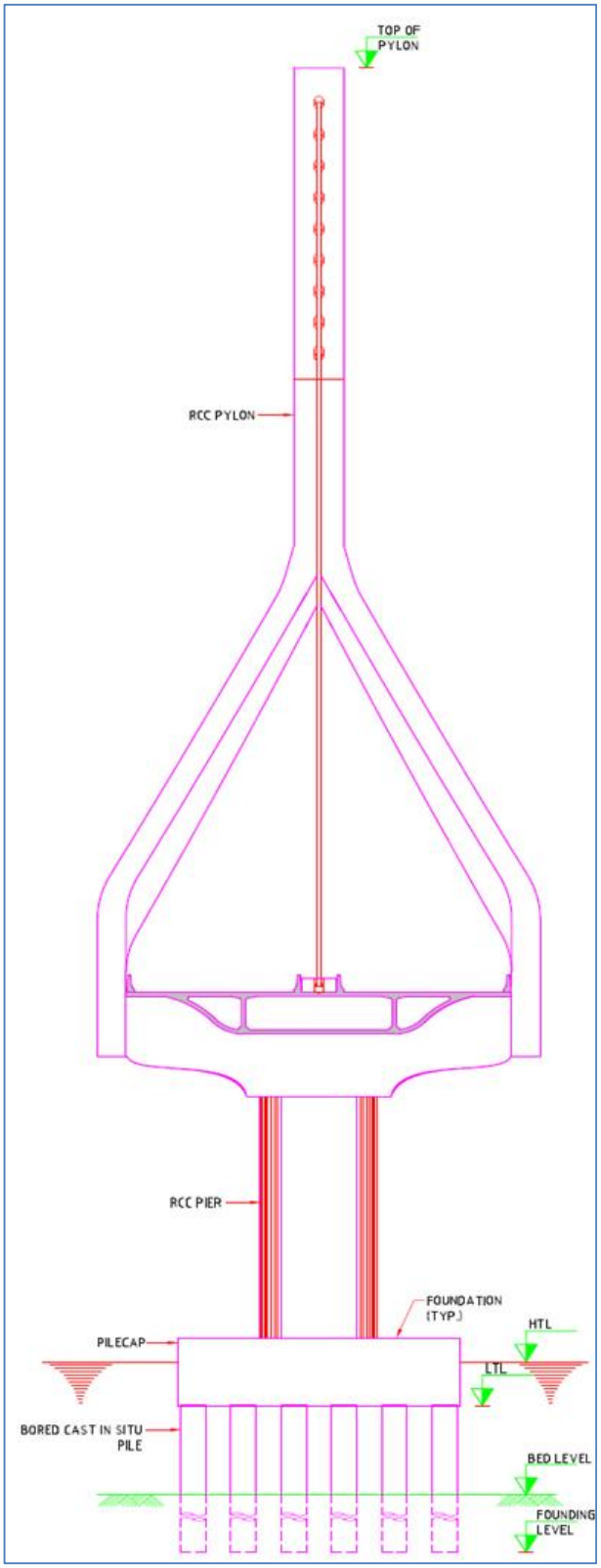
500
2000
500
9500
500
PAVER BLOCKS(TYP.)
FRL
DECK SLAB
WEARING COAT (TYP.)
SLOPE %
RCC HAND RAIL (TYP.)
RCC CRASH BARRIER (TYP.)
RCC END DIAPHRAGM (TYP.)
DRAINAGE SPOUT
PRECAST PSC I-GIRDER (TYP.)
BEARING (TYP.)
BEARING PEDESTAL (TYP.)
RCC PIER CAP (TYP.)
RCC PIER
PILE CAP TOP LEVEL
BED LEVEL
PILE CAP BOTTOM LEVEL
FOUNDING LEVEL

F□□□r□ □-□□ T□□□□□□Cr□□□ S□□□□□□ □□□□□d□□□□TCS-□□



Figu **r**e 2**-**11: **T**ypical c **r**oss section of **M**ain **Br□d□□** (T**CS-**5)

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2.12 Project Cost

2.12.1 Civil Cost

To□a□□□□□□o□□n□□d□n□ road □or□□ and □rd□□ □or□□ □□a□o□□**INR** □□□□□□□□ **Cr□r□□□**

2.12.2 Project Cost

T□□ □o□a□pro□□□□ □o□□propo□□d d□□□□op□ □n□o□□ □an□ □rd□□ and approa□□ road □□□□□□□□□ pa□□□ □n□□□ a□o□□**INR** □□□□□□□□ **Cr□r□□□**T□□□ □o□□□□ □□□□□d□n□ □□□□y □□□□□n□□LA and R□R □o□□□□T□□ □on□□r□□□□on p□r□od □□ a□□n a□ □y□ar□ and □□□ □o□□□ar□ □□□a□a□d □o a□□o□n□□or □n□a□on□E□a□a□on on □□□ pro□□□□□o□□ro□ □□□ □□rr□n□pr□□ □□□□□□□ □nd o□□□□ □on□r□□□□on □o□p□□□on □a□ □□□n □on□d□r□d a□□□ p□r ann□□ □

2.13 Project Schedule

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Mi□es□□ nes	□ OT T□ □
Concession period (in years)	24
Assumed Construction Commencement Date	July 2020
First FY during Construction	31-Mar-21
Construction period in Months	24
Completion of Construction	31-Jul-22
Date of commencement of operation period	01-Aug-22

3 Analysis of Proposed Development/Alternatives

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3.2 Pros and Cons of the Options

3.2.1 Option I

Pr□s
• Land acquisition – Minimal • Road has 2-lane configuration. • Connects all major traffic junctions. • Provides connectivity to Karma road. • After ch; 4/100, proposed structure follows the parallel path to the existing road. So that movement on the existing road is unaffected and it will also helpful for the construction of new viaduct. After landing on

ground, proposed road merge with existing road within 250 m. So that traffic merging of both i.e., existing and proposed is smooth. • Land need not to be acquired at harbour location
□ □ ns
• Follows stopping sight distance / 80 kmph speed at structure location to avoid resettlement and avoids land acquisition. • Restricted to 40 kmph speed from Ch; 2/200 to 2/500 to follow the existing road and avoids land acquisition.

3.2.2 Option II

Pr□ s
• Land acquisition – Minimal • Road has 2-lane configuration. • Connects all major traffic generators • Land not need to be acquired at harbour location. • Provides connectivity to Karma road.
□ □ ns
• Follows stopping sight distance / 80kmph speed at structure location to avoid resettlement and avoids land acquisition. • Restricted to 40 kmph speed from Ch; 2/200 to 2/500 to follow the exiting road and avoids land acquisition. • Proposed structure follows the same path to the existing road. Due to this movement on the existing road will be disturbed and it will also produce difficulties for the construction of new viaduct.

3.2.3 Option III

Pr□ s
• Land acquisition – Minimal • Road has 2-lane configuration. • Connects all major traffic generators • Provides connectivity to Karma road. • Land need not to be acquired at harbour location
□ □ ns
• Follows stopping sight distance /80 kmph speed at structure location to avoid resettlement and land acquisition. • Restricted to 40 kmph speed from Ch: 2/200 to 2/500 to follow the existing road and avoids land acquisition. • Proposed structure follows the same path to the existing road. Due to this movement on the existing road will be disturbed and it will also produce difficulties for the construction of new viaduct.

3.3 Scoring of Alternative Alignment Options

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		I	II	III
1	Obligatory Span Length (km)	0.250	0.250	0.250
2	Structure length including bridge length	1.66	1.66	1.84

S. N□	□es□ri□i□n	A□i□nmen□ Op□i□ns		
		I	II	III
3	Land Use	Built-up and Harbour land	Built-up and Harbour land	Built-up and Harbour land
4	Speed achieved	40 to 80 kmph	40 to 80 kmph	40 to 80 kmph
5	Length in which land acquisition Required (km)	3.33	3.33	3.33
6	Cost of road construction (in Crores)	9.11	9.58	10.31
7	Major Critical Issues	-	-	More no of piers are in river which may affect free navigation of fishing boats

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		I	II	III
Geometrics (Speed achieved/Sight distance)	30%	10	10.0	10
Land Acquisition	25%	8	8	9
Cost of Construction	25%	10	8	7
Environmental Acceptability	10%	9	9	8
Constructability	10%	8	8	7
Weighted Score	**100**□	**9.2**	□**.7**	□**.5**

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Introduction Area

Malappuram district has a total cropped area of 1 lakh hectares paddy is the only crop raised during the kharif season and pulses vegetables and banana are the crops raised during rabi Paddy is the predominant crop and coconut occupies the second crop Paddy is cultivated in a year The Virippu season crop Mundakan season crop and Punja crop Punja crop area is the area is fully dependent on the availability of irrigation water The area is bounded on the east by Kaya and on the north by Kuttippuram and Ponnani taluks and on the west by Arabian Sea and on the south by Kadalundi river Ponnani Kole wetlands are the only large contiguous paddy area in Malappuram district Pookkottur Kavanna Manjada Ponnani Manjeri Kuttippuram Perumpadappu Vengad and Kondotty Taluks in Malappuram district also have paddy cultivation

Soil Characteristics

The district consists of laterite and red sandy soil and old alluvium and in the coastal area The district has a total area of 1 lakh hectares and the majority of the population is engaged in agriculture The agricultural activities are concentrated in the Ponnani Parappanangadi and Tanur Ponnani taluks The important crops cultivated in the district are Coconut banana tapioca and rice The agricultural operations in the Ponnani and Parappanangadi Taluks are mainly dependent on the Southwest monsoon and Northeast monsoon Soil survey Soil and Land Use Survey of India Ministry of Agriculture and Farmers Welfare

Industrial Development

The Malappuram district is one of the industrially developed districts in Kerala The district has a total area of 1 lakh hectares and the industrial activities are concentrated in the Kozhikode Palakkad and Thrissur districts The district has a total area of 1 lakh hectares and the industrial activities are concentrated in the Ponnani and Parappanangadi Taluks

An Electronics Technology Park is functioning at Kakkancheri under the Kerala State Electronics Development Corporation Limited at Payyanad in Tirur Taluk in an area of 1 lakh hectares The park is developed in the 1 lakh hectares area and the total area is 1 lakh hectares

Irrigation

The Chalakudy Right Bank Canal starts from Parambikulam Aliyar Project and passes through Ponnani and the Chalakudy River Valley project starts from Chalakudy and ends in Malappuram and Thrissur districts The Chalakudy Project is the oldest project in the district and is operational The canal is 1 lakh hectares and the canal is 1 lakh hectares and the canal is 1 lakh hectares and the

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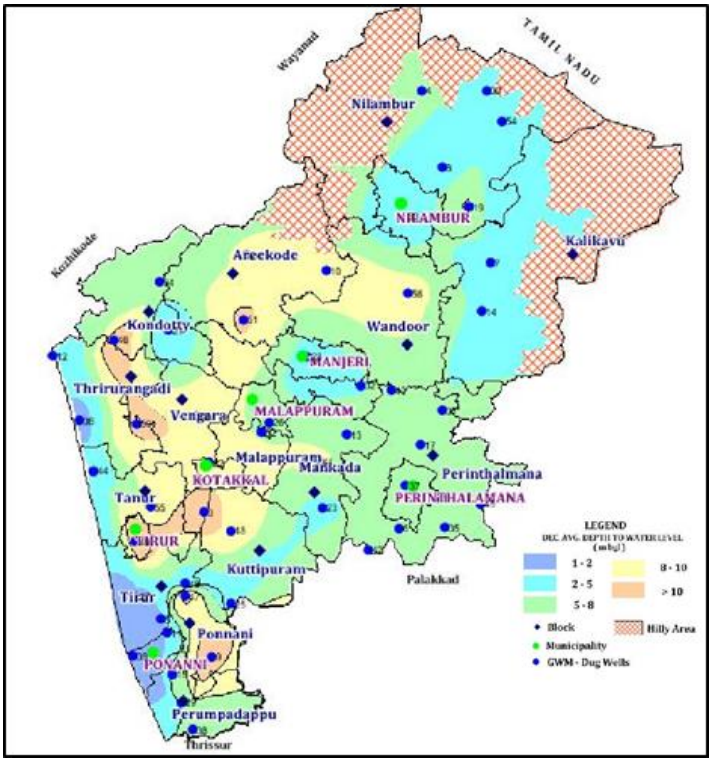

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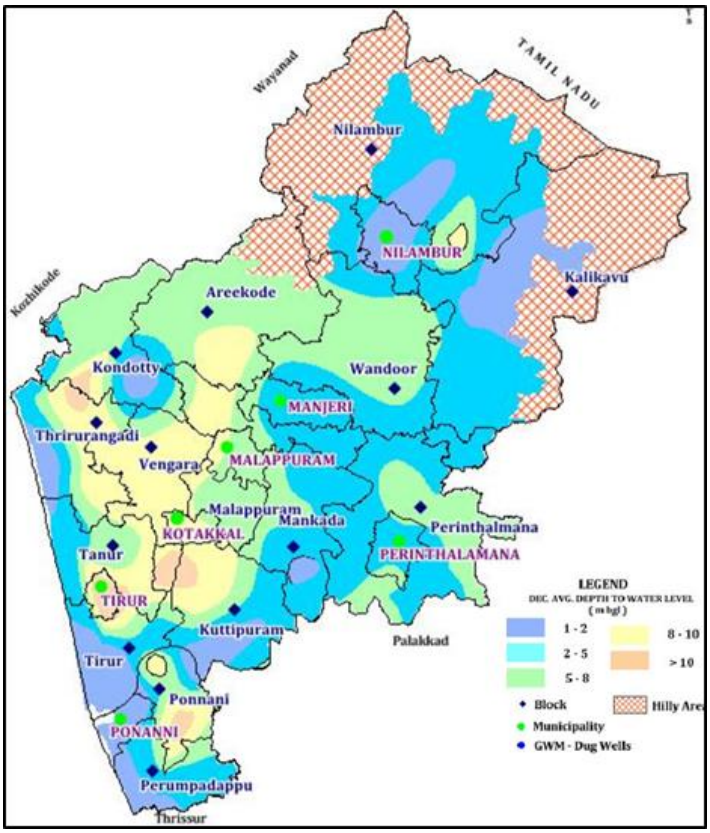

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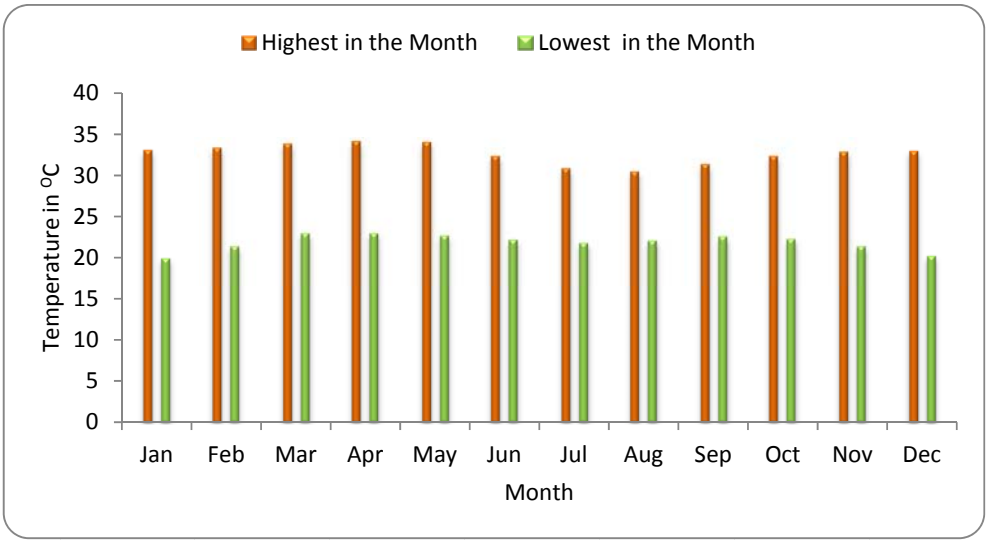

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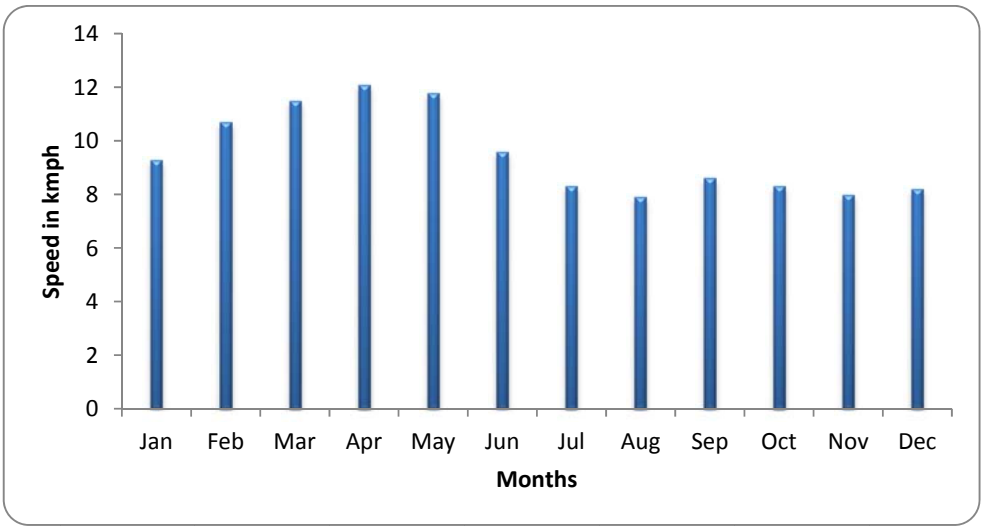

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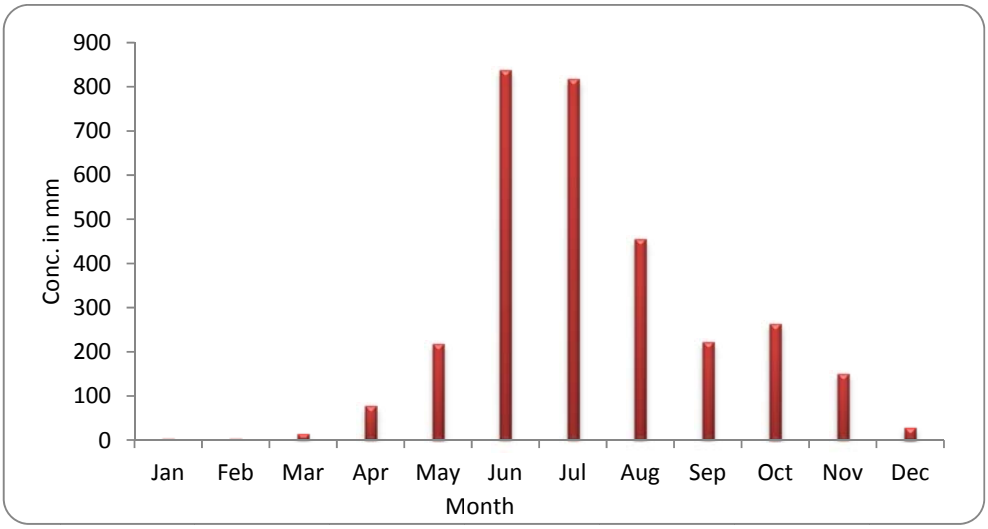

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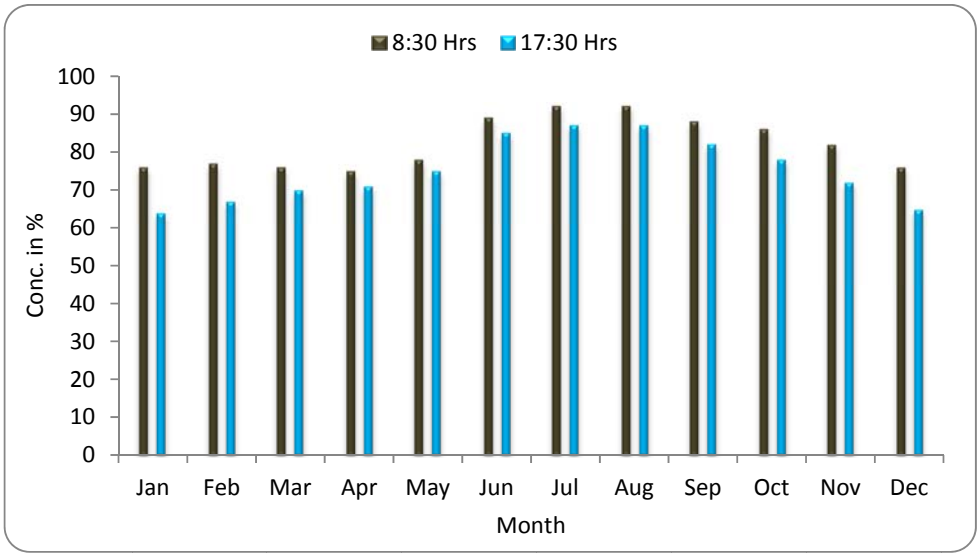

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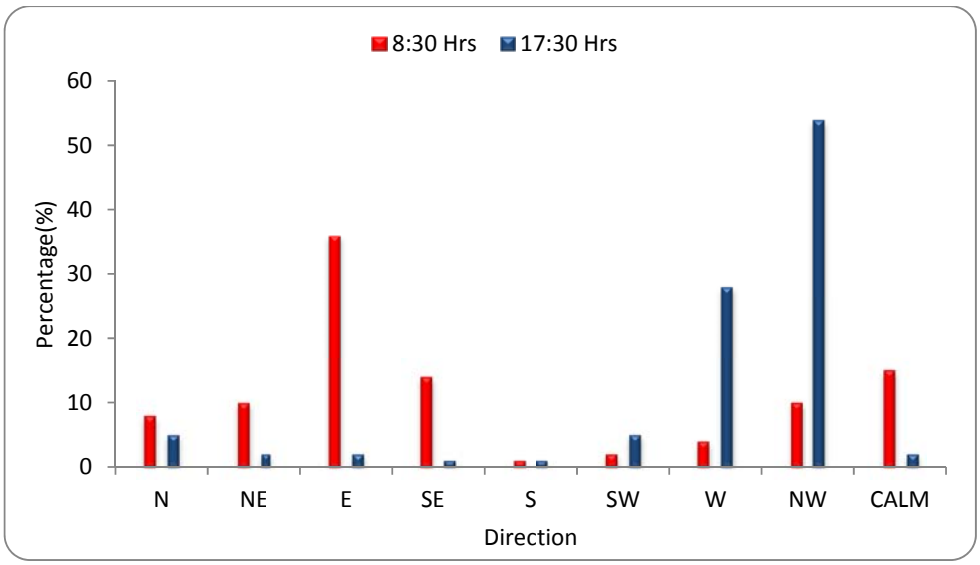

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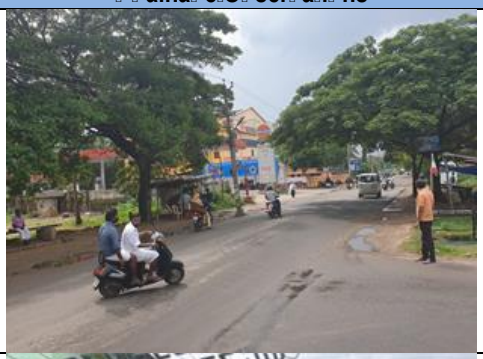
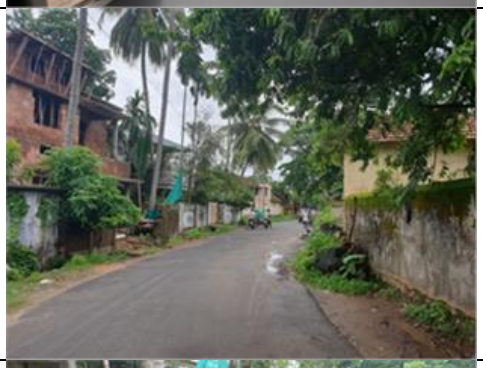
	• Alignment start point at Ponnani Junction
	• Approach road towards proposed bridge • Densely populated area along approach road • Based on final RoW, Land Acquisition could be likely
	• Narrow road stretch along the approach road • Based on final RoW, Land Acquisition could be likely
	• Open storm drains along the approach road

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	• Houses adjacent to the road • Have covered storm drains • Most of the structures are Pucca structures
	• Hand pump/bore well (common property resource) along the project corridor
	• Solid waste along the corridor (seen rarely though)
	• Project corridor passes adjacent to the sea coast • Is in CRZ area • Erosion seen in the project area along the coast • Rock bund have been provided at some stretches as mitigation measure
 	• Ponnani fishing harbour along the project corridor • Ponnani is one of the major fishing centres in Malappuram district • Shed along project corridor – used for fishing related works (boat/net maintenance, temporary storage, etc.)

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	• Ferry (Jungar) service to cross the river • Ferry service is not available after day light hours (normal operation hours about 6:00 AM to 7:00 PM) • Proposed bridge will provide an alternative to the Ferry service
	• Casuarina plantation in the project area at Padinjarekara beach • There are also some coconut plantations as well as other trees along the corridor
	• Recreation park at Padinjarekara Beach
	• Corridor end point • Merging with the Coastal Highway section (where construction activities are in progress) • Mosque seen along the corridor

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4.3.1 Flora and Fauna

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4.4 Baseline Environment

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4.4.1 Ambient Air Environment

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4.4.2 Noise Environment

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4.4.3 Water Environment

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4.4.4 Marine Environment

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HH	7,93,999	15,816	5,787	**□,15,602**
TOT_P	41,12,920	90,491	31,915	**42,35,326**
TOT_M	19,60,328	42,627	15,062	**20,1□ ,017**
TOT_F	21,52,592	47,864	16,853	**22,17,309**
M_06	2,92,132	6,057	2,136	**3,00,325**
F_06	2,81,909	5,860	2,154	**2,□ 9,923**
M_SC	1,51,557	2,485	1,853	**1,55,□ 95**
F_SC	1,56,709	2,717	1,941	**1,61,367**
M_ST	11,272	103	31	**11,406**
F_ST	11,718	93	34	**11,□ 45**

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Malappuram District	911	1,036	967	962
Ponnani Municipality	891	1,034	915	1,108
Purathur Village	894	992	955	912

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1	Malappuram District	7,93,999	41,12,920	15,97,404	17,13,911	3,62,924	4,38,681

S. N□	Area	□ □	TOT□ P	TOT□ M Li□	TOT□ F Li□	TOT□ MI □i□	TOT□ FI □i□
2	Ponnani Municipality	15,816	90,491	34,140	36,574	8,487	11,290
3	Purathur Village	5,787	31,915	12,043	13,004	3,019	3,849
T□ □a□		**□,15,602**	**42,35,326**	**16,43,5□ 7**	**17,63,4□ 9**	**3,74,430**	**4,53,□ 20**

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Malappuram District	10,62,424	8,98,157	1,64,267	8,52,047	2,10,377	10,62,171	19,88,325	10,62,424
Ponnani Municipality	22,813	20,270	2,543	19,407	3,406	22,357	45,321	22,813
Purathur Village	8,854	7,483	1,371	7,232	1,622	7,579	15,482	8,854

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Malappuram District	10,62,424	42,693	3,017	69,919	11,922	11,295	2,155	6,24,524	86,522
Ponnani Municipality	22,813	58	10	307	24	303	56	16,859	1,790
Purathur Village	8,854	218	23	223	22	91	25	6,030	600
T□□a□	**10,94,091**	**42,969**	**3,050**	**70,449**	**11,96□**	**11,6□ 9**	**2,236**	**6,47,413**	**□□,912**

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Site clearance	---	Yes	---	---
Generation of debris	---	Yes	Yes	---
Non Concrete waste	---	Yes	Yes	---
Hot Mix/Ready Mix Concrete waste	---	Yes	Yes	---
Planning Traffic diversion	---	Yes	Yes	---
Quarries	---	Yes	Yes	---
Transportation of construction material	---	Yes	Yes	---
Material storage	---	Yes	Yes	---
Excavation	---	Yes	Yes	---
Natural drainage	---	Yes	Yes	---
Construction in Aquatic Environment (piers)	---	Yes	Yes	---
Bridge and Road construction	---	Yes	Yes	---
Environmental Attributes				
Air	---	Yes	Yes	---
Water	---	Yes	Yes	---
Noise	---	Yes	Yes	---
Soil	---	Yes	Yes	---
OPERATION P□ ASE (M□ □emen□ □ Tra□i□)				
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Air	Yes	---	---	Yes
Noise	Yes	---	---	Yes
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Increase in property Value	Yes	---	---	Yes
Transportation Development	Yes	---	---	Yes

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Employment Opportunities	Yes	---	---	Yes
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Safety, Improved Facility, Benefits to Locals	Yes	---	---	Yes

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1.	Land Use	Impacts due to road development/ concrete structures and felling of trees	Required activity for proposed construction of cable stayed/ suspension bridge
2.	Air Quality	Impacts due to vehicular emissions, dust from use of construction machinery, hot mix plants/concrete batching plants, etc.	Most impacts are envisaged during construction phase, which will be short term and be localized to the areas of construction related activities
3.	Noise	Impacts due to vehicular traffic noise, heavy machinery noise, etc.	Most impacts are envisaged during construction phase and will be short term and localized to the areas of construction related activities
4.	Soil Characteristics	Potential for soil contamination due to construction related activities such as generation of debris, fuel & lubricants, waste etc.	Impacts shall be short-term; appropriate mitigation measures shall be recommended. Also, impacts are not envisaged during the operation stage.
5.	Ecology/Flora & Fauna	Impacts due to tree felling; Loss biomass, removal of vegetation; disturbance & habitat loss, etc.	No loss of bio-diversity is envisaged due to the proposed project; some trees will need to be felled for which compensatory afforestation will need to be taken up. The proposed project site doesn't have endangered floral and/or faunal species. As such proposed development is not envisaged to cause adverse impacts to Flora and Fauna.
6.	Water Quality	Minimal impacts due to construction related activities (construction of piers/pillars in the river, site clearance, earthworks, storage of construction materials, worker camps near water bodies (if any), transportation of construction material, etc.)	Impacts are expected to be localized; proposed project is not expected to alter the existing water quality on a permanent basis. Also, impacts are not envisaged during the operation stage.

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Air	All parameters prescribed by MoEF&CC	Once in a quarter during construction period	2 locations (based on habitations)	Contractor/ Project Proponent	National Ambient Air Quality Standards released during November, 2009 **(En□□sed as Anne□□re 1)**
Noise	Same as above		2 locations (based on habitations)	Contractor/ Project Proponent	National Ambient Noise Standards, GSR 1063 (E), 1989 **(En□□sed as Anne□□re 2)**
Water Quality	Same as above		2 locations (based on habitations)	Contractor/ Project Proponent	IS10500:2012 drinking water standards for Groundwater and ISI-IS: 2296-1982, the tolerance limits of parameters are specified as per classified use of water depending on various uses of water for Surface water **(En□□sed as Anne□□re 3 & Anne□□re □)**
Soil	Same as above		2 locations (based on habitations)	Contractor/ Project Proponent	CPCB standards/ National Agricultural research Institute **(En□□sed as Anne□□re 5)**
Marine Water and Sediment	Same as above	Once in a quarter during construction	2 locations (based on habitations)	Contractor/ Project Proponent	Water quality parameters shall be monitored as per applicable surface water

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Quality		period (when construction is taken up in the river)			guidelines/ standards

Table 6 **-**2 **M**onito **r**ing **Pr**□□**r**□□ **d**u**r**ing **O**pe**r**ation **S**tage

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Air	All parameters prescribed by MoEF&CC	At least twice a year* (suggest to incorporate this monitoring with the local PCB monitoring activities, if any)	2 locations (based on habitations)	Contractor/ Project Proponent	National Ambient Air Quality Standards released during November, 2009 **(En□ □sed as Anne□ □re 1)**
Noise	Same as above	At least twice a year* (suggest to incorporate this monitoring with the local PCB monitoring activities, if any)	2 locations (based on habitations)	Contractor/ Project Proponent	National Ambient Noise Standards, GSR 1063 (E), 1989 **(En□ □sed as Anne□ □re 2)**

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8.1 Economic Benefits

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8.1.1 Vehicle Operating Cost (VOC) Savings

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8.1.2 Value of Time (VOT)

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8.1.3 Ease in Transportation

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1	**Impa□ □s □ n Land En□ ir□ nmen□**		
	• Contamination of soil	• Inappropriate handling of wastes/debris/hazardous wastes	• Waste debris should not be disposed in nearby water bodies, should not be left unmanaged at the project site • Indiscriminate dumping of wastes shall be avoided • Transport of hazardous materials by road shall be regulated by Motor Vehicle Act 1989 • Hazardous waste management rules to be enforced • All hazardous wastes shall be retained in secure containers and shifted to appropriate locations for disposal • Methods for solid waste management are recommended to be implemented which will serve as an environmental enhancement opportunity benefiting the society in general and not specific to the road users • Indiscriminate dumping of wastes shall be avoided • Oils/fuels shall be stored/placed in designated areas to avoid spills onto the soil • Oil spill control/collection equipment's shall be available at the project site; any spills at the project site shall be cleaned up immediately to avoid likely contamination of the soil • Contaminated soils, if any, shall be stored properly at the site before disposing it off-site through authorised vendors • Appropriate waste collection facilities shall be provided at the work areas • All spoils shall be collected and disposed off appropriately • Vehicles and equipment's used at the project site shall be properly maintained to avoid/minimise soil contamination due to leaks/spills of fuels, lubricants, etc. • Soil quality monitoring shall be carried out during the construction period
		• Maintenance/repair works	• Oil interceptors are recommended to be provided at locations like repair

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			yards to prevent the waste oils, fluids, etc. from reaching the soil cover • Only essential maintenance of equipment, vehicles shall be carried out at site • Onsite spill cleanup kits shall be made available
	• Soil Erosion • Loss of topsoil	• Corridor development	• Measures such as silt fencing to be provided to prevent excavated/eroded material from entering the water body • The top soil will be stripped and stockpiled at the construction site for future appropriate use, where applicable • The stockpiled topsoil shall be spread back to maintain the physico-chemical and biological activity of the native soil
	• Likely negative impacts due to improper handling of sewage and domestic solid waste generated at labour camps	• Solid waste contamination from labor camps	• Construction labour camps shall be allotted specified area (preferably away from habitations) with adequate sanitary facilities, drainage, washing and toilet facilities with septic tanks and refuse collection and disposal facilities
	• Impacts due to loss of land, Changes in Land Use	• Corridor development (addition of paved surface/ concrete structures)	• Required activity for proposed development of the bridge/road project • Changes in land use due to proposed development is not envisaged/will be negligible • Based on the final designed alignment and PRoW, the extent of land to be acquired especially private land, will be known. The affected persons/structures will be identified and appropriate compensation packages as per applicable rules will be worked out.
2	**Impa□□s □ n Air □ □a□i□**		
	• Generation of Dust	• Site clearance • Use of construction vehicles and machinery • Construction activities	• Areas prone to fugitive dust emissions such as demolition, excavation and grinding sites should be stabilized by spraying water • Sprinkling of water shall be done on all haul roads, especially areas passing through residential areas, to minimise fugitive dust emissions due to vehicular movement; water sprinkling shall be carried out at least twice a day on a regular basis during the construction period especially in the summer seasons • Trucks/vehicles used for transporting materials shall be provided with

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			dust covers (tarpaulins, etc.) to minimize dust emissions • Construction equipment and transport vehicles will be periodically washed to remove accumulated dirt. • Construction debris shall be cleared from the site regularly
		• Stone crushing, ready mix concrete batch plants, etc.	• The concrete mix plants, hot mix units, stockyards, etc. shall be away (~ 500 m down windward direction) from residential areas/labor camps • Crushing and grinding machinery should be enclosed. All the drilling operations are to be coupled with dust collectors
	• Generation of exhaust gases	• Transportation of materials	• Movement of material will be mostly during non-peak hours and will be regulated during peak hours
		• Movement of vehicles	• Idling of trucks or other equipment should not be permitted when they are being loaded/unloaded or not in active use • Low emission construction vehicles /equipment's shall be used wherever possible
		• Use of construction vehicles and machinery	• Vehicles and equipments used at the project site shall be properly maintained to ensure pollution emission levels are as per KSPCB norms • Contractors shall be asked to regularly provide Pollution Under Control (PUC) certificate for their equipment's and machinery as per prevalent norms • All stationary equipment should be located as far as practicable from receptor locations in order to allow dispersion of emitted pollutants • Native species of plantation can be grown along the corridor wherever possible • Air quality monitoring shall be carried out during construction and operation phases of the project
3	**Impa□ □s □ n N□ ise □ □ a□i□**		
	• Noise from Vehicles, Plants, Equipment, Construction works	• Movement of vehicles • Transportation of materials • Use of construction vehicles and machinery	• During construction, noise levels will be maintained below threshold levels stipulated by Central Pollution Control Board (CPCB) by selecting appropriate equipment, machinery and using enclosures

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		• Stone crushing, ready mix concrete batch plants, hot mix, units, piling works, construction activities, etc.	• Noise level limits for construction equipment shall not exceed 75 dB (A) (measured at one meter from the edge of equipment in the free field), as specified in the Environment (Protection) rules, 1986 • Well-maintained construction equipment, which meets the regulatory standards for source noise levels, will be used • Equipment emitting high noise, wherever possible, will be oriented so that the noise is directed away from sensitive receptors and shall be provided with noise shields (like a physical barrier, etc.) • Citing of construction yard sites shall be at least 500 m distance from major residential areas or sensitive receptors which will allow noise levels to attenuate • Noisy construction work such as crushing, concrete mixing, batching will be stopped during the night time between 10.00 pm to 6.00 am. • All vehicles and equipment used in construction will be fitted with exhaust silencers • The main stationary noise producing sources such as generator sets should be provided with noise shields around them. Noise shields can either be a brick masonry structure or any other physical barrier that is effective in adequate attenuation of noise levels • Noise protection personal protection equipment (earplugs, ear muffs etc.) should be provided to those working very close to the noise generating machinery. • Noise barriers should be provided during both construction and operation stages at locations with potential for high noise impacts and at sensitive locations (schools, hospitals, etc.), if found to be necessary • Ambient noise levels will be monitored at regular intervals during construction and operation phases of the project
4	**Impa□ □s □□ F□□ ra and Fa□ na**		
	• Proposed development is not envisaged to cause impacts to Flora	• Site clearance • Noise creating activities like movement of	• Construction activity is not envisaged to have negative impact on the flora of the project site

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	and Fauna	vehicles, use of construction vehicles and machinery, stone crushing, ready mix concrete batch plants, etc.	• Noise control measures shall be followed to avoid inconvenience to the birds present in the project development area • Construction activity shall be avoided during monsoon season, due to possibility of flooding in the river and any likelihood of potential impacts on fish breeding season
5	**Impa□ □ □ n □ a□er Res□ □ r□es**		
	• Water Quality	• Site clearance, Earthworks	• Indiscriminate dumping of wastes shall be avoided • Construction debris shall not be dumped into water bodies, or dumped in areas which can affect the flow of water or even cause reduction in width of the river • Sites for disposal of construction and related wastes should be identified and approved by the authorized representatives prior to commencement of construction activities • Adequate silt fencing measures should be provided as needed • No unauthorized clearing of vegetation will be permitted • Water quality monitoring shall be carried out during the construction period
		• Storage of construction materials	• Construction yards/material storage shall be away from the water bodies and in secured locations
		• Maintenance activities	• Oil interceptors are recommended to be provided at locations like repair yards to prevent waste oils/fluids, etc. from discharging into the water bodies • Only essential maintenance works shall be carried out at site • Onsite spill cleanup kits shall be made available • Construction equipment shall not be cleaned or washed near the water body; the wash water shall not be discharged into the Bharathapuzha River • Vehicles and equipment's used at the project site shall be properly maintained to avoid/minimise soil contamination due to leaks/spills of fuels, lubricants, etc.

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		• Construction activities • Transportation of construction material, etc.	• Stone crushers, hot mix plants and other heavy machinery should be located away from the water bodies • Ensure good practices and take precautions to minimize the risks of spillage of pollutants like oils, fuels, grease, etc. into the water body • No vehicle entry to water body shall be permitted • All vehicles that will be used will be with PUC certificates • Total number of vehicles used shall be restricted • Construction works of the piers shall be taken up during the lean flow periods in summer to minimize the impacts
		• Labour/Worker camps	• Labour camps, if to be provided, shall be located away from the water bodies • There shall be no direct discharge of domestic sewage into the waterbodies • Provisions for appropriate collection and disposal of wastewater generated at labour camps shall be made (wastewater shall be discharged to the existing sewage network)
	• Water Resources	• Water requirement for construction activities, use in labour camps	• For the construction purpose water shall be purchased (or) outsourced from appropriate Government bodies or private water supplying agencies • Uncontaminated water for drinking, cooking and washing, bathing, latrines and urinals shall be made available to the workers and they should not be relying on local water resources for their needs and the water availability and supply to nearby communities remain unaffected
6	**Impa□ □s d□ e □□ □ □ns□r□ □ □i□ n □ □r□s in A□ □a□i□ En□ ir□ nmen□**		
	• Increased sedimentation/turbidity • Construction material/debris getting into the water body • Oil spills, spillage of other residues • Obstruction of drainage patterns/flow of water due to inappropriate dumping of debris	• Construction of piers and installation of substructure/ superstructure to be carried out in aquatic environment of Bharathapuzha River	• Contractor shall install temporary structures like caissons which will help suspended sediments to be minimal • All excavated material as well as material stock piles will be maintained as far as possible away from the edge of the river (~100 m) • The earthwork or excavations along banks of the Bharathapuzha River shall not be carried out during high tides/flood and monsoon seasons • Construction equipment shall not be cleaned or washed near the water

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	• Water stagnation due to inappropriate debris dumping • Drainage alteration		body; the wash water shall not be discharged into the Bharathapuzha River • Precautionary measures shall be in place to prevent/minimize sediments from entering the Bharathapuzha River

Introduction to Environmental Management Plan

An Environmental Management Plan is developed to incorporate the recommendations and mitigation measures and environmental monitoring plan into the construction and operation phases of the project. The EMP and the associated documents will be a part of the contract documents for the project. The contractor will be required to adhere to the EMP requirements. The environmental monitoring plan will be implemented by the contractor under the supervision of the Environmental Officer. In addition to the EMP implementation, the contractor will be responsible for obtaining all the statutory clearances required for the project. The construction activities will be carried out only after obtaining the necessary clearances from the MoEF&CC/NHAI/ appropriate authority. The construction activities will be carried out only by the contractor and his sub-contractors. The contractor will be responsible for implementing the EMP. In addition to the EMP implementation, the contractor will be responsible to provide adequate facilities to the workers employed by him and his sub-contractors and will be responsible for the compliance of all the statutory requirements.

In the event of any violation by the contractor, the Engineer-in-charge may issue notice for implementation and compliance of the EMP or terminate the contract for EMP implementation and compliance to a stipulated authority.

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1	Horticulture/ Soil	Tree cutting/felling	Nos.	238	2000	0.0476
		Tree plantation and maintenance including metallic guards, etc.	Nos.	476	2500	0.119
		Environmental Monitoring***	Nos.	16	4000	0.0064
2	Noise	Environmental Monitoring***	Nos.	16	1500	0.0024
3	Water Quality	Silt fencing around soil stockpiled near water bodies	m	2500	1500	0.375
		Environmental Monitoring***	Nos.	16	6000	0.0096
4	Air Quality	Water sprinkling, covers for material transport on trucks, etc.	Lump sum	1	500000	0.05
		Environmental Monitoring***	Nos.	32	8000	0.0256
5	Marine Water and Sediment Quality	Environmental Monitoring***	Nos.	8	12000	0.0096
6	Administrative Charges	Vehicle usage, data processing, data entry, maintenance of collected data/ database, stationery, etc.	Per Month	24	150000	0.36
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7	Air Quality	Environmental Monitoring***	Nos.	120	8000	0.096
8	Noise	Environmental Monitoring***	Nos.	30	1500	0.0045
		Sign boards (restrictions on horn, speed limits, etc.)	Lump sum	1	100000	0.010
9	Administrative Charges	Vehicle usage, data processing, data entry, maintenance of collected data/ database, stationery, etc.	Per Month	180	150000	2.70
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ANNEXURES

Annexu **r**e 1: **N**ationa □**A**mbient **A**□r Quality **S**□□□**d**□**rd**□, Go **I**

[भाग III—खण्ड 4] भारत का राजपत्र : असाधारण 3

NATIONAL AMBIENT AIR QUALITY STANDARDS
CENTRAL POLLUTION CONTROL BOARD
NOTIFICATION

New Delhi, the 18th November, 2009

No. B-29016/20/90/PCI-L—In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No.14 of 1981), and in supersession of the Notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect, namely:-

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Government)	Methods of Measurement
(1)	(2)	(3)	(4)	(5)	(6)
1	Sulphur Dioxide (SO_2), µg/m^3	Annual*	50	20	- Improved West and Gaeke
		24 hours**	80	80	-Ultraviolet fluorescence
2	Nitrogen Dioxide (NO_2), µg/m^3	Annual*	40	30	- Modified Jacob & Hochheiser (Na-Arsenite)
		24 hours**	80	80	- Chemiluminescence
3	Particulate Matter (size less than 10µm) or PM_{10} µg/m^3	Annual*	60	60	- Gravimetric - TOEM
		24 hours**	100	100	- Beta attenuation
4	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$ µg/m^3	Annual*	40	40	- Gravimetric - TOEM
		24 hours**	60	60	- Beta attenuation
5	Ozone (O_3) µg/m^3	8 hours**	100	100	- UV photometric - Chemilminescence
		1 hour**	180	180	- Chemical Method
6	Lead (Pb) µg/m^3	Annual*	0.50	0.50	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper - ED-XRF using Teflon filter
		24 hours**	1.0	1.0	
7	Carbon Monoxide (CO) mg/m^3	8 hours**	02	02	- Non Dispersive Infra Red (NDIR) spectroscopy
		1 hour**	04	04	
8	Ammonia (NH_3) µg/m^3	Annual*	100	100	-Chemiluminescence
		24 hours**	400	400	-Indophenol blue method

(1)	(2)	(3)	(4)	(5)	(6)
9	Benzene (C_6H_6) $\mu g/m^3$	Annual*	05	05	- Gas chromatography based continuous analyzer - Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP) - particulate phase only, ng/m^3	Annual*	01	01	- Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	- AAS /ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Note. — Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

SANT PRASAD GAUTAM, Chairman
[ADVT-III/4/184/09/Exty.]

Note: The notifications on National Ambient Air Quality Standards were published by the Central Pollution Control Board in the Gazette of India, Extraordinary vide notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998.

Printed by the Manager, Government of India Press, Ring Road, Mayapuri, New Delhi-110064
and Published by the Controller of Publications, Delhi-110054.

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SCHEDULE

(see rule 3(1) and 4(1))

Ambient Air Quality Standards in respect of Noise

Area Code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
(A)	Industrial area	75	70
(B)	Commercial area	65	55
(C)	Residential area	55	45
(D)	Silence Zone	50	40

Note:- 1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A "decibel" is a unit in which noise is measured.

"A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

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1	Colour (Max)	Hazen	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate sources
2	Odour	--	Agreeable	Agreeable	Part 5	a) Test cold and when heated b) Test at several dilutions
3	Taste	--	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
4	Turbidity (Max)	NTU	1	5	Part 10	--
5	pH	--	6.5 to 8.5	No Relaxation	Part 2	--
6	Temperature	^{O}C	--	--	--	--
7	Electrical conductivity	µ mhos/cm	--	--	--	--
8	Salinity	ppt	--	--	--	--
9	Total solids	mg/l	--	--	--	--
10	Total Hardness as CaCO3 (Max)		200	600	Part 21	--
11	Total Alkalinity as Calcium Carbonate (Max)		200	600	Part 23	--
12	Iron as Fe (Max)		0.3	No Relaxation	Part 53	Total concentration of manganese (as Mn) and iron (as Fe) shall not exceed 0.3 mg/l
13	Chlorides as Cl (Max)		250	1000	Part 32	
14	Free Residual Chlorine (Min)		0.2	1	Part 26	To be applicable only when water is chlorinated. Tested at consumer end. When protection against viral infection is required, it should be minimum 0.5 mg/l
15	Total dissolved solids (Max)		500	2000	Part 16	--
16	Calcium as Ca (Max)		75	200	Part 40	--

S. N□.	Parame□er	□ ni□	Re□ □iremen□ (A□ □ep□a□ □e Limi□)	Permissi□ □e Limi□ in A□ sen□ e □ □ A□□erna□e S□ □ r□ e	Me□□ □ d □ □ Tes□, Re□ □□ Par□ □ □ IS 3025	Remar□ s
17	Magnesium as Mg (Max)		30	100	Part 46	--
18	Copper as Cu (Max)		0.05	1.5	Part 42	--
19	Manganese as Mn (Max)		0.1	0.3	Part 59	Total concentration of manganese (as Mn) and iron (as Fe) shall not exceed 0.3 mg/l
20	Sulphate as SO4 (Max)		200	400	Part 24	May be extended to 400 provided that Magnesium does not exceed 30
21	Nitrate as NO3 (Max)		45	No Relaxation	Part 34	--
22	Fluorides as F (Max)		1	1.5	Part 60	--
23	Sodium as Na		--	--	--	--
24	Potassium as K		--	--	--	--
25	Total Nitrogen		--	--	--	--
26	Total phosphorous		--	--	--	--
27	Free Ammonia as NH4		--	--	--	--
28	Phenolic compounds as C6H5OH (Max)		0.001	0.002	Part 43	--
29	Biochemical oxygen demand	mg/l	--	--	--	--
30	Chemical oxygen demand		--	--	--	--
31	Dissolved oxygen		--	--	--	--
32	Mercury as Hg (Max)		0.001	No Relaxation	Part 48(1) Mercury analyser	--
33	Cadmium as Cd (Max)		0.003	No Relaxation	Part 4 (I)	--
34	Selenium as Se (Max)		0.01	No Relaxation	IS 3025 (Part 56) or IS 15303*	In case of dispute, the method indicated by ,*, shall be the referee method
35	Arsenic as As		0.01	0.05	Part 37	--

S. N□.	Parame□er	□ ni□	Re□ □iremen□ (A□ □ep□a□ □e Limi□)	Permissi□ □e Limi□ in A□ sen□ e □ □ A□□erna□e S□ □ r□ e	Me□□ □ d □ □ Tes□, Re□ □□ Par□ □ □ IS 3025	Remar□ s
	(Max)					
36	Cyanides as CN (Max)		0.05	No Relaxation	Part 27	--
37	Lead as Pb (Max)		0.01	No Relaxation	Part 47	--
38	Zinc as Zn (Max)		5	15	Part 49	--
39	Anionic detergent as MBAS (Max)		0.2	1	Annex K of IS 13428	--
40	Chromium as Cr^{6+} (Max)		0.05	No Relaxation	Part 52	--
41	Total coli forms	MPN/100 ml	Shall not be Detectable in any 100 ml sample		IS 1622	--
42	Faucal coli forms					--
It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 5, above which the sources will have to be rejected						

A□□□□□r□ □□□□ □□□r □ □□□□□□ S□□□d□rd□□□ □l

T□□r□□□□ □□d C□□□□□□□□□□□□

A□ p□r ISI□IS□□□□□□□□□□□□□□ □o□ran□□ □□□ □□□ o□para□ □□□r□ ar□ □p□□□□□d a□ p□r □a□□□□□d □□□ o□ □a□r □Ta□□□ □□□□□□□□□□ □□□o□□d□p□nd□n□ on □ar□o□□ □□□□ o□ □a□r□T□□ □o□o□n□ □a□□□□□a□on□ □a□□ □□□n adop□□d □n Ind□a□

C□□□□ □□□ □□□r

□lassi□i□a□i□n	T□pe □ □ □se
Class A	Drinking water source without conventional treatment but after disinfection
Class B	Outdoor bathing
Class C	Drinking water source with conventional treatment followed by disinfection.
Class D	Fish culture and wild life propagation
Class E	Irrigation, industrial cooling or controlled waste disposal

TOLERANCE LIMITS

TABLE-□□TOLERANCE LIMITS FOR INLAND S□RFACE □ ATERS□CLASS □A

S. N□.	□ □ ara□ □eris□i□	T□ □eran□ e
(1)	(2)	(3)
(i)	pH	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/l,	6.0
(iii)	Bio-chemical Oxygen Demand	2.0
(iv)	Total Coliform Organisms, MPN/100 ml, Max	50
(v)	Colour, Hazen units, Max	10
(vi)	Odour	unobjectionable
(vii)	Taste	Agreeable taste
(viii)	Total Dissolved Solids, mg/l, Max	500
(ix)	Total Hardness (as CaCO3), mg/l ,Max	300
(x)	Calcium Hardness (as CaCO3), mg/l, Max	200
(xi)	Magnesium (as CaCO3), mg/1,Max	100
(xii)	Copper (as Cu), mg/l, Max	1.5
(xiii)	Iron (as Fe), mg/l,Max	0.3
(xiv)	Manganese (as Mn), mg/1,Max	0.5
(xv)	Chlorides (as Cl), mg/l,Max	250
(xvi)	Sulphate (as SO4), mg/l ,Max	400
(xvii)	Nitrates (as NO2), mg/1,Max	20
(xviii)	Fluorides (as F,) mg/l,Max	1.5
(xix)	Phenolic compounds(as C6H5OH), mg/l,Max	0.002
(xx)	Mercury (as Hg), mg/l ,Max	0.001
(xxi)	Cadmium (as Cd), mg/1,Max	0.01
(xxii)	Selenium (as Se), mg/l ,Max	0.01
(xxiii)	Arsenic (as As), mg/1,Max	0.05
(xxiv)	Cyanides (as CN), mg/l, Max	0.05
(xxv)	Lead (as Pb), mg/l, Max	0.1
(xxvi)	Zinc (as Zn), mg/l, Max	15
(xxvii)	Chromium (asCr6+), mg/l,Max	0.05
(xxviii)	Anionic detergents, (as MBAS), mg/l ,Max .	0.2
(xxix)	Poly-nuclear aromatic hydrocarbons (PAH),	0.2

S. N□ .	□ □ ara□ □eris□i□	T□ □eran□ e
(1)	(2)	(3)
(xxx)	Mineral oil, mg/l ,Max	0.01
(xxxi)	Barium (as Ba), mg/l ,Max	1.0
(xxxii)	Silver (as Ag), mg/l Max	0.05
(xxxiii)	Pesticides	Absent
(xxxiv)	Alpha emitters, µc/ml, Max	10-9
(xxxv)	Beta emitters, µc/ml, Max	10-8

TABLE- □□TOLERANCE LIMITS FOR INLAND S□RFACE □ ATERS□CLASS □ B

S. N□	□ □ ara□ □eris□i□	T□ □eran□ e Limi□
(1)	(2)	(3)
(i)	pH Value	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/1,Max	5.0
(iii)	Biochemical Oxygen Demand (5 days at 20 °C), Max	3.0
(iv)	Total Coliform Organisms, MPN/100 ml, Max	500
(v)	Fluorides (as F)<mg/l, Max	1.5
(vi)	Colour, Hazen units, Max	300
(vii)	Cyanides (as CN), mg/l, Max	0.05
(viii)	Arsenic (as As), mg/l, Max	0.2
(ix)	Phenolic Compounds (as C6H5OH) mg/l, Max	0.005
(x)	Chromium (as Cr6+), mg/l, Max	1.0
(xi)	Anionic detergents (as MBAS), mg/l, Max	1.0
(xii)	Alpha emitters, µc/ml, Max	10-8

TABLE - □□TOLERANCE LIMITS FOR INLAND S□RFACE □ ATERS□CLASS □ C

S.N□ .	□ □ ara□ □eris□i□	T□ □eran□ e Limi□
(1)	(2)	(3)
(i)	pH Value	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/l Minimum	4.0
(iii)	Biochemical Oxygen Demand	3.0
(iv)	Total coliform organisms, MPN/100 ml, Max	5000
(v)	Colour, Hazen units, Max	300
(vi)	Fluorides (as F), mg/l ,Max	1.5
(vii)	Cadmium (as Cd), mg/l, Max	0.01
(viii)	Chlorides (as Cl), mg/l, Max	600
(ix)	Chromium (as Cr6+), mg/l, Max	0.05
(x)	Cyanides (as CN), mg/l, Max	0.05
(xi)	Total Dissolved Solids, mg/l, Max	1500
(xii)	Selenium (as Se), mg/l, Max	0.05
(xiii)	Sulphates (as SO4), mg/l, Max	400
(xiv)	Lead (as Pb), mg/l, Max	0.1
(xv)	Copper (as Cu),mg/l,Max	1.5
(xvi)	Arsenic (as As), mg/l, Max	0.2
(xvii)	Iron (as Fe), mg/l, Max	50
(xviii)	Phenolic compounds (as C6H5OH), mg/l, Max	0.005
(xix)	Zinc (as Zn), mg/l, Max	15
(xx)	Insecticides, mg/l, Max	Absent

S.N□ .	□ □ ara□ □eris□i□	T□ □eran□ e Limi□
(1)	(2)	(3)
(xxi)	Anionic detergents (as MBAS), mg/l, Max	1.0
(xxii)	Oils and grease, mg/l, Max	0.1
(xxiii)	Nitrates (as NO3), mg/1,Max	50
(xxiv)	Alpha emititers, µc/mg, Max	10-9
(xxv)	Beta emitters, µc/ml, Max	10-8

TABLE- □□TEOLERANCE LIMITS FOR INLAND S□RFACE □ ATERS□CALSS □ D

S.N□ .	□ □ ara□ □eris□i□	T□ □eran□ e Limi□
(1)	(2)	(3)
(i)	pH value	6.5 to 8.5
(ii)	Dissolved Oxygen, mg/l, Min.	4.0
(iii)	Free Ammonia (as N), mg/l, Max.	1.2
(iv)	Electrical Conductance at 25 °C, µS, Max	1000
(v)	Free Carbon Dioxide (as C02),mg/1, Max	6.0
(vi)	Oils and Grease, mg/l, Max	0.1
(vii)	Alpha emitters, µc/ml, Max	10-9
(viii)	Beta emitters, µc/ml, Max	10-8

TABLE- □□TOLERANCE LIMITS FOR INLAND S□RFACE □ ATERS□CLASS □ E

S.N□ .	□ □ ara□ □eris□i□	T□ □eran□ e Limi□
(1)	(2)	(3)
(i)	pH value	6.0 to 8.5
(ii)	Electrical Conductance at 25°C, µS, Max	2250
(iii)	Sodium Adsorption Ratio, Max	26
(iv)	Boron (as B), mg/l, Max	2.0
(v)	Total Dissolved Solids, (inorganic), mg/l, Max	2100
(vi)	Sulphates (as SO4), mg/l, Max	1000
(vii)	Chlorides (as Cl), Mg/l, Max	600
(viii)	Sodium Percentage, Max	60
(ix)	Alpha emitters, µc/ml, Max	10-9
(x)	Beta emitters, µc/ml, Max	10-8

A□□□□□r□ □□S□□□□ □□□□□ S□□□d□rd□□□ □I

STANDARD SOIL CLASSIFCATION

S□. N□	S□ i□ Tes□s	□ □assi□i□a□i□ n
1	pH	<4.50 extremely acidic 4.51 -5.00 very strongly acidic 5.01 – 5.50 Strongly acidic 5.51 – 6.00 moderately acidic 6.01 – 6.50 Slightly acidic 6.51 – 7.30 neutral 7.31 – 7.80 Slightly alkaline 7.81 – 8.50 moderately alkaline 8.51 – 9.00 Strongly alkaline 9.01 Very strongly alkaline
2	Salinity Electrical Conductivity (mmhos/cm) (1 mmho/cm = 640 ppm)	Upto 100 average 101 – 200 harmful to germination 201 – 300 harmful to crops (Sensitive to salts)
3	Organic Carbon	Upto 0.2 : Very less 0.21 – 0.4 : less 0.41 – 0.5 : medium 0.51 – 0.8 : On an average sufficient 0.81 – 1.0 : Sufficient > 1.0 : More than sufficient
4	Nitrogen (kg/ha)	Upto 59 very less 51 – 100 less 101 – 150 good 151 – 300 better Above 300 sufficient
5	Phosphorus (kg/ha)	Upto 15 very less 16 – 30 less 31 – 50 medium 51 – 65 on an average sufficient 66 – 80 Sufficient Above 80 more than sufficient
6	Potassium (kg/ha)	0 – 120 very less 120 – 180 less 181 – 240 medium 241 – 300 average 301 – 360 better Above 360 more than sufficient

□*ource□Indian Council o□□□ricultural Re□earc□□□e□ Del□i*

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Roads and Bridges Development Corporation of Kerala Limited (RBDCK)

Kerala Infrastructure Investment Fund Board (KIIFB)

Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches

Detailed Project Report
(Volume-V: Technical Specifications)

March 2020

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L&T Infrastructure Engineering Ltd.

Client:	**Roads and Bridges Development Corporation of Kerala Ltd (RBDCK)** (A Government of Kerala undertaking)		
Project:	Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches	**Project No.:** C1193601	
Title:	Detailed Project Report (Volume – V:Technical Specifications)	**Document No.:** RP 010	**Rev.:** 0

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I:\bridges\2019\c1193601 - dpr-ponnani cable stayed br\working\reports\rp 009 - detailed project report\volume-v (technical specifications)\rp 010-bsp-technical specifications.docx

Notes:

1.

Revision Details:

Rev.	Date	Details	Prepared		Checked		Approved	
			Init.	Sign.	Init.	Sign.	Init.	Sign.
0	12/03/2020	First Submission	BSP	BSP	PML		KGN	

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1 PREAMBLE

The Technical Specifications contained herein shall be read in conjunction with the other Bidding Documents as specified in Volume-XI. The original specifications followed is specifications for Road and Bridge works (Fifth Revision April 2013), issued by Ministry of Road Transport & Highways, Government of India & Published by the Indian Roads Congress and Guidelines for Planning and Design for Roads & Highway Projects funded by KIIFB

2 GENERAL REQUIREMENTS

a) SITE INFORMATION

The information given hereunder and provided elsewhere in these documents is given in good faith by the Employer and the Contractor shall satisfy himself regarding all aspects of site conditions and no claim will be entertained on the plea that the information supplied by the Employer is erroneous or in sufficient.

The area in which the work is located is in plain terrain, and lies in the State of Kerala.

b) GENERAL CLIMATIC CONDITIONS

The temperature in this region is as under:

i) During summer months, the maximum temperature is 38.6^0C.

ii) During winter months, the minimum temperature is 11.2^0C.

The average annual rainfall in Malappuram is above 3000mm

The High Tide Level (HTL) is 1.0m

The Low Tide Level (HTL) is -1.0m

Humidity at the location is 75.5%

c) SEISMIC ZONE

The work is located in Seismic Zone –III as defined in IRC: 6-2017.

The Technical Specifications in accordance with which the entire work described hereinafter shall be constructed and completed by the Contractor shall comprise of the following

2.1 Part A - Additional Technical Specifications

The Clauses here in after have been added to the ‘Specifications for Road and Bridge Works (Fifth revision, April2013)

SECTION A: EARTHWORK & METAL PACKING AND SUBSURFACE DRAINAGE

SECTION B: CONCRETE: PLAIN & REINFORCED

SECTION C: FORM WORK

SECTION D: REINFORCEMENT

SECTION E: STRUCTURAL STEEL SPECIFICATIONS

SECTION F: CABLE STAY WORK

SECTION G: EXTERNAL LIGHTING INSTALLATION

SECTION H: WATERPROOFING MEMBRANE

SECTION I: COAL TAR EPOXY PAINT

SECTION J: ANTI CARBONATION PAINT

SECTION K: REINFORCED EARTH WALL

SECTION L: EXPANSION JOINT

In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the latest codes and specifications of IRC, BIS, BS, ASTM, AASHTO and CAN/CSA in that order. Where even these are silent, the construction and completion of the works shall conform to sound engineering practice as approved by the Engineer and in case of any dispute arising out the interpretation of the above, the decision of the Engineer shall be final and binding on the Contractor.

2.2 Part-B: Amendments/Modifications/Additions to Existing Clauses of General Technical Specifications.

The Supplementary Technical Specifications shall comprise of various Amendments/ Modifications/Additions to the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS" referred to in Part-C below and Additional Specifications for particular item of works not already covered in Part-C.

2.2.1 A particular Clause or a part thereof in "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (fifth Revision, April 2013)", as corrected in the original referred in Part -C, where Amended/Modified/Added upon, and incorporated in Part-B, referred to above, such Amendment/ Modification/ Addition supersedes the relevant Clause or part of the Clause.

2.2.2 The Additional Specifications shall comprise of specifications for particular items of works not already covered in Part-C.

2.2.3 When an Amended/Modified/Added Clause supersedes a Clause or part thereof in the said Specifications, then any reference to the superseded Clause shall be deemed to refer to the Amended/Modified/Added Clause or part thereof.

2.2.4 In so far as Amended/Modified/Added Clause may come in conflict or be inconsistent with any of the provisions of the said MORT&H Specifications under reference, the Amended/Modified/Added Clause shall always prevail.

2.2.5 The same of the Clauses in the "SPECIFICATIONS FOR ROAD AND BRIDGE WORKS (Fifth Revision, April 2013") have been amended/modified/added as specified in this document.

3 PART A

3.1 ADDITIONAL TECHNICAL SPECIFICATIONS

The specifications hereunder Section A to L are over and above all other specifications mentioned in the tender document at various locations & shall supersede contrary provisions, if any made in the tender or in references thereof.

SECTION – A

3.2 EARTHWORK & METAL PACKING AND SUB SURFACE DRAINAGE

Section 300 of MORT&H gives the specifications for Earthwork, erosion control and drainages. Some of the important specifications apart from MORT&H specifications are as follows

1) Excavation for all works and of materials required for filling shall be to the exact width, length and depth shown on the drawings or as directed by the Engineer. If excavation is carried out to greater width, length, depth than required, the Contractor shall make good, at his own cost, the extra depth by sound masonry or concrete filling and extra length or width filled in by well consolidated earth or if the Engineer thinks it necessary for the stability of the work, by masonry or concrete as he may direct.

2) Excavation material required for filling shall be stacked or dumped where indicated by the Engineer. Excavated material not required for filling and any surplus material shall be removed and spread on the site anywhere within the premises and as directed by the Engineer or carted away from the site as directed by the Engineer. Dumping of this surplus material shall be in an orderly manner and according to the levels/grades as indicated by the Engineer. The cost of such removal and spreading shall be borne by the Contractor and held to be included in the Contract Rates.

3) The Contractor shall, at the contract rates make provision for all shoring, pumping, dredging, bailing out or draining water whether subsoil or rain or other water and the excavation shall be kept free of water while the masonry work or concrete work is in progress and until the Engineer considers the work well set (Refer IS: 3764 Safety Code for Excavation Work). The sides of trenches shall be kept vertical and the bottom horizontal and shall be run level throughout or properly stepped as directed by the Engineer. The Contractor shall erect and maintain during progress of works temporary fences around dangerous excavations.

4) Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact soil or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50cu.m.

5) Excavation in soft rock includes limestone, sandstone, laterite, etc. or other rock which can be quarried or by mechanical equipment like JCB, Poclain, or compressed air equipment like breaker, etc. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.75cu.m.

6) Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete, excavation of which in the opinion of the Engineer requires the use of compressed air, equipment, chiselling sledge hammer and blasting or any other method. Blasting shall be carried out through authorized agencies and all statutory laws, regulations shall be observed.

7) Excavation in saturated soil means excavation in loose to medium or medium to dense course of clayey silty sand, soils like soft clays requiring continuous pumping or bailing out of water.

8) In case of any difficulty concerning the interpretation of Clauses A.4, A.5, A.6 and A.7 above, the Engineer shall decide whether the excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the Contractor and without appeal. Merely the use of higher category equipment on explosive in excavation will not be considered as a reason for higher classification unless same are clearly necessary in the opinion of the Engineer.

9) The foundation trenches shall be inspected and passed by the Engineer before concrete or masonry work is commenced and the Contractor shall hold an order in writing to this effect, otherwise the Contractor shall be liable to have this work removed for inspection.

10) The earth for backfilling in foundation and plinth shall be got approved by the Engineer. In the foundation the backfilling shall be done in layers not more than 200mm thick and shall be thoroughly watered and consolidated by approved method. The rate for backfilling in foundation is deemed to include in the excavation rate.

11) The backfilling in plinth and other places which are required for levelling shall be done in layers not more than 300 mm thick except minimum of top three layers shall be done in layers not more than 150 mm thick. Each layer shall be watered and thoroughly consolidated by power driven roller/pan vibrator/vibratory roller of approved capacity. The process shall be repeated till the required level is achieved. After the backfilling is completed the surface shall be uniformly dressed and levelled.

    For large area or for deep filling or instructed by Engineer, the degree of compaction for filling will be measured as follows:

Top layer of filling	98% modified Proctor Dry density at OMC
Lower two layers below top layer	95% modified
Below above mentioned three layers	90% modified

3.3 Backfilling for subsurface drains (Filter drains)

Backfilling materials for subsurface drains shall conform to one of the following grades as specified

Sieve Designation	Percent by weight passing the sieve		
	Class I	Class II	Class II
50mm	-	-	100

Sieve Designation	Percent by weight passing the sieve		
	Class I	Class II	Class II
40mm	-	-	95-100
25mm	-	100	-
20mm	-	90-100	50-100
4.75mm	90-100	25-40	0-25
2.36mm	80-100	18-33	0-5
1.18mm	50-95	-	-
600 micron	30-75	5-15	-
300 micron	10-30	0-7	-
150 micron	0-10	-	-
75 micron	0-3	0-3	0-3

3.4 Metal Packing

Unless otherwise specified, stones for metal packing shall consist of crushed or broken stone. It shall be hard, durable and free from disintegrated particles, excessive dust and other objectionable matter.

Grading of aggregates shall conform to one of the grading given in the following tables

Grading No	**Size Range (mm)**	**Sieve design Nation (IS:460) (mm)**	**% by weight passing the sieve**	**Remarks**
1	90mm	100	100	Suitable For 100mm consolidated thickness
	To 40mm	80	65-85	
		63	25-60	
		40	0-15	
		20	0-5	
1	63mm	80	100	Suitable for 75mm consolidated thickness
	To 40mm	63	90-100	

Grading No	Size Range (mm)	Sieve design Nation (IS:460) (mm)	% by weight passing the sieve	Remarks
		50	35-70	
		40	0-15	
		20	0-5	
3	50	63	100	Suitable for 65mm consolidated thickness
	To 20mm	50	95-100	
		40	35-70	
		20	0-10	
		10	0-5	

Screening to fill the voids shall consist of same material as coarse aggregates and shall conform to the grading given below

Classification	Size of screening (mm)	Sieve design Nation	% by weight Passing the sieve
A	12.5mm	12.5	100
		10	90-100
		4.75	10-30
		150 microns	0-8
B	10.0mm	10	100
		4.75	85-100
		150 microns	10-30

The metal packing shall be done in layers not more than 100mm compacted thickness. For 150 mm compacted thicknesses, it shall be done in two layers each of 75 mm compacted thicknesses.

After laying, each layer shall be compacted thoroughly either by rollers or small vibratory roller, as specified or by other equivalent method approved by the Engineer. Slight sprinkling of water shall be done at the time of rolling.

After rolling has been completed, screening shall be applied uniformly and gradually to fill the interstices and the surface shall be dry rolled. In no case shall the screenings be dumped in a heap on the rolled surfaces. Rolling shall be accompanied with brooming.

After application of screening and rolling, the surface shall be copiously sprinkled with water and rolled. Additional screenings shall be applied to fill the voids if any. Rolling shall be continued until the coarse aggregates are well bonded. Care shall be taken that the base or sub grade does not get damaged due to addition of excessive quantities of water during the construction.

3.5 Planking and Strutting

When the depth of trench in soft / loose exceeds 2 meters, stepping, sloping and / or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken shall be determined by the Engineer according to the nature of soil.

Planking and strutting shall be 'close' or 'open' depending on the nature of soil and the depth of trench. The type of planking and strutting shall be determined by the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of trenches from collapse.

3.6 Close planking & Strutting

Close planking and strutting shall be done by completely covering the sides of the trench, generally with short, upright, members called 'polling boards'. These shall be 250 x 38mm in section or as directed by the Engineer.

The boards shall generally be placed in position vertically in pairs, one board on either side of cutting. These shall be kept apart by horizontal walling of strong wood at a minimum spacing of 1.2 meters cross-strutted with ballies or as directed by the Engineer. The length and diameter of the ballie-struts shall depend upon the width of the trench.

When the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical ‘walling’s’, which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken in the ground for a minimum depth of 75mm. No portion of the vertical side of the trench shall remain exposed, so that the earth is not liable to slip out.

The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and preceded systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber, which cannot be withdrawn and is lost or buried, unless required by the Engineer to be left permanently in position.

SECTION – B

4 CONCRETE: PLAIN & REINFORCED

The work shall be executed in conformity with section 1700 of MORT&H specifications for road & bridge works supplemented with relevant provisions of IRC publications. The relevant clauses for important items are stated as below

4.1 Concrete plain & reinforced / structural concrete

The concrete for use in structures shall conform to the provisions in clause 6.4.1 and 6.4.2 of IRC 112-2011 and Section 1700 of MORTH specifications. Whenever high performance concrete (HPC) is proposed to be used, the same shall conform to the provisions of IRC: SP: 70. The sampling & testing shall be as per and 18.5 of IRC 112-2011.

Acceptance criteria for concrete shall conform to and clause 18.6 of IRC 112-2011. Concrete to be produced shall conform to the requirements as specified below.

1) A dense and well compacted concrete provides effective protection against corrosion of steel in reinforced / pre stressed concrete members. To achieve this, the bidder shall pay special attention to the following elements, which have a bearing on the production of a durable concrete
    i) Quality of materials – cement, aggregate, water and ad-mixtures, both mineral and chemical.
    ii) Mix Design
    iii) Mixing & placing of concrete – Concrete shall preferably be produced in a mixing and batching plant.
    iv) Vibration & compaction.
    v) Curing
    vi) Cover to reinforcement/ tendons
    vii) Detailing
2) The following points are also important in production of durable concrete, which shall be duly considered and adopted
    i) Maximum chloride contents as specified in clause 14.3.2.3 of IRC 112.
    ii) Regular testing of water used for making concrete as per IRC 112.
    iii) Compatibility testing of admixtures with type of cement.
    iv) Permeability test for concrete.
    v) Testing of aggregate for alkali-silica reaction.
3) The mix design for concrete shall be got reviewed by the authority Engineer prior to construction.

4.2 Cement

Any type of cement specified in IRC: 112 may be used for the works subject to limitations, if any, specified therein. However, use of OPC 43 grade is preferred.

4.3 Coarse Aggregate

1) Before commencement of the works, at least three samples in accordance with the procedure laid down in IS: 2430 shall be taken for each quarry source to ascertain the quality, suitability and fitness of the available material for use in the works. Fresh tests shall be conducted in case there is any change in the source or the type of rock being quarried. The proposal along with a copy of test reports shall be submitted to the independent engineer for review and comments, if any.
2) Aggregates having more than 0.5% of sulphate as SO3 with water absorption more than 2% of its own weight shall not be used.
3) In case of doubt, the alkali – aggregate reactivity shall be tested in accordance with IS: 2386 (Part VI). Coarse aggregates having positive alkali-silica reaction (ASR) shall not be used.
4) The maximum value of flakiness index for coarse aggregates shall not exceed 35 percent.

4.4 Sand / Fine Aggregates

5) All fine aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS:2386 (Part I to VIII). The fineness modules of fine aggregates shall be between 2.0 and 3.5.
6) Before commencement of the works, at least three samples in accordance with the procedure laid down in IS: 2430 shall be taken for each quarry source to ascertain the quality, suitability and fitness of the available material for use in the works. Fresh tests shall be conducted in case there is any change in the source or the type of rock being quarried. The proposal along with a copy of test reports shall be submitted to the independent engineer for review and comments, if any.
7) Fine aggregates having positive alkali-silica reaction shall not be used.

4.5 Water

1) Water for use in the works for mixing & curing shall be in conformity with clause 18.4.5 of IRC 112-2011
2) Water from each source shall be tested before the start of the works and thereafter every three months and after each monsoon, till the completion of works and proposal along with a copy of test reports shall be submitted to the independent Engineer for review & comments, if any.

4.6 Permeability Test

The concrete will be verified for permeability by the following procedure and shall confirm to IS: 3085-1965 – 'Permeability of Cement Mortar & Concrete'.

1) The Engineer shall select random batches of concrete for examination without warning the Contractor and sampling will generally be done at the point of discharge from the mixer and at placing point.

2) From the batches thus selected 2 concrete cylinders shall be made in accordance IS: 3085.

3) All cylinders shall be made, cured, stored, transported and tested in accordance with IS: 3085. The tests shall be carried out in a laboratory approved by the Engineer.

4) At least 2 cylinders shall be made on each day's concreting until 60 cylinders have been made for each grade of concrete. This is in the initial period.

5) After the initial period, subject to the acceptance of the Engineer, the frequency at which the cylinders shall be made may be reduced as follows:-

6) After the initial period, subject to the acceptance of the Engineer, the frequency at which the cylinders shall be made may be reduced as follows:-

7) Set = 2 cylinders, representing concrete from a different batch.

8) At least 1 set for each day's concreting consisting of

   a. Set for every 10 m3 or part thereof concrete for critical structural elements plus 1 set for every 40 m3 or part thereof for all other elements.

   b. If concrete is batched at more than one point simultaneously the above frequency of making cylinders shall be followed at each point of batching. The cylinders will be tested as per the procedure, given in Clause 6 next.

4.7 Test Procedure

The permeability of concrete will be verified by the following procedure

1) Prepare a cylindrical test specimen 150 mm dia and 160 mm high.

2) After 28 days of curing, test specimen will be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars

3) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.

4) After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.

5) The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 75 mm).

4.8 Failure to meet specified Requirements

1) If from the cube test results it appears that some portion of the Works has not attained the required strength, the Engineer may order that portion of the structure be subjected to further testing of any kind whatsoever as desired by the Engineer, if so desired by him, full load testing of the suspected as well as adjacent portions; of the structure as specified in the Conditions of Contract. Such testing shall be at the Contractor's cost. The Engineer may also reject the work and order its demolition and reconstruction at the Contractor's cost.

2) If the strength of concrete in any portion of the structure is lower than the required strength, but is considered nevertheless adequate by the Engineer so that demolition is not necessary, the Contractor shall be paid a lower rate for such lower strength concrete as determined by the Engineer.

4.9 Ready Mix Concrete and Pumping

1) Ready-mixed concrete

Ready-mixed concrete may be manufactured in a central automatic weigh Batching plant and transported to the job in agitating transit mixers. The maximum size of coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe used for pumping. Provision shall be made for elimination of over-sized particles by screening or by careful selection of aggregates. To obtain proper gradation it may be necessary to combine and blend certain fractional sizes of aggregates. Uniformity of gradation throughout the entire job shall be maintained. The quantity of coarse aggregate shall be such that the concrete can be pumped, compacted and finished without difficulty.

2) Fine aggregates

The gradation of fine aggregate shall be such that 15 to 30 percent should pass the 0.30 mm screen and 5 to 10 percent should pass 0.15 mm screen so as to obtain a pump able concrete. Sands which are deficient in either of these two sizes should be blended with selected finer sands to produce these desired percentages. With this gradation, sands having a fineness modulus between 2.4 and 2.8 are generally satisfactory. However, for uniformity, the fineness modulus of the sand should not vary more than 0.2 from the average value used in proportioning.

3) Water, Admixtures and slump

The amount of water required for proper concrete consistency shall take into account the rate of mixing, length of haul, time of unloading, and ambient temperature conditions. Additions of water to compensate for slump loss should not be resorted to nor should the design maximum water-cement ratio be exceeded. Additional dose of be retarder be used to compensate the loss of slump at contractor's cost. Re-tempering water shall not be allowed to be added to mixed batches to obtain desired slump.

4) Transportation

The method of transportation used should efficiently deliver the concrete to the point of placement without significantly altering its desired properties with regard to water-cement ratio, slump, and homogeneity.

The revolving-drum truck bodies of approved make shall be used for transporting the concrete. The number of revolutions at mixing speeds, during transportation, and prior to discharge shall be specified and agreed upon. Reliable counters shall be used on revolving-drum truck units. Standard mixer uniformity tests, conforming to ASTM standards C 94-69 "Standard Specifications for Ready Mix Concrete", shall be carried out to determine whether mixing is being accomplished satisfactorily.

5) Pumping of concrete

Only approved pumping equipment, in good working condition, shall be used for pumping of concrete. Concrete shall be pumped through a combination of rigid pipe and heavy-duty flexible hose of approved size and make. The couplings used to connect both rigid and flexible pipe sections shall be adequate in strength to withstand handling loads during erection of pipe system, misalignment, and poor support along the lines. They should be nominally rated for at least 3.5 MPa pressure and greater for rising runs over 30 m.

Couplings should be designed to allow replacement of any section without moving other pipe sections, and should provide full cross section with no construction or crevices to disrupt the smooth flow of concrete.

All necessary accessories such as curved sections of rigid pipe, swivel joints and rotary distributors, pin and gate valves to prevent backflow in the pipe line, switch valves to direct the flow into another pipe line, connection devices to fill forms from the bottom up, extra strong couplings for vertical runs, transitions for connecting different sizes of pipe, air vents for downhill pumping, clean-out equipment etc, shall be provided as and where required. Suitable power controlled booms or specialized crane shall be used for supporting the pipe line.

6) Field control

Sampling at both truck discharge and point of final placement shall be employed to determine if any changes in the slump and other significant mix characteristics occur. However, for determining strength of concrete, cubes shall be taken from the placement end of line.

7) Planning

Proper planning of concrete supply, pump locations, line layout, placing sequence, and the entire pumping operation shall be made and got approved. The pump should be as near the placing area as practicable, and the entire surrounding area shall have adequate bearing strength to support concrete delivery pipes. Lines from pump to the placing area should be laid out with a minimum of bends. For large placing areas, alternate lines should be installed for rapid connection when required. Standby power and pumping equipment should be provided to replace initial equipment, should breakdown occur. The placing rate should be estimated so that concrete can be ordered at an appropriate delivery rate. As a final check, the pump should be started and operated without concrete to be certain that all moving parts are operating properly. A grout mortar should be pumped in to the lines to provide lubrication for the concrete, but this mortar shall not be used in the placement.

When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a go-devil inserted and shall be forced through the line by water under pressure to clean it out. The go-devil should be stopped at a safe distance from the end of the line so that the water in the line will not spill into the placement area. At the end of placing operation, the line shall be cleaned in the reverse direction.

SECTION – C

FORM WORK

5 FORMWORK

The Formwork shall be in conformity with section 1500 of MORT&H specification for road & bridge works supplemented with relevant provisions of IRC publications. The some important clauses for are stated as below

5.1 Definition

The term "Formwork" or "Shuttering" shall include all forms, moulds, sheeting, shuttering planks, walers, poles, posts, shores, struts and strutting, ties, uprights, wallings, steel rods, bolts, wedges and all other temporary supports to the concrete during the process of setting.

5.2 Materials

i. All facing formwork to come in contact with concrete in different elements of the structure shall be of such material and size as specified on drawings or as instructed by the Engineer.

ii. Timber facing formwork to come in contact with concrete for "Exposed Concrete Surfaces" shall consist of lap-jointed or tongue and grooved planks as directed by the Engineer and no joint shall permit leakage of mortar at all from cast-in-situ concrete.

iii. The materials for other backing and supporting formwork and their sizes shall be selected by the Contractor and shall be subject to the approval of the Engineer.

5.3 Design

The formwork shall be designed and constructed so that the concrete can be properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. It is the responsibility of the Contractor to obtain the results required by the Engineer, whether or not some of the work is sub-contracted. Approval of the proposed formwork by the Engineer will not diminish the Contractor's responsibility for the satisfactory performance of the formwork, nor for the safety and co-ordination of all operations.

5.4 Formwork for Exposed Concrete Surfaces

The facing formwork, unless indicated otherwise on drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure

i. Plain slab soffits, and sides of beams, girders, joists and ribs and side of walls, fins, parapets, sun-breakers, etc shall be made with :

   a) Steel plates not less than 3mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane with a tolerance of +/- 2mm within the plate

b) Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length

c) Plywood plates not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) or 3mm thick with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework.

ii. Bottoms of beams, girders and ribs, sides of columns shall be made with:

a) Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane with a tolerance of +/- 2mm within the plate.

b) Timber planks of 35mm actual thickness and of specified surface finish, width and reasonable length,

c) Plywood plates not less than 12mm thick, of specified sizes stiffened with a suitable timber framework

5.5 Erection of Formwork

The following shall apply to all formwork:

i. To avoid delay and unnecessary rejection of the Contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms (Ref. ACI 347 Formwork for Concrete or equivalent I.S. Code).

ii. All shutter planks and plates shall be adequately backed to the satisfaction of the Engineer by a sufficient number and size of framework to ensure rigidity during concreting. All shutters shall be adequately strutted, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand vibration. No joints in props shall be allowed.

iii. Vertical props shall be supported on wedges or other measures shall be taken where the props can be gently lowered vertically during removal of the formwork. Props for an upper story shall be placed directly over those in the story immediately below, and the lowest props shall bear on a sufficiently strong area. Care shall be taken that all formwork is set plumb and true to line and level or camber or better where required and as specified by the Engineer.

iv. Provision shall be made for adjustment of supporting struts where necessary. When reinforcement passes through the formwork care should be taken to ensure close fitting joints against the steel bars so as to avoid loss of fines during the compaction of concrete.

v. If the formwork is held together by bolts or wires, these shall be so fixed that no iron will be exposed on surfaces against which concrete is to be laid. In any case wires shall not be used with exposed concrete formwork.

vi. The Engineer may at his discretion allow the Contractor to use tie-bolts running through the concrete and the Contractor shall decide the location and size of such tie-bolts in consultation with the Engineer. Holes left in the concrete by these tie-bolts shall be filled as specified by the Engineer at no extra cost.

vii. Provision shall be made in the shuttering for beams, columns, and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.

viii. Formwork shall be so arranged as to permit removal of forms without jarring the concrete. Wedges, clamps and bolts shall be used wherever practicable instead of nails.

ix. The formwork for beams and slabs shall be so erected so that forms on the sides of the beams and the soffit of slabs can be removed without disturbing the beam bottoms or props under beams.

x. Surfaces of forms in contact with concrete shall be oiled with a mould oil of approved quality or clean diesel oil. If required by the Engineer the contractor shall execute different parts of the work with different mould oils to enable the Engineer to select the most suitable. The use of oil which results in blemishes of the surface of the concrete shall not be allowed. Oil shall be applied before reinforcement has been placed and care shall be taken that no oil comes in contact with the reinforcement while it is being placed in position. The formwork shall be kept thoroughly wet during concreting and the whole time that it is left in place.

xi. Immediately before concreting is commenced, the formwork shall be carefully examined to ensure the following:

  i. Removal of all dirt, shavings, sawdust and other refuse by brushing and washing.

  ii. The correct location of tie bars, bracing and spacers, and especially connections of bracing.

  iii. That all wedges are secured and firm in position.

  iv. That provision is made for traffic on formwork not to bear directly on reinforcing steel.

xii. The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. (IS:3696 - Safety Code of Scaffolds and Ladders, IS:4014 Steel Tubular Scaffolding I & II) It is imperative that for scaffolding heights of 3.6m and above timber posts or steel scaffolding be used with adequate bracings at several levels in each perpendicular direction connecting each prop. In addition to this diagonal bracing should be provided in elevation ideally at 45 degrees on between 30 and 60 degree. Bracings with bamboos will not be permitted. When timber posts are used the bracings shall consist of minimum 25mm thick wooden planks fixed to each post with at least two nails. The contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the decentering period. (IS 8989 safety code for erection of concrete framed structures)

xiii. Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any distress the work shall be stopped and remedial action taken.

5.6 Exposed Concrete Work

Exposed concrete surfaces shall be smooth and even, originally as stripped without any finishing or rendering. Where directed by the Engineer, the surface shall be rubbed with carborundum stone immediately on striking the forms. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made

true to their sizes, shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Honeycombed parts of the concrete shall be removed by the Contractor as directed by the Engineer and fresh concrete placed without extra cost, as instructed by the Engineer. All materials, sizes and layouts of formwork including the locations for their joints shall have are prior approval of the Engineer or the Architect.

5.7 Camber

Forms and false work shall be generally cambered as indicated in the drawings or as instructed by the Engineer. However, for beams up to 5m span and slabs up to 4m span camber is not normally required to be provided.

5.8 Tolerances

In accordance with IS: 456.

5.9 Age of Concrete at Removal of Formwork

In accordance with IS: 456.

The Engineer may vary the periods specified in IS: 456 if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

5.10 Stripping of Formwork

Formwork shall be removed carefully without jarring the concrete, and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with carborundum stone to obtain a smooth and even finish. Where the concrete requires plastering or other finish later the concrete surface shall be immediately hacked lightly all over as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

5.11 Reuse of Forms

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works more than 5 times for exposed concrete formwork and 8 times for ordinary formwork. 5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may in his absolute discretion order rejection of any forms he considers unfit for use for a particular item, and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be allowed.

5.12 Hacking-Out

Immediately after removal of forms, the concrete surfaces to be plastered shall be roughened with a bush-hammer or with chisel and hammer as directed by the Engineer to make the surfaces sufficiently coarse and rough to provide a key for plaster.

5.13 Formwork for Prestressed Concrete

a) The provisions in this section shall be considered supplementary to the general provisions stated above. Precast concrete members and panels shall be made in accurately constructed moulds, on a properly prepared casting bed. All aspects of the making, curing and erection of precast units shall be subject to the approval of the Engineer.

b) The formwork should be so designed that it does not restrain the shrinkage movements and possible shortening due to prestress of the concrete. The formwork shall be of sturdy construction with special considerations to shutter vibrators when used. At edges and joints the formwork should be designed and sealed (as mentioned above in C.6-7b) so that no cement grout can escape and there is no wedging or keying to the concrete. The effect of curing on the formwork should be given special consideration. Depending on care, curing erection and maintenance after stripping, the following number of uses can be made with different types of formwork.

Plywood with timber backed formwork	6 to 10 uses
Steel moulds	50 to 100 uses

In cases concrete moulds can be satisfactorily provided by the contractor for the Engineer's approval before use.

5.14 Stripping

As soon as the precast units have attained sufficient strength, the formwork shall be stripped. The precast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects.

SECTION - D

6 REINFORCEMENT

The reinforcement shall be in conformity with section 1600 of MORT&H specification for road & bridge works supplemented with relevant provisions of IRC publications. The some important clauses for are stated as below

6.1 Steel

Steel used in the works shall be corrosion resistance steel (CRS 500 or equivalent) conforming to IS: 1786. The Rolled steel made from structural steel conforming to IS: 226 and the steel for the dowel bars and wire mesh shall conform to IS: 432. Any other steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications, IRC 112 clauses 18.2 and 18.3 and shall be of tested quality under the ISI Certification Scheme. All reinforcement work shall be TMT &executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications (IS: 2502).

6.2 Corrosion protection

Corrosion protection shall be as per 6.3.2.2 of IRC 112. Reinforcement bars conforming to IS: 1786 shall be coated by fusion bond epoxy coating confirming to IS 13620-1993.

6.3 Inspection &Testing

Every bar shall be inspected before assembling on the works and any defective, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out. Specimens sufficient for three Tensile Tests for each different size of bar for each consignment delivered, or for 10 tons of supply of that size, whichever is less shall be sampled and tested by the Contractor. Batches shall be rejected if the average results of each batch are not in accordance with the specifications.

6.4 Lapping &Welding

a) As far as possible bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the Contractor of bars of maximum length. In case the Contractor wishes to use shorter bars, laps shall be provided at the Contractor's cost in the manner and at the locations approved by the Engineer.
b) As and when necessary welded laps shall be provided as specified by the Engineer.

6.5 Spacing, Supporting and Cleaning

a) All reinforcement shall be placed and maintained in the positions shown on the drawings.

b) The Contractor shall provide approved types of supports as specified on the drawings for maintaining the top bars of the slab in position during concreting. All cover blocks shall be of concrete (not sand cement mortar) and of the same strength as that of the surrounding concrete and properly compacted. They shall be circular in shape and not square.
c) Bars must be cleaned before concreting commences of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete.
d) The bars shall be cleaned with dry gunny bags if they are coated lightly with rust or other impurities. On no account shall the bars be oiled or painted nor shall mould oil used on the formwork be allowed to come in contact with the bars. Cement wash to bars shall not be permitted.

6.6 Welding

a) Wherever specified all welding shall be carried in accordance with IS: 2571. Only qualified welders shall be permitted to carry out such welding.
b) For cold twisted reinforcement welding operations must be controlled to prevent a supply of large amounts of heat larger than that can be dissipated. The extreme non twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.
c) The welding procedure shall be approved by the Engineer and tests shall be made to prove the soundness of the welded connection.

SECTION E

7 STRUCTURAL STEEL SPECIFICATIONS

The Structural steel shall be in conformity with section 1900 of MORT&H specification for road & bridge works supplemented with relevant provisions of IRC publications. The some important clauses for are stated as below

7.1 Materials

Plate girders, box girders, rolled sections etc. are to be of welded construction. Generally, the steel materials are to conform to IS 2062 Grade B or higher meeting specified impact strength, and are to be individually identified by plate numbers/heat numbers against mill certificates. Mill certificates are to carry endorsement by a reputed independent inspection authority. Additional random tests to confirm mechanical properties / chemical composition would also be carried out from steel materials received at the construction site. Steel materials of higher strength, conforming to national / international standards, may be used in specific areas as called for by design. Steel plates are to be of the largest size available to minimize welding. All flat bar stiffeners are to be cut from plates (rolled flat bars are not to be used). The steel is to be free from visible surface defects (mechanical damages / pitting). Repair of surface defects by welding is not permissible. Steel plates / sections to be used in critical areas may require to be ultrasonically tested for internal defects.

7.2 Fabrication and welding

Experienced supervisors, skilled markers, cutters and fitters are to be used for good fitting tolerance and dimensional accuracy, and for maintaining traceability of materials where required. Adequate handling-equipment, skids and jigs and fixtures are to be available for maintaining dimensional accuracy during fabrication of sub-assemblies and girders. During monsoon weathers in Goa, all fabrication is to be carried out under adequate cover. Good fabrication practices are to be followed minimizing welded lifting lugs /tacked support bars and eliminating arc strikes.

Only Automatic / semi-automatic submerged arc (CO2) / Manual metal arc welding, appropriate to fabrication configurations are to be used. All welding, including tack welding, is to be carried out only by certified welders. Approved welding consumables are to be appropriate for the base material grade. Approved consumables are to be procured from works approved by reputed certifying agencies. Generally Low hydrogen electrodes (E-7018 grade) are to be used for MMAW. Approved WPSs as per reference PQRs are to be followed. Confirmatory WPSs and Welder qualification tests will need to be carried out **under third party certification**. Cleanliness of fabrication area and dry consumables (in heated containers) and welding arrangements must be maintained. Excessive welding is to be avoided. Weld reinforcement should not be made flush unless necessitated by structural arrangement. Proper sequence of welding is to be followed to minimize distortion and residual stresses. Where specified by design, stress relief heat treatment shall be carried out.

7.3 Erection of Spans

Procedure / Arrangements for erection of girders over land spans and over the river are to be such as not to stress any part of the girders beyond designed loads. Procedures / Arrangements are to be made in close consultation with the designers. Any additional welding in tensile members, necessitated by erection procedures, is subject to approval by the designer.

7.4 Inspection

A QAP, covering all stages of construction from approval of materials till completion of construction, including protective painting, is to be approved by the client/consultant. Random confirmatory testing of materials, establishing WPSs, approval of welders, witnessing NDT (RT / UT/ MPI), and general supervision of QA / QC arrangements will be carried out by accredited and approved agency in close co-ordination with the designer and the contractor. Sub-contractors, if employed by the main contractor, will be subject to such inspections and approvals. All the costs towards such inspections/ testing shall be deemed to have been included in contractor's rates.

7.5 Corrosion Protection

All structural steel shall be free of mill scale and are to be shot / grit blasted to SA 2 ½ standard, surface mopped clean, be moisture free and to be painted by airless spray before the surface turns. If coating is delayed, any turned surface should be sweep blasted before painting.

The protective paint system is to consist of inorganic zinc-rich primer, epoxy mid-coats, and poly urethane topcoats. The specifications are to conform to paint manufacturers recommendations. Only reputed international paint manufacturers are to be considered. The surface roughness of blasted steel after fabrication and thicknesses of various coats are to conform to the paint manufacturers recommendations. The paint manufacturer's representative is to supervise the surface preparation and painting. The painting is to be guaranteed for 10 years.

7.6 METALISATION

7.6.1 SURFACE PREPARATION BY SAND BLASTING

a) The surface should be cleared thoroughly and roughened by compressor air blasting or centrifugal blasting with a suitable abrasive material in accordance with Cl.3 of IS 6583.
b) The cleaned surface should be completely free from grease, scale, rust, moisture and any other foreign material.
c) The roughness should be comparable with reference to surface product in accordance with appendix A of IS 5909 and shall provide an adequate key for the subsequently sprayed metal coating and also maintained without visible change for at least 25 percent of the total blasting time.

d) The roughness should be comparable with reference to surface product in accordance with appendix A of IS 5909 and shall provide an adequate key for the subsequently sprayed metal coating and also maintained without visible change for at least 25 percent of the total blasting time.
e) The equipment can be of the conventional force-fed of pressure type. The dia of the nozzle should not be more than 12 mm and air pressure to be maintained at the nozzle should not be less than 5.273 Kg/Cm.
f) If any paint, oil or bituminous materials are present, they may be removed by flame cleaning or blast cleaning with fine sand prior to the final blast preparation. The used for cleaning the heavily contaminated surface should not be reused even though it is rescanned.
g) Washed, salt free and angular silica sand or crushed granite free of feldspar tend to break down and remain on the surface of invisible quantity and passing through mesh size 30 and retained with mesh size 12 with a minimum 40% retention on a size mesh only should be used for sand blasting.
h) Sand blasting should be carried out only during dry day light hours and when the ambient temperature is not less than 25 degrees Centigrade.

7.6.2 METALISING WITH ALLUMINIUM

a) The aluminium metal spraying should be carried out as soon as possible after the surface preparation by sand blasting and in any case within such period that the surface is still clean and without any visible oxidation. If deterioration, in the surface to be coated is observed by comparison with strictly proposed stock surface, similar quantity preparation treatment by sand blasting be repeated before the aluminium spray is applied.
b) The aluminium metal spraying shall be done by wire melted with metal spray gun. The dia of aluminium wire shall be 3 to 5 mm.
c) The composition of the aluminium to be sprayed shall conform to IS 2590 (99.5% aluminium). Pure aluminium wire to IS specification No. 2590 used for metalizing shall be tested at CMT/LGD before use.
d) Dry and clean air with not less than 4.218 Kgs/Cm2 at the air control unit shall be used for this purpose and air pipe used shall not be longer than 10.668m between the air control unit and the spraying gun. The bore of the pipe not be more than 9.55mm.
e) The thickness of the sprayed aluminium shall be uniformly 1.40 microns and in any small area it cannot be (+) or (-) 10 microns of the thickness.
f) The specified thickness of aluminium coating shall be applied in multiple layers and in no case it shall not be less than two phases of the metal spraying made over every part of the surface.
g) At least one layer aluminium spray must be applied within 4 hours of blasting and the surface must be completely coated to the specified thickness within 8 hours of sand blasting.
h) The surface, after spraying shall not leave any un-coated parts or lumps coated areas and loosely adherent, spattered metal articles. If any such cases are found, they shall be attended properly.

7.6.3 MEASUREMENT OF THICKNESS OF METALISATION

Any magnetic or electro-magnetic thickness meter, that measures local thickness with an accuracy of (+) or (-) 10% shall be used.

a) Calibration of thickness measuring instrument Calibrate and check the meter on one of the following standards (as appropriate)
   i. (Applicable to magnetic and electro-magnetic meters other than the pull-off type) A soft brass shim, free from burns in contact with the grit blasted surface of the base metal prior to its being sprayed. The thickness of the shim shall be measured by micro meter and shall be approximately the same as the thickness of the coating.
   ii. A sprayed metal coating of uniform known thickness approximately the same as the thickness of the sprayed coating to be tested, applied to a base of similar composition and thickness to the article being sprayed, grit blasted in accordance with Clause I.

SECTION F

8 ADDITIONAL SPECIFICATIONS FOR CABLE STAY PORTION

8.1 STRAND/WIRE STAY CABLES

8.1.1 GENERAL

This Section specifies the requirements for fabricating, furnishing, installing, and adjusting stay cables, complete with anchorage components, anchor pipes, split shims, wedges, bearing plate, tension ring, steel or polyethylene pipes including, painting, sealing & damping rings, boots, bolts, clamping bands, temporary corrosion protection, erection devices and all incidental materials &labour necessary to construct the stay cables in accordance with the Plans, Special Provisions, and the Post-Tensioning Institute (P.T.I.) Recommendations.

8.1.2 APPLICABLE PUBLICATIONS

The publications listed below form a part of these specifications to the extent referenced. The publications are referred to in the text basic designation only. In case of conflict between provisions of codes, laws, ordinances, and these specifications, including the Contract Drawings, the most stringent requirements will apply.

a) “Recommendations for Stay Cable Design, Testing and Installation” by Post Tensioning Institute Committee on Cable-Stayed Bridges, August 1993.

8.1.3 SUBMITTALS

Furnish all test report and data specified in accordance with the procedures listed in these specifications.

8.1.4 TESTING

This work shall consist of the furnishing of all materials, anchorages; stay cable specimens, strand specimens and all labour and equipment for fatigue, and static load testing.

The specimen assemblies shall be tested by a recognized independent testing laboratory approved by the Engineer. Testing must be witnessed by representatives of the Engineer during the following:-

a) Testing of fully assembled cables for fatigue, ultimate strength and acceptance.
b) Testing individual strands for fatigue, ultimate strength and acceptance.
c) Strand anchorage acceptance.

All testing data and testing results shall be submitted to the Engineer for review and approval.

Fabrication of anchors or stay cable strands shall not begin until the tests are successfully completed and written approval is given by the Engineer.

8.1.4.1 STRAND/WIRE ACCEPTANCE TEST

In order to ensure strand fatigue resistance is incorporated into the stays, the following conditions shall be met

a) One 5m long sample of strand/wire shall be taken for every 10 tonnes of strands/wire produced from each heat of steel. This sample shall be used for both fatigue and ductility testing.

b) All strands/wires and test samples shall be marked in such a manner to ensure traceability during production, transit, storage and testing.

c) The test strands/wires shall be protected from failure in the gripping zone. Should any test strand fail in the gripping zone, the test will be discarded and another test specimen made from the same sample.

d) One test for each manufactured length shall be made for the following

Minimum guaranteed ultimate tensile strength	fs=1860MPa (strand) fs= 1655MPa (wire)
Minimum yield strength	fy = 0.90 fs
Young's Modulus	E = 197,000 MPa ± 5%

8.1.4.2 FATIGUE STRENGTH TEST

a) One tensile fatigue test shall be conducted on an approximately 2mlong specimen from each sample. Minimum length shall be 1mfrom face-to-face of grips.

b) The strand/wire specimens shall be tested at an upper bound stress of 0.45 fs and a stress range of 159 MPa (strand) / 194 MPa (wire) for 500,000 cycles.

c) After successful completion of the fatigue testing, each test specimen shall withstand a minimum static load of 95.0 percent of the Guaranteed Ultimate Tensile Strength (GUTS) of the strand/wire.

8.1.4.3 DUCTILITY TESTING

A "One-Pin Test" shall be conducted on a sample taken from each manufactured length. The details and method of the test shall be as defined in Section 6.3.2 and Appendix "C" of the 1993 edition of the PTI "Recommendations for Stay Cable Design, Testing and Installation." For acceptance, the tensile force in the sample during the one-pin test shall equal at least 80% of the ultimate strength of the sample.

8.1.4.4 FATIGUE STRENGTH TESTING OF STAY CABLES

Three completed fully assembled stay cable specimens shall be fabricated for testing, one specimen each shall be made representing the smallest stay cable, a mid-range stay cable and the largest stay cable in the bridge. Each specimen shall be fully representative of all details and procedures proposed for production of anchorages, but need not be full length. All specimens shall be assembled and tested in the position they will be installed in the field. All specimens shall be fabricated in accordance with these plans and specifications.

a) Stay cables shall be tested with all load-bearing appurtenances.

b) The specimens shall consist of two anchorages with a clear space of5m (± 1m) between anchor faces. Specimens shall be placed in the position they will be installed in the field.

c) The Contractor shall submit full details of the stay cable specimens, including anchorages, detailed drawings and computations. Tests will proceed upon written approval of the Engineer.

d) Rejection Criteria: If the first valid test strand from each sample fails, two additional tests shall be made from the same samples. If failure occurs in either of these tests, the strand represented by that sample shall be rejected. Retesting shall not be permitted

8.1.4.5 FATIGUE ACCEPTANCE TEST

The stay cable specimens shall be tested for two million cycles for an upper stress of 0.45 fs and a stress range of 159 MPa.

a) During fatigue testing, not more than two percent of the number of individual wires within a strand (rounded to the nearest whole number) may fail. Multiple fractures of the same wire shall be counted as one failure. No failure shall occur within the anchorage material, or in any components of the anchorage. The frequency for all fatigue tests shall be a constant value between 2Hz and 4Hz.

b) After fatigue loading, the test specimen shall be reloaded and shall develop a minimum tensile force equal to 95 percent of the guaranteed ultimate tensile strength (GUTS) of the stay cable.

c) The actual fatigue strength of the stay cable test materials shall be determined from the result of fatigue tests from companion strands. Test procedures for the individual companion specimen fatigue tests shall be as outlined hereinbefore in Article 507.05.B.2 "Fatigue Strength Test".

8.1.5 **ALERNATE STAY CABLE SYSTEMS**

The Contractor may at his option propose any stay cable system like the parallel strand stay cables with wedge anchorages outlined in this Section. All options and/or variations indicated in this section, shall meet the stay-cable anchoring provisions specified herein and shall be subjected to review and approval by the Engineer.

Options and/or variations which are approved by the Engineer for incorporation in structure shall be at no additional cost.

The design criteria, test criteria and individual strand acceptance criteria shall be as stated in these Special Provisions.

8.1.6 MATERIALS

8.1.6.1 STRAND

Strand for cables shall be 15.2mm diameter uncoated seven wire strand conforming to the requirements of Class II IS: I4268:I995 or ASTM A 416 M, Grade 1860, fy = 0.9fs. Weld less Grade, low-relaxation strand. The strand shall either be epoxy coated or greased and sheathed in accordance with the specifications set forth herein.

The Contractor shall require the strand supplier to furnish to the Engineer for approval, complete mill test reports and certificates for the strand from each heat, including stress-strain curves and modulus of elasticity.

8.1.6.1.1 Epoxy Coated Strand

The strand shall be furnished by the supplier in coils and shall have padded contact areas, wherever possible. Each coil shall be protected by a manufacturer approved method to ensure a uniformly coated strand having no adhering foreign matter or damage to epoxy coating, including that from ultraviolet exposure. The ends of the strand shall be sealed to prevent intrusion of moisture into the annular space between the 7 wires. No welds or joints shall be present in the finished strand.

8.1.6.1.2 Greased-Sheathed Strand

The strand shall be furnished by the supplier in coils and shall have padded contact areas, wherever possible: Each coil shall be protected by a manufacturer approved method to ensure a uniformly coated strand having no adhering foreign matter or damage to the sheathing, including that from ultraviolet exposure. The ends of the strand shall be sealed to prevent intrusion of moisture into the annular space between 7 wires. No welds or joints shall be present in the finished strand. Upon delivery to the cable fabricator, the strand shall be properly stored in a weatherproof enclosure to prevent corrosion. Each coil shall be marked with the order number, coil number and heat number. The starting end of each coil shall also be marked. When uncoiled, the strand shall lay straight with a maximum deviation not exceeding 25mm offset from a theoretical centre line in any 2m of length. Sharp kinks or short radius bends (less than the reel radius) shall be cause for rejection.

8.1.6.2 EPOXY COATING (For Epoxy Coated Strand)

Epoxy coating of strand shall be with a protective fusion bonded polymer coating applied by the electrostatic deposition method. Epoxy coating and patching materials shall be in accordance with AASHTO M284. All coating materials shall be from one manufacturer to assure uniformity. A written certification shall be furnished by the strand coater that clearly identifies each batch of coating material as to material, quantity, date of manufacturer, shelf life (date) and that all supplied coating material meets all requirements specified herein.

The epoxy coating manufacturer and the coating material shall be approved by the Engineer prior to furnishing the material. For plant approval, the plant shall furnish quality control procedures to insure compliance with these specifications.

The material shall be tested by a private testing laboratory approved by the Engineer and test data furnished to the Engineer prior to use.

The coating applicator shall furnish, at the time of shipment, written certifications that the coated strands were cleaned, coated and tested in accordance with the requirements of this specification. The certification shall include quality control reports indicating preheat temperatures, cure times, coating thickness measurements, holidays detected, and bend test results.

a) Application/Coating Procedure

i. The surface of the strand scheduled for coating shall be cleaned by ultrasonic agitation in an alkaline solution or other approved method until all residual drawing lubricants have been removed. The strand shall then be rinsed thoroughly with fresh potable water and air dried with no residue of the cleaning solution remaining. The cleaning solution shall not degrade the parent strand steel surface and shall not induce hydrogen embrittlement in the strand. The cleaned strand must be free of rust.

ii. The coating shall be applied to the cleaned surface as soon as possible after cleaning and before oxidation of the surface discernible to the unaided eye occurs. However in no case shall application of the coating be delayed more than 8 hours after cleaning. The coating is to be applied in a continuous process after drying. The coating shall be applied by the electrostatic deposition method and fully cured in accordance with the recommendations of the manufacturer of the coating materials. No inert particles may be impregnated into the surface of the coating.

b) Requirements for Coated Strand

The film thickness of the coating after curing shall be 25 to 45 mils inclusive. The thickness of the coating film shall be determined with a magnetic gauge with ± 5 percent allowable error, capable of measuring along a curved surface. The thickness of the coating film shall be measured on the crown of the wires, on a straight length of strand. The magnetic gauge shall be placed at one point on the strand and reading shall be taken at the crown of each outer wire. For each reel of strand, thickness measurements shall be conducted at five locations spaced evenly along the manufactured length of strand. Records of inspection during manufacturing shall be available when requested.

c) Continuity of Coating

After curing, the coating shall be free of holes, voids, cracks and damaged areas discernible to the unaided eye. During the coating process, a continuous holiday detection procedure shall be employed using an appropriate holiday detector such as the 67 1/2 volt holiday detector using water as the conductor following the manufacturer's recommended procedure. During the continuous holiday detection procedure, if more than two holidays are detected, the strand shall be rejected and the coating manufacturing procedure shall be corrected.

Coated strand with two holidays or less per hundred feet shall be patched in accordance with the patching material manufacturer's recommendations.

Abrasion Resistance

The resistance of the strand coating to abrasion shall be determined by the falling sand method of ASTM D968 adapted for testing coated strand. The net loss of coating shall not exceed 10 mils per 1,000 litters.

d) Adhesion of Coating

The adhesion and shear strength of the coating shall be evaluated by bending a sample from a finished reel of coated strand 180 degrees around a mandrel diameter equal to 32 times the nominal diameter of the strand. Test specimens shall be at thermal equilibrium between 20 and 30 degrees Celsius.

No cracking or dis-bonding of the coating shall be visible to the unaided eye on the outside radius of the bent strand. Evidence of cracking or dis-bonding of the coating shall be considered cause for rejection of the coated strand represented by the bent test sample.

Fracture of the steel wire or strand in the bend test shall not be considered as adhesion failure of the coating. Another sample of the same production shall be tested if wire or strand failure occurs.

The adhesion of coating shall also be evaluated by a tensile test in accordance with Section-6 of AASHTO M203 and the tensile strength shall be recorded for comparison with that determined in the Salt Spray (Fog) test. The coated strand shall satisfy the requirements for breaking strength, yield strength (1 percent extension) and ultimate elongation delineated in AASHTO M203. No cracks visible to the unaided eye shall occur in the coating up to an elongation of 1 percent (yield point). Sample length of the bend test shall be at least 2m long. Sample length for the tension test shall follow the requirements of AASHTO T244. Evidence of cracking or dis-bonding of the coating shall be considered cause for rejection of the coated strand represented by the tensile test sample.

Tests for adhesion of coating shall be conducted at the tail end of each manufactured length. “If the specimen for coating thickness, continuity, and adhesion of coating fail to meet the specified requirements, two retests on random samples from the same reel shall be conducted for each failed test. If the results of both retests meet the specified requirements, the coated strands represented by the samples will be accepted”.

e) Handling and Inspection

All systems for handling coated strands shall have added contact areas. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. All reels of coated strand shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent abrasion. The reels shall not be dropped or dragged. All strands shall be blown free of trapped moisture and all strand ends of all strand shall be maintained throughout the coating processes to be sealed with approved epoxy patching materials by the end of the same day that the strand is cut.

The inspector representing Engineer shall have free entry while work on this contract is being performed to those parts of the manufacturer's work that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All test sand inspections shall be made at the place of the manufacturer prior to shipment, unless otherwise specified, and shall be conducted so there is no unnecessary interference with the manufacturer's operation.

f) Repair of Coating

The maximum amount of damage in anyone strand shall not exceed 2% of the surface area in which case is cause for rejection. All damaged areas visible to the unaided eye shall be repaired with patching material. Patching shall be done in accordance with the recommendations of the manufacturer of the patching materials.

Coated strand represented by test samples that do not meet the requirements of this specification shall be rejected. At the manufacturer's option, such strand shall be replaced or alternatively, may be stripped of coating, cleaned, recoated and resubmitted for acceptance testing in accordance with the requirements of this specification.

g) Coating Material Properties - Chemical Resistance

The chemical resistance of coating shall be evaluated in accordance with ASTM G20 by immersing coated strands in each of the following: distilled water, a 3 M aqueous solution of CaCI2, a 3 M aqueous solution of NaOH and a solution saturated with Ca(OH)2. Tests with specimens without holidays and specimens with intentional 6mm diameter holes drilled through the coating shall be performed at 24±2°C.

Minimum test time shall be 45 days. The coating must not blister, soften, lose bond, nor develop holidays during this period. The intentionally made holes shall exhibit no undercutting during the 45-day period.

h) Chloride Permeability

The chloride permeability characteristics of the films of cured coatings have the minimum thickness as proposed for use shall be measured by the methods outlined in FHWA-RD-74-18. The test shall be performed at 24±2°C for 45 days. The accumulative concentration of chloride ions permeating through the film shall be less than 1×10^{-4}M.

i) Impact Test

The resistance of a strand coating to mechanical damage shall be determined by the falling weight test. A test apparatus similar to that described in ASTM G 14 shall be used along with a 1.8-kg tap. Impact shall occur on the crown areas on the coated strand. The test shall be performed at room temperature. With an impact of 9 N-m., no shattering, cracking, or bond loss of the coating shall occur except at the impact area, that is, the area permanently deformed by the tap.

j) Salt Spray (Fog) Test:

Coated strand specimens shall be tensioned to 70 percent of the maximum ultimate tensile strength and exposed to salt fog for 3,000 hours in accordance with ASTM B117. Care shall be taken to protect the end anchorage used from salt fog or corrosion so as not to influence the test results. Observations for signs of corrosion shall be made and recorded every 250 hours. After 3,000 hours of exposure, no evidence of rust shall be present, and the specimen shall be holiday free. After the salt spray (fog) test is completed, the specimen shall undergo a tensile test, in conformance with AASHTO T244 to determine if the ultimate tensile strength of the strand has been affected. The tensile strength of the strand after being exposed to the salt spray shall satisfy the requirements Section6, AASHTO M203.

8.1.6.3 STAY CABLE SHEATHING

Cable sheathing for each individual parallel strand cable shall be heavy duty light coloured (approved by the Engineer) polyethylene (HDPE) plastic pipe conforming to ASTM F714 and to Section 3.43 of the 1993 edition of the PTI "Recommendations for Stay Cable Design, Testing and Installation". The maximum allowable ratio of outside diameter of the HDPE pipe to the minimum wall thickness shall be 18.

The required length of the HDPE pipe shall be obtained by continuous extrusion or by fusion welding. Fusion welding of the HDPE shall be performed in accordance with ASTM D2657.

The manufacturer of the proposed cable sheathing shall certify that the construction procedure utilized by the contractor shall not result in any damage to the cable sheathing.

Procedures for packaging, handling and shipping the pipe shall ensure the pipe will not be damaged when delivered at the fabricator's plant. A certificate of analysis shall be furnished for each shipment of pipe stating the material supplied meets this specification and showing results of tests.

Verification tests may be performed by the Engineer on each size of pipe used. Samples for verification testing will consist of one 2m length of pipe per size thickness per l000m. Additionally, the fabricator shall submit samples to qualify the fusion welding procedure and these samples shall consist of three (3) 2mlengths of pipe per pipe size thickness.

8.1.6.4 STAY CABLE-ANCHORAGES

Stay cable anchorages shall meet the acceptance criteria as specified in Section 6.0 of the 1993 edition of the Post-tensioning Institute (PTI) "Recommendations for Stay Cable Design, Testing and Installation" and elsewhere in this Special Provision. The Contractor shall submit to the Engineer for review design calculations for the cable anchorages. The cable anchorages use for the full scale cable testing shall be fully instrumented and monitored during the total test program in order to verify the design and performance of the cable system. The stay cable anchorage system shown on the Plans is basically schematic. It shall consist of a threaded socket head and ring nut in the live end (stressing) anchorage to allow the anchorage to pass through the recess tube. The Contractor shall furnish all material specifications, not specified herein or on the Plans, to the Engineer for review and approval. Each component of the assembly shall have an AASHTO or ASTM material and test

designation number. The anchorage system shall provide approximately 5% additional holes in the anchor heads for contingency. These additional holes shall be positively sealed, to protect the stay cable interior from the elements, using approved plugs that can resist any stresses that may be imposed on it. The anchorage assembly and components shall be protected at all times against corrosion. Corrosion protection measures shall be shown on the shop drawings. The system shall include a steel cap to protect the exposed anchor plate and wedges from corrosion. The steel cap shall be galvanized in accordance with AASHTO M-111. Prior to the installation of the cap, the anchor plate and exposed strand shall be coated with suitable grease.

All other components such as bearing plates, keeper plates, recess tubes, steel flanges, socket bearing flanges, wedges, rubber gaskets, O-rings, etc. shown on the plans, but not specified herein, are only shown schematically. They shall be of suitable type and sufficient strength suitable for the intended use. The supplier of the stay cable system shall submit to the Engineer for review and approval material specifications, calculations and detail drawings for the sizes, types and materials for such components.

Shop drawings shall be submitted to the Engineer for approval showing all dimensions, materials and operations for fabrication of the anchorage assembly. Detailed procedures for installing all socket assembly components, insertion of the strands, installation of wedges, stressing and grouting the assembly shall be developed and submitted to the Engineer for approval. Complete shop drawings with supporting calculations shall be submitted showing all equipment (jack, stressing chair, etc.) and procedures required for stay cable force adjustments and for complete de-tensioning. No approval will be given to any portion of the stay anchorage assembly or procedures until all required submittals are made and found acceptable.

8.1.6.5 STRAND SPACER

8.1.6.5.1 Epoxy Coated Strand

The spacer shall be a helically wound epoxy coated 6mm diameter wire conforming to the requirements of ASTM A421 and the requirements for epoxy coating specified in these provisions.

8.1.6.5.2 Greased-Sheathed Strand

The spacer shall be helically wound and made of high-density polyethylene (HDPE). Helical spacer material requirements will be the same as that specified for polyethylene sheathing in accordance with the 1993 P.T.I. Recommendations for Stay Cable Design, Testing and Installation.

8.1.6.6 NEOPRENE BOOTS AND NEOPRENE DAMPERS

Neoprene boots and neoprene dampers shall be manufactured from 100% Virgin chloroprene (neoprene) of the thickness, shapes and hardness shown on the plans. The sole polymer shall be 100% virgin chloroprene, which shall be not less than 60% by volume of the

total compound. Neoprene shall meet the following requirements (ASTM C864 as amended herein).

Property	Physical Requirements			Test Procedure as per ASTM
	50 Duro	60 Duro	70 Duro	
Hardness, Durometer A	50+5	60+5	70+5	D2240
Tensile Strength, kPa, min.	360	360	3607	D412 (Die C)
Ultimate Elongation, percent min	450	350	300	D412 (Die C)
Property	Physical Requirements			Test Procedure as per ASTM
	50 Duro	60 Duro	70 Duro	
Accelerated Test to Determine Long -Term Characteristics Oven- Aged - 70 hours at degrees F				D573
Change in Durometer hardness, Maximun Points	+15	+15	+15	
Change in Elongation at Break, Maximum Percent	-40	-40	-40	
ppm Ozone in Air by Volume - 20 percent Strain 380C + 10C hours Mounting Procedure ASTM D518 Procedure A	No Cracks	No Cracks	No Cracks	D1149-Samples to be solvent wiped before test to remove any trace of impurities
Compression Set - 22 hrs at 1000C, % Max	35	35	35	D395, Method B

8.1.6.7 WASHERS, SHIMS, BEARING PLATES AND GUIDE PIPES

Material for split washers, shims, bearing plates and cable guide pipes, embedded in concrete, used in the cable anchorage shall be high-strength low-alloy structural steel conforming to the requirements of AASHTO M222, Grade 345.

8.1.6.8 STAINLESS STEEL BANDS

Bands for securing the neoprene boots in place around the polyethylene pipe and the neoprene sleeve shall be 25mm wide by 1 mm thick stainless steel strapping material Grade 316 with stainless crimp type seal of a type approved by the Engineer.

8.1.6.9 STAINLESS STEEL BOLTS AND NUTS

Bolts and Nuts for use as retainer devices for the elastomer washers at the upper and lower cable anchorages shall be stainless steel alloy 316 meeting the requirements of ASTM F593, for bolts and F594 for nuts and shall be passivated in accordance with U.S. Federal Specs QQ-P-35. The Contractor shall furnish Client with not less than 50 additional spare stainless steel bolts and nuts for the Client future maintenance use.

8.1.6.10 CABLE TIES AND/OR SUPPLEMENTAL VIBRATION DAMPERS

(Cable Vibration Suppression System) – If needed, this will need specific approval of Engineer. Refer to SP3: STAY CABLE VIBRATION SUPPRESSION SYSTEM Special Provisions.

8.1.7 **Fabrication, Transportation & Painting**

8.1.7.1 Fabrication

Stay cables shall be fabricated in a manner consistent with the design and testing requirements for the stay cable system as indicated herein. Appropriate measures shall be taken to ensure that all strands are installed parallel to each other. The pitch of the helix strand spacer shall not exceed 1 m. Strands/wires may be fabricated into fixed length cables or fabricated in-situ. Flame cutting of the strands/wires is not permitted. The individual strands/wires comprising the cable shall be cut to their pre calculated lengths while fully supported on a rigid calibrated cutting bed. Standard calibrated steel measuring tapes shall be employed to set and check the position of the stop and the cutting tool. Care shall be exercised throughout the fabrication process to protect the strands from damage and corrosion. Pre-tensioning for in-situ fabrication shall be limited to 10 percent of the final installation force called for in the strand. The Contractor shall develop procedures to assure that the Pre-tensioning is uniform (± 2 1/2%) for all strands in a given cable.

8.1.7.2 Shipping and Storage

Completed cable shall be wound or spooled on reels for shipment to and handling at the job site. The reels shall have a diameter at least equal to sixteen (16) times the outside diameter of the PE sheath.

Cables shall be stored at the job site prior to erection in a manner acceptable to the Engineer or in an approved weatherproof enclosure in order to prevent damage to the cable. If, in the opinion of the Engineer, the strands in a cable have been damaged or if they have adhering foreign matter, that cable shall be replaced at the Contractor's expense. The fabrication and

installation schedule for each cable shall be coordinated in such a way that the storage time on site for the cables is minimized.

8.1.7.3 Handling

The Contractor shall develop procedures to assure that stay cable components will not be damaged during handling. Stay cables shall be protected from corrosion, heat, abrasion and other harmful effects throughout the fabrication and installation.

Spreader bars and slings or other appropriate devices shall be used to handle all cables. The minimum bending radius for all such cables during handling shall be 25 times the diameter of the cable sheath. Slings or similar devices shall be positioned on the cable to carry both the anchor and adjacent cable in a tangent position, preventing bending of the cable at the anchor. Slings and spreader devices shall be padded to prevent damage to the cable sheath.

All damage to stay cables or components thereof shall be evaluated by the Engineer and remedied prior to installation of the cable. Damaged strand shall be replaced Damage to non-load carrying components shall be repaired to the Engineer's satisfaction prior to the installation of the stay cables.

8.1.7.4 Silicone Sealant

Prior to clamping the stainless steel bands, the Contractor shall seal the interface of the neoprene boot and the stay cable using an approved silicone sealant, suitable for permanent bonding to the neoprene boots and stainless steel bands.

8.1.7.5 Painting

All ferrous metal surfaces, other than stainless steel and hot dip galvanized surfaces of the stay cables system shall be painted in accordance with the painting specifications elsewhere in the Special Provisions. Colour of the top coat shall be as directed by the Engineer. Bearing plates, and guide pipes, shall be galvanized in accordance with AASHTO M-111.

8.2 LOCKED COIL STAY CABLES

8.2.1 **General**

This specification covers requirements to materials. Workmanship and inspection, including requirements to quality assurance/quality control for the locked coil cable stays. The Contractor shall prepare all documentation, among other things, drawings, calculations and method descriptions which are necessary for all parts of his work.

8.2.2 **Materials**

8.2.2.1 General

Materials manufactured to other standards may only be used provided it meets the requirements in the standards mentioned herein and additional requirements specified

herein. In such cases, the Contractor shall demonstrate that the materials meet all applicable requirements. The Engineer reserves the right to reject alternative materials. Substitution of a specified material quality with a material of another strength and/or quality class shall be submitted to the Engineer for acceptance. All orders for materials shall include precise statements of the specified requirements. The Contractor shall purchase sufficient quantities of material considering possible requirements for supplementary material testing, including material for testing required by the Engineer.

8.2.2.2 Locked Coil Ropes

The wires for the cable stays shall comply with DIN 2078 and DIN 779 or ASTM A586 when DIN 2078 and DIN 779 are not applicable. The wires shall have the following properties

i. **Tensile Strength** - The tensile strength 1570 $N/mm^2 < R^m < 1810\ N/mm^2$
ii. **Elongation** - The total elongation after fracture shall be greater than 4% in a 250 mm gauge length.
iii. **Proof Stress** - The proof stress $R_{p0.2}$ corresponding to 0.2% non-proportional elongation shall be in the range: 1180 $N/mm^2 < R_{p.0.2} < 0.90 \times Rm$
iv. **Ductility** -The wire ductility shall comply with the requirements stated in DIN 3051.
v. **Galvanizing** - The wires shall be hot dip galvanized m in 270 g/m² for the central circular wires and min 300 g/m² for the outer Z-shaped wired according to DIN 2078).
vi. **Fatigue** - The fatigue endurance of the individual wires shall be at least 2 x 106 for a stress variation = 350 N/mm² in the range 400-750 N/mm².

8.2.2.3 Sockets

Steel for sockets shall comply with the requirements of BS 1, and be of grade A5, normalized and tempered. Alternatively, socket material according to DIN-standards can be accepted. The steel grade shall as a minimum fulfil the mechanical requirements valid for St. 52-3 according to DIN 17100.

8.2.2.4 Wrought Steel

Special high tensile steel for nuts shall comply with BS 970 grade 605M36R. The 0.2% proof stress requirement shall be satisfied. The socketing material shall be zinc/ aluminium/copper alloy, grade Z610 in accordance with DIN 1743 or zinc of 99.95% purity. Alternatively, the Contractor may propose other socketing materials, e.g. the HIAM-anchorage system based on hardened steel balls, zinc dust and epoxy resin or polyester resin. The Contractor shall deliver full documentation for the mechanical properties, chemical composition and test procedure for the alternative products to the Engineer for acceptance before the start of production.

8.2.2.5 Neoprene for Damper and Cover

The neoprene shall be 100% pure neoprene. As polymer shall be used, pure chloroprene forming at least 60% of the final material.

8.2.2.6 Documentation

All materials specified in section 8.1.6.2 to 8.1.6.5 shall be delivered with a certificate which complies with the requirements in ISO 404 as follows

a) Certificate Type Wires for locked coil cables Inspection Report
b) 2. Casting for sockets Inspection Report
c) 3. Wrought Steel for nuts and pins Inspection Report
d) 4. Metal for socketing Inspection Report

The Contractor's representative and his scope of work with respect of Certification according to ISO 404 are subject to acceptance by the Engineer.

For Steel Products

The certificate shall include information on the steel making method.

The certificate shall give details and results of each test carried out in accordance with requirements stated in the applicable codes. These certificates must demonstrate that all tests specified were completed with a satisfactory result. The chemical composition of each cast shall be stated in the certificate. The original certificates shall be included in the Contractor's QA Journal and a copy submitted to the Engineer for acceptance.

8.3 Execution

8.3.1 General

The execution of the cable stays include the following main objects

a) Manufacture of wires.
b) Manufacture of locked coil wires.
c) Manufacture of anchorage items.
d) Transport of items to site.
e) Erection of cable stays.
f) Tensioning and adjustment of cable stay forces during erection of the bridge.
g) Arrangements to prevent harmful wind-induced oscillations of the cable stays during erection of the bridge, if necessary.

The execution shall be performed applying the most appropriate methods with respect to the purpose and function of the structure.

8.3.2 Shop Work

The shop work shall be planned in such a way that the items are completed in good time for the erection. The Contractor shall submit the following documents to the Engineer for acceptance before materials are ordered

a) General information about the manufacturing procedures for wires and proposals for testing.
b) Full documentation for the design of prefabricated cable and sockets.

c) Genera information about the procedures for assembling and socketing and proposals for testing.
d) Provisional shop drawings for. 1he cast steel items (sockets, etc.) and general information about proposed repair procedures.
e) Provisional shop drawings for the fabricated items and general information about welding procedures.
f) General information regarding transport and storage of all items.

8.3.3 **Manufacture of locked coil cable stays**

8.3.3.1 General

The cable stays are arranged with similar socket types at the two ends. The fixation at the top of pylon is through a cylindrical socket with an external thread and nut to allow for adjustments. The fixation to the girder is through a cylindrical socket, which does not necessarily require adjustment. Both sockets are steel castings. Each wire shall be in a continuous length, free from welds. Measurement and marking shall be carried out under well-defined uniform temperature conditions, under cover or at night, and while the strand is held under dead load tension. Allowance shall be made for the anticipated deformation in the sockets. The length of the socketed cable stay between upper pin and the face of the lower socket shall be correct to within the following tolerance:

$$L = \pm L \text{ mm} + 5 \text{ mm}; \; L \text{ in meter.}$$

Cable stays shall be stored in a clean dry area, protected against corrosion.

8.3.3.2 Locked Coil Ropes

Locked coil ropes shall at a minimum have three out layers of Z-shaped steel wires. The ropes are to the lubricated internally in a manner to be accepted by the Engineer, and the interstices between the wires are to be filled with the lubricating compound so that moisture cannot enter.

The ultimate strength of the finished cable stay shall be demonstrated by tests described in clause1.4. The ultimate minimum strength is specified on the drawings.

The modulus of elasticity of the rope, based on steel area of the cross section shall not be less than 1.58 x 105 N/mm2 with a tolerance + 5%/-0%. Before measuring, each length of rope to be used in making the cable stays shall be pre-stressed and loaded to at least 50% of the specified minimum breaking load for a sufficient number of applications of load to eliminate its initial stretch. The final application of this load shall be for at least one hour.

8.3.3.3 Sockets

The Contractor shall design and detail the cast steel sockets and bearing nuts for the cable stays. The design shall comply with the requirements stated in DIN 18800, Teil1. The length of the conical hollow part of the sockets shall be at 4.5 times the diameter of

the cable. Alternatively the cylindrical sockets may be in forged steel. In this case, the Contractor shall submit the specifications to the Engineer for acceptance. All sockets shall be capable of resisting the actual ultimate strength of the strands. Before the permanent socketing is carried out, tests to destruction are to be made in accordance with clause SP 2.4.2.

8.3.3.4 Socketing of ropes

Socketing of locked coil ropes is to be carried out in accordance with the requirements of DIN 3092. During cleaning the brush, care shall be taken to ensure that the strand lubricant is not removed inside the strand.

8.3.3.5 Castings

All castings shall comply with BS 1.

Acceptance standards shall be established and .agreed with the Engineer before the commencement of manufacture. In general, no linear crack-like or tear defects are acceptable. However, a few small isolated rounded defects would be acceptable. A prototype of the largest and smallest cylindrical sockets shall be cast and the form accepted by the Engineer before production casting is started. The prototypes can be included in the supply, if the form is accepted and the sockets fulfil the requirements of quality.

No paint or oil shall be applied to the castings, nor shall any rectification work be carried out, until the casting has been inspected by the Engineer, without whose agreement no repairs or welding shall be carried out. Rectification by welding shall be in accordance with BS 4570: Part 1. After rectification, castings shall be re-examined by the appropriate non-destructive testing techniques.

8.3.3.6 Erection of Cable Stays

Cable stays shall be kept dry until they are erected. They shall only be erected a short while before the girder section to which they will be attached, so that the risk of absorbing rainwater in the unloaded condition is minimized. Immediately after girder erection, each cable stay shall be painted, as specified in clause 8.5 of this manual.

The connections shall be packed with suitable hard, water-resistant grease. The gaps between the cable band and the lugs of the socket shall be sealed by wrapping with Denso tape or similar material. It is recommended that the Contractor has the disposal of eight jacks for tensioning of cable stays (two jacks on each cantilevered part of the bridge deck).

It is an absolute requirement that a pair of cable stays is tensioned simultaneously and that force and movement for both jacks can be watched and operated from a common control unit. By the equipment it shall be possible to adjust the forces in cable stays with a tolerance of ±1%. The Contractor shall assume that cable stays shall be adjusted during erection to avoid unacceptable sectional forces in the bridge deck during erection

and to obtain the assumed cable stay forces in the finished bridge or the correct longitudinal profile of the bridge deck. If the proposed erection method is followed, a pair of cable stays shall be tensioned just after placing of the corresponding prefabricated part of the deck and adjusted once or twice afterwards.

After erection of the suspended structure, the cable stays shall be stabilized and sealed at top of the anchor tubes. Stabilization and sealing shall be either permanent according to the drawings or provisional according to the Contractor's proposal. Detailed procedures for installation of permanent or provisional structures shall be tested before installation and be approved by the Engineer.

8.4 Inspection and Testing

8.4.1 General

It is the Contractor's responsibility by inspections and testing to establish assurance that work on cable stays complies with the requirements specified.

The Contractor, shall, when the work commences, establish and maintain a QA Journal throughout the construction period.

The QA-Journal shall, as a minimum, contain the following documentation

i. All drawings
ii. All welding plans
iii. All welding certifications for welders engaged in the production
iv. All procedure specifications
v. All procedure test certificates
vi. All certificates of materials
vii. All certificates regarding supplementary testing of materials All certificates of semi-manufactured components
viii. All inspection reports in connections with receipt of goods, including also non-conformance reports
ix. All inspection reports in connection with inspection of welds All inspection reports in connection with lamination tests All reports regarding inspection of bolted joints
x. All reports in connection with inspection of geometry
xi. All weight reports
xii. All reports on calibrating of measuring equipment
xiii. All reports regarding deviations.

8.4.1.1 Fatigue Tests of Cable Stays

One fatigue test for each 10 tonnes of wire production shall be performed to verify the requirements specified in clause 8.4.1.2 of this manual

The test procedure shall be specified by the Contractor for the Engineer's acceptance. If the coil from which the test specimen is taken fails, the test shall be repeated on two further specimens from the same end of the coil as the original specimen.

If any re-test is unsatisfactory, the coil may be subdivided and the subdivided coils resubmitted for approval. Such subdivided coils must satisfy the specified requirements on one test at each end of the coils.

8.4.1.2 Tensile Strength

The breaking strength of the cable stays shall be tested by three fully-assembled stay cable specimens shall be verified by breaking tests. Cables with diameters representing the smallest, a mid-range, and the largest stay cable used in the bridge. A test sample shall be cut from the cable production, socketed and tested to determine the modulus of elasticity and the breaking strength of the cable. The sockets shall be identical to those specified for the permanent cable stays.

The Contractor shall assemble the test stay cables at the testing facility in a manner consistent with the sequence of operations that will be used in the actual stay cable installation.

The test stay cables shall be fabricated straight and shall consist of two anchorages, including all appurtenances with a clear space of no less than 5m between bearing faces and a clear length of 2m of typical stay section between anchorage assemblies.

The sockets used in the tests shall not be incorporated into the permanent works.

8.4.1.3 Fatigue Strength

The fatigue performance of the cable stays shall be verified by fatigue tests on three test specimens, taken at the same time as the specimen for the tensile strength tests. Test samples shall be made in the same way as for the tensile tests and shall be subjected to cyclic loading for 2 x 10^6 cycles and then loaded to breaking. Cables with identical diameters to those used in the Tensile Strength tests (i.e. the smallest, amid range, and the largest) shall be tested.

The mean load of the load cycle shall correspond to a stress of 475 N/mm² and the varying load shall correspond to a stress range of 150 N/mm².

The breaking load after this cyclic loading shall not be less than 85% of the specified minimum breaking load of the cable.

8.4.1.4 Inspection of Socketing Procedure

Before any permanent socketing, one test to destruction shall be carried out on a sample length of cable, complete with two sockets identical to those specified for the permanent cable stays. The sockets are to be attached using the precise procedure to be used for the permanent sockets. For a satisfactory procedure, failure shall not occur by pulling out of the strand from the socket. .After the test, the two sockets shall be sectioned in three places to demonstrate that each wire is surrounded by zinc or other socketing material.

8.4.1.5 Inspection of Castings

The following tests shall be carried out on material from each cast: Chemical Analysis Tensile Test (Tensile strength, lower yield stress and elongation to be determined) Impact Test at +20°C In addition, hardness test is to be made on each casting. As soon as any casting is removed from the moulds and has been dressed and cleaned, the Engineer shall be informed so that he may inspect it.

In addition to visual inspection, all castings shall be subjected to crack detection at all accessible fillets and changes of section etc. and in areas requested by the Engineer.

Each casting shall be examined by ultrasonic and/or radiographic methods in all areas until the results of such examination indicate that the production technique fulfils the requirements.

For ultrasonic tests, the acceptance standard specified in DIN 17245, October 1977, table 4 and 5 respectively, shall be fulfilled. Furthermore, all sockets inclusive of nuts shall be subject to crack detection by magneto flux.

8.4.1.6 Inspection of Wrought Steel

Wrought steel shall comply with the requirements of BS 970. Chemical analysis, tensile, hardness and impact tests shall be made (Impact test at +20°C).

Codes and Standards etc.

ISO 404	Steel and steel products. General technical delivery requirements
BS 443	Specification for testing zinc coatings on steel wire and for quality requirements.
BS 970	Specification for wrought steels for mechanical and allied Engineering purposes.
BS 2763	Round carbon steel wire for wire ropes.
BS 1	Steel castings for general engineering purposes.
BS 4429	Rigging screws and turnbuckles
BS 4545	Mechanical testing of steel wire.
BS 4570	Fusion welding of steel casting.
D779	Formstahldrahte fur vollverscholsseneSpiralseile.
DIN 1681	Stahlguss fur allgemeineVerwendugnszwecke.

DIN 1743	Feinzink -Gusslegierungen, GysstuckeaudDruck-Sand-und Kokillenguss, Teil 1 and Teil2
DIN 2078	Stahldrahte fur Drahtseile.
DIN 3051	DrahtseileausStahldriihten.
DIN 3053	DrahtseileausStahldrahteSpiralseil 1 x 19.
DIN 3092	MetallischeDrahtseil- Vergusse.
Din 17100	WarmgewaltzeErzeugnisseausunlegiertenStahlen fur den algemeinenStahlbau, Entwurff
DIN 17245	WarmfesterferritischerStahlgussTechnischerLieferbedingungen.
DIN 18800	Stahlbauten.

Issues at the time of signing the Contract are valid for the work.

8.5 Corrosion Protection

8.5.1 **General**

In general, the corrosion protection system for stay cables must meet the performance requirements given in Special Provisions - STAY CABLES-CORROSION PROTECTION SYSTEM REQUIREMENTS. The specifications given below shall be considered minimum requirements and shall not be deemed to meet or exceed the corrosion protection system requirements.

8.5.2 **Materials**

8.5.2.1 Paint for Cable Stays

The Contractor shall propose for acceptance by the Engineer a paint system which is compatible with the lubricating compound.

The paint system must have a certain plasticity thus allowing minor slippage between wires without cracking.

The Contractor's proposal shall include a detailed surface treatment application procedure comprising proper cleaning of wires.

To avoid pollution of the wires, cleaning and applications of the first coat of paint shall be performed shortest after erection or allowed by climatic conditions. -

Two layers of primer shall be provided on galvanized wires, total thickness, 40m. Total dry film thickness of paint over the wires shall be min. 250 m.

8.5.2.2 Sockets and Nuts

Sockets and nuts shall be zinc sprayed with 50m on threaded parts and 120 m on all smooth surfaces. After assembly, they shall be painted with the same system as steel structures.

9 STAY CABLE VIBRATION SUPPRESION SYSTEM

9.1 DESCRIPTION

This work shall consist of the design, installation, and testing of the stay cable vibration suppression system as shown on the Plans and as specified herein. The stay cable vibration suppression system shall consist of cable ties, supplemental vibration dampers or a combination of the two systems in accordance with the requirements given in the plans and these specifications. In order to determine the appropriate combination of supplemental dampers and cable ties, it is necessary to estimate the effective damping ratio of the proposed stay cable with the supplemental damping system (if proposed). The determination of effective damping ratio shall be based upon full-scale test results where possible and is subject to review and approval of the Engineer.

9.2 MATERIALS

Cable ties shall be wire rope meeting the requirements of Military Specification MIL-W-83420D. Wire rope shall be corrosion resistant steel material and shall be nylon jacketed. Diameter of cable ties shall be as shown on the plans.

Stainless steel bands and neoprene materials shall meet the requirements specified in SP-1 of these additional specifications for cable stayed bridge.

Turnbuckles, wire rope clips, and bolts shall be stainless steel.

Supplemental vibration dampers shall be fabricated of corrosion resistant materials and shall require minimal maintenance. The dampers must be accessible for easy maintenance. The dampers must be accessible for easy maintenance and inspection.

9.3 INSTALLATION AND TENSIONING

Cable ties shall be installed at locations shown on the Plans. Stainless steel bands shall be placed and bolts tightened sufficiently to prevent movement of the bands along the stay cable but not damage the stay cable covering or corrosion protection system. Neoprene sheet material shall be placed between the stainless steel band and the cable covering. Cable ties are de-tensioned by dynamic wind loads acting on the connected main stay cables. Complete de-tensioning of the cable ties would result in shock upon reloading and must be avoided by sufficiently tensioning the cable ties. Therefore, the force in each cable tie segment between attachment points shall be tensioned to a force equal to twice the force in the segment as produced by dynamic wind loads on the main connected cables. An

estimate of the dynamic wind loads on the main cables is obtained by multiplying the static drag force normal to and in the plane of the main cables by a gust factor of 2.

9.4 SYSTEM PERFORMANCE REQUIREMENTS

Full scale damping measurements of the 3 stay cables (longest, shortest, and middle range) shall be made to ensure that stay cable damping estimates used in the design of the vibration suppression system are met. If actual damping differs sufficiently from the values used in design of the vibration suppression system, additional cable ties or damping shall be provided, at no cost to the owner, to ensure that the vibration suppression system meets with the intended performance level specified on the plans.

10 STAY CABLES - CORROSION PROTECTION SYSTEM

10.1 Corrosion Protection

10.1.1 General

This specification covers stay cable systems that use wire, pre stressing wire, or strand for the main tension elements (MTE). As a result, the corrosion protection systems are limited to those that are most appropriate for the protection of these elements.

Stay cables shall be provided with a corrosion protection system capable of protecting the main tension element from corrosion for the design life of the cables. A minimum of two nested qualified barriers shall be provided for main tension element corrosion protection. Requirements for the corrosion protection system are divided into the free length and the anchorage length.

In addition, temporary corrosion protection shall be provided if the permanent corrosion protection system is not installed at the time of stay cable fabrication. Unless noted otherwise, all barrier qualification and temporary corrosion tests shall consist of three independent specimens, each 2 m long. In order to satisfy these recommendations, all specimens shall satisfy the acceptance criteria as noted in this Section.

The Supplier's quality control program shall include provisions to assure that the materials used in each cable installation are of the same specification and quality those used for the qualification testing required under this Section.

10.1.2 Barriers

Corrosion protection shall be provided for the main tension elements using at least two complete nested barriers. Internal barriers shall completely encase the main tension element for the full free length and the anchorage length. The external barrier shall completely encase the inner barrier for the full free length. The barriers shall be arranged such that if corrosive elements breach the external barrier, the interior barrier will protect the main tension element.

When a physical barrier is to be used as the internal barrier on each pre-stressing strand, the barrier shall completely cover the exterior of the strand as well as completely fill the interstitial spaces between the wires with inert material. The internal barrier shall not permit free water to enter the interstitial space.

10.1.2.1 Anchorage/Free Length Interface

If the barrier systems are not continuous across the interface between the anchorage and free length then additional protection shall be provided to protect the main tension element.

10.1.3 **Materials**

Materials used in the corrosion protection system shall meet the requirements given in the Stay Cable Specifications. Materials not specified in these recommendations shall be subjected to quality control tests verifying performance equal to the requirements of the Stay Cable Specifications before consideration for use in the corrosion protection system. Materials and design details for the prototype tests shall be same quality and shall meet all of the same certifications as those used for the actual structure. Changes to basic materials or design shall be cause for re-qualification in accordance with these recommendations. Use of alternative materials shall be subject to the approval of the Engineer.

10.1.4 **Qualification of Barriers**

10.1.4.1 Internal Barriers

Internal barriers shall be subjected to a salt fog test. The specimen shall be prepared using samples of the main tension element (MTE) wire, strand, or bar. If the barrier is to be applied to the MTE sample during the manufacturing process then the test shall be conducted with the MTE stressed to 50% of MUTS. If the barrier is applied after the MTE is assembled, then the MTE shall be stressed to 30% MUTS prior to application of the barrier. After the barrier has been applied and cured, the specimen shall be stressed to 50% MUTS for the salt fog test. The prepared salt fog test specimens shall be exposed to salt for 3000 hours in accordance with ASTM B 117. Care should be taken to protect or seal the end anchorage from salt fog or corrosion so as not to unduly influence the test results. After 3000 hours of exposure, the specimen shall be de-tensioned and removed from the test apparatus. Seven-wire strand shall be un-stranded and fully inspected on all surfaces. Acceptance criteria shall be in accordance with Section SP10.1.7

10.1.4.2 External Barrier

External barriers shall meet the requirements of Section SP10.1.4.1. The external barrier test shall demonstrate that the external barrier alone can protect the Main Tension Element (MTE) as indicated in Section SP10.1.4.1 above. If the external barrier will be strained by virtue of compatibility with the MTE in the actual cable installation, then the external barrier shall be similarly strained for the tests required under this Section. The

circumference and thickness of external barriers shall be consistent with those used for the range of cable sizes in the Supplier's inventory. Inspection of any metallic barrier material after testing shall reveal no evidence of rust.

Any external barrier that is susceptible to degradation from exposure to ultraviolet light and or moisture shall be subjected to testing in a weatherometer in accordance with ASTM G26. The length of test specimen shall be compatible with size limitation of the weatherometer.

10.1.5 **Qualification of Temporary Corrosion Protection System**

A sample consisting of not less than 3 strands or 15 wires shall be placed in a prototype of the temporary corrosion protection system. This prototype shall include all elements of the temporary system for the free length of cable, including inhibitors, sheathing, coatings, or other external elements of the systems it will be installed in the field. Samples ends shall be sealed. The prototype shall be exposed in a weather meter to thermal and wetting cycles of a number equivalent to 125% of the number of days for which the system will be qualified. Temperature cycles shall range from not more than 5°C to not less than 38°C. Wetting in each cycle shall consist of water spray applied at 5°C as necessary to completely wet the specimen. Acceptance shall be in accordance with Section SP10.1.7. Temporary corrosion protection shall encompass the entire length of MTE prior to cable assembly and installation.

10.1.6 **Acceptance Criteria**

10.1.6.1 Barriers

Each tested barrier sample shall be destructively examined and recorded by colour photographs. The dissected samples shall be de stranded (in the case of strand) and compared with the reference standards for surface corrosion. In order to be acceptable, the tested sample shall not show signs of tensile element corrosion that cannot be fully removed by wiping with a soft untreated cotton cloth. Photograph Two of the PCI reference shall apply. Any pining shall be cause for rejection.

10.1.6.2 Anchorage Assembly

The tested anchorage assembly shall be dissected to inspect the MTE for signs of dye. Specimens will be acceptable if visual inspection shows that dye has not reached the MTE. The above testing procedures notwithstanding, all elements of the specified corrosion protection system shall be inspected during and at the end of bridge construction, and shall be totally intact as the bridge construction phase is completed. Nothing is this testing program should be construed as permitting partial damage to the corrosion protection system as the bridge is placed into service.

10.1.7 **Documentation**

Each test produced under these recommendations shall be documented by a written report. The report shall include, but not be limited to the following information:-

i. Complete description of the test set-up, design details of all cable components and test procedures.
ii. Complete description of the chamber and methods used-for the salt fog testing.
iii. Complete description of all materials used for all components of the tests, including material sources and certifications
iv. Complete documentation of the results from testing, including colour photographs or colour copies of photographs that document the condition of all MTE and metallic elements of the prototype specimen tests from companion wires, strands or bars.

11 TESTING OF ANCHORS

i. Mandatory
ii. 2 Representative of Engineer + 2 representatives of Employer + 2 representatives of Contractor shall attend the testing to witness the same.

12 APPROVED LIST OF MANUFACTURER'S / SUPPLIER'S

a) VSL INDIA
b) FREYSSINET Menard India
c) BBR INDIA
d) DEXTRA INDIA (Only for HT rods)
e) Dywidag (Only for HT rods)

SECTION G:
EXTERNAL LIGHTING INSTALLATION

1. The lighting arrangement for the main bridge shall be as per the approved authority drawing.
2. For the approach lighting of 30lux illumination shall be provided.

SECTION H

13 WATERPROOFING MEMBRANE

13.1 BRIDGE DECK WATERPROOFING

All the concrete bridge decks including insitu and precast segmental decks shall be waterproofed.

13.2 Materials

The waterproofing shall be a polymer waterproofing membrane and shall be fast cure acrylic based system for concrete bridge decks. The waterproofing system shall be spray applied and shall include a primer, waterproof membrane, bituminous based hot melt adhesive bond coat and a 2mm aggregate over scatter unless otherwise approved by the Engineer. The waterproofing membrane shall be not less than 2mm thick. The tensile strength of the waterproofing membrane shall be not less than 4MPa when tested in accordance with BS903 Pt A2 1989.

The adhesion of the waterproofing system to the concrete deck and the bituminous course shall be sufficient to resist, without distress and detachment, the worst condition caused by road surfacing operation, traffic and temperature. The minimum adhesion strength between the bituminous paving and the waterproofing system when tested shall be 0.35 N/mm2. The average adhesion strength between the waterproofing system and the concrete deck should not be less than 1.0 N/mm2. The minimum adhesion between the waterproofing system and the concrete deck shall be 0.7 N/mm² when tested using an Elcometer Adhesion Tester or products having equivalent functions or performance.

The waterproofing membrane shall be resistant to puncturing during surfacing operations, resistant to microbial attack and chemical spillage. Each layer of the polymer waterproofing system shall be of a different color.

Site trials shall be carried out by the Contractor to demonstrate the method of application and the establishment of satisfactory adhesion of the proposed waterproofing system to the concrete deck and bituminous surfacing, including any necessary testings. Testing shall be carried out in accordance with UK BD 47/99 suitably modified to suit local climatic conditions including temperature extremes.

Subject to the Engineer’s satisfaction of the demonstration in the site trial, the Contractor shall seek approval of the Engineer of his proposed waterproofing system to be applied on the concrete bridge decks.

The Contractor shall ensure an approved representative from the waterproofing system manufacturer is present at all times during the preparation and conduction of the site trials. No preparation or carrying out of the site trials shall be permitted without the presence of such a representative. This representative shall have been employed by the manufacturers

for at least 12 months at the time of the site trials and shall be approved in advance by the Engineer.

The 2.0mm thick layer of aggregate over scatter should also be applied in accordance with the recommendations from the waterproofing system manufacturer. The Contractor shall pay particular attention to ensuring the waterproofing membrane is not punctured by the over scatter. The over scatter material shall be approved by the Engineer.

All components of the system shall be suitable for use in permanently exposed locations as well as in applications where it may be constantly immersed in water.

The Contractor shall be responsible for ensuring that the Eliminator proprietary waterproofing system including the bond coat is compatible with the proposed surfacing specification and will provide the adhesion as stated above.

The Contractor shall submit to the Engineer for review evidence of the co-ordination between the following parties before the commencement of the laying of the waterproofing system

a) Waterproofing System Supplier
b) Waterproofing System Applicator
c) Bituminous Course Supplier
d) Bituminous Course Applicator
e) This evidence will identify the steps taken between these parties to ensure the bond adhesion values at the interface between the waterproofing system and the bituminous course material are achieved.

13.3 Delivery and Storage of Materials

Polymer waterproofing materials shall be stored in accordance with the manufacturer's recommendations.

13.4 Installation of Water Proofing System

Surfaces on which waterproofing systems will be laid or applied shall be clean, dry and free from voids, loose aggregate, sharp protrusions, projecting tying wire, release agents and other substances which are likely to damage or affect the waterproofing system. Oil and grease shall be removed with detergent and water or solvent followed by wash down to remove any contamination. Laitance and all loose materials shall be removed by high pressure lancing, sand blasting, power or hand wire brushing, etc.

All materials must be supplied to site in unopened packaging with batch numbers marked and corresponding manufacturer's certificates of conformity, and must be used within the products shelf life or "use by date". Polymer waterproofing membranes shall be spray applied.

The surface preparation, priming, bond coating and aggregate over scatter layer shall be carried out in accordance with the manufacturer's recommendation and to the satisfaction of the Independent Consultant.

The membrane shall continue up the vertical or inclined surfaces of parapet, median, movement joint, gullies, etc. as illustrated on the Drawings.

Membrane thickness shall be checked every 10m² using a gauge pin or standard comb type thickness gauge unless otherwise agreed by the Independent Consultant. The weight of materials used shall also be monitored against area covered.

All components of the system shall be provided by one supplier who must operate a Quality System registered to ISO 9002.

The Contractor shall not place any waterproofing membrane on the concrete deck without the presence of an approved representative from the waterproofing system manufacturer. This representative shall have been employed by the manufacturer for at least 12 months at the time of installation of the waterproofing and shall be approved in advance by the Independent Consultant.

Following deck preparation and before application of the primer, tests shall be carried out in accordance with BS EN ISO 4624:2003 on random areas agreed by the Engineer, to assess the adhesive strength of the cured primer and membrane to the deck. Three tests will be carried out per 500m²; smaller structures shall receive a minimum of three tests. A minimum tensile adhesion value as noted above should be achieved at all temperatures expected to be encountered in Mumbai.

Prior to the application of the second coat of membrane, the fully cured surface of the first coat shall be examined.

Within a maximum period of four minutes of applying the second coat the aggregate over scatter must be applied to the system. Application should be such that 80% of the membrane is obliterated with over scatter. The over scatter should be applied such that it falls vertically into the membrane. The aggregate over scatter must be applied in accordance with the waterproofing system manufacturers' recommendations.

The Contractor shall not allow construction traffic to run over the waterproofing membrane without approval from the Engineer and following consultation with the waterproofing membrane manufacturers.

The Contractor shall ensure that the minimum temperature in laying the surface course above the waterproofing system is recorded. The minimum temperature should be such so as to ensure the bond coat adheres to the surface course as required by the waterproofing system manufacture. The appropriate melting point of the bond coat shall be confirmed by the waterproofing system manufacture.

APPROVED LIST OF MANUFACTURER'S/SUPPLIER'S

a) NINA Concrete System Pvt. Ltd
b) FOSROC
c) BASF
d) Sika
e) Fairmate
f) McBauchemie

SECTION I

14 COAL TAR EPOXY PAINT

This paint shall be applied to all concrete surfaces in contact with soil / water. The paint shall provide protection to concrete surface against corrosion from aggressive environments.

14.1 Specifications

The High build, pitch extended epoxy coating shall be a 100% solids, solvent free, tough abrasion resistant protective coating. The product shall exhibit excellent bond strength with the substrate at least exceeding 2.5 MPa, when tested as per ASTM D4541. The product shall be formulated to have high build thickness exceeding 150 microns per coat on average and shall be applied to achieve overall thickness of 300 microns in two coats. The product shall be formulated to resist exposure to accelerated weathering test as per ASTM D4587 and shall not exhibit any flaking or blistering.

14.2 Resistance to aggressive environment

Exposure to accelerated weathering (ASTM D4587-91)	No cracking No blistering No flaking
Exposure to salt spray (Hong Kong CE dept, model spec for prot coating)	Resistant
Exposure to sewage (MTS international test method)	Resistant
Exposure to marine environment -cyclic immersion in chloride solution	Resistant

14.3 Application

Coal Tar epoxy paint shall be applied on dust free surface, free from laitance, loose material and grease etc. The surface should be roughly cleaned before the application. The paint shall not be applied on wet or uncured surface. The manufacture of the paint and primer shall be as approved by Engineer.

The paint shall be applied by brush or spray to achieve uniform finish. The paint shall be stored, mixed and applied as per manufacture's specifications. The painting shall be done such a way that it covers concrete surface not more than manufacture's specified area.

A minimum of 2 coats shall be applied on the fully prepared surface. Primer coat shall be applied as directed by Engineer. A minimum dry film thickness of 100 microns shall be achieved.

APPROVED LIST OF MANUFACTURER'S/SUPPLIER'S

a) FOSROC
b) BASF
c) Fair mate
d) McBauchemie

SECTION J

15 ANTI CARBONATION PAINT

The item is for providing and applying anti-carbonate acrylic based paint to exposed concrete surface. The supplier for paint shall be as approved by Engineer.
The paint shall be approved from the Engineer-in-charge. The specifications given by the company shall be followed strictly which shall generally be as under

15.1 SPECIFICATION

The protective coating system for concrete shall be a single component, high build, elastomeric, crack-bridging, acrylic coating applied at an average thickness of 300 microns DFT in two coats. The product shall be applied on suitably primed substrate as per manufacturers specification. The product must be crack-bridging high elongation type with elongation at break, exceeding 300% & tensile strength exceeding 2.5 MPa. The system shall exhibit excellent bond strength with the substrate at least exceeding 1.5 MPa, when tested as per ASTM D 4541.

15.2 PROPERTIES

Elongation, (ASTM D 638)	>300%
Tensile strength, (ASTM D 638)	>2.5 MPa
Adhesion, (AS 1580 408.2)	4/5 (excellent)
Dirt pickup (AS 1580 481.1.4, 12 months), on a scale of 0-5 (0 = 'no dirt retained') Water vapour permeability	1
(DIN 52615)	26.0 g/m2/24 Hours
Chloride ion diffusivity	4.98 x 10-10 cm^2/s
Reduction in chloride ion ingress CO2 diffusion resistance	97% at 28 Days
Equivalent air layer thickness, R Appearance after 2000 hr	> 200 m
accelerated weathering	No colour change or chalking observed

15.3 Preparation of Surface

Clean the surface to remove dirt, loose particles, laitance, flaking and rub down to original hard surface. If necessary and as directed by Engineer the surface shall be cleaned by air blow.

a) Examine the surface. Any surface irregularities and blowhole defects should be rectified with the material prescribed by the company.
b) Primer shall be applied before application of first coat of the paint. It shall be applied with brush / rollers or spray as per manufactures directions.
c) Second coat of paint shall be applied after 8 hours or as specified by manufacturers.
d) Approximate total dry thickness of film shall be not less than 190 micron.

15.4 Testing:

Testing of paint shall be done as per manufacturers direction.

15.5 APPROVED LIST OF MANUFACTURER'S/SUPPLIER'S FOR RE STRUCTURE:

a) FOSROC
b) SIKKA
c) BASF
d) Fair mate
e) McBauchemie

SECTION K

16 REINFORCED SOIL WALL

16.1 GENERAL

a) The work shall be executed in conformity with Section 3100 of MORT&H specifications for Road &Bridge works (Fifth Revision) supplemented with relevant provisions of IRC/IS/BS/FHWA publications.

b) The section specifies the work includes detailed design and drawings for the entire Reinforced Soil Structure for different sectional heights, supply of soil reinforcing elements, facia panels, accessories and fittings, construction of reinforced soil structure including placement of facia panels, reinforcing elements, providing and placing earthwork in layers and all associated components in conformity with the specifications and in compliance with the lines, grades, design and dimensions as per approved drawings including supervision of all work. The work also includes preparing, submitting & getting approval to all the designs and drawings and method statement along with program to match with over all completion of the work.

c) The reinforced soil shall be designed for a service life of 120 years. The guarantee period for all types of Reinforced Soil Structures shall be ten (10) years from the date of completion of flyover, underpass, overpass, interchange, bridge works irrespective of defect liability period specified elsewhere in the tender document. The contractor(s) shall furnish the guarantee bond as directed by the Engineer-in-Charge.

d) The reinforced soil structure shall be designed to cater for all the design loads including earth pressure, surcharge, live loads, seismic loads etc., as per IRC guidelines and other design criteria specified in IRC codes. The design of reinforced soil structure shall be based on the actual site conditions and shall match with the approved construction drawings of bridges/flyovers/underpasses/ROB etc. The work shall be done in conformity with the specifications of contract and MORT&H Specifications for Road and Bridge works.

e) The Contractor shall submit within three months from the date of commencement to the Engineer, the complete design, computation and working drawing, and also the methodology proposed to be adopted for the works. The submission shall include the following

   i. Existing ground levels including cross-sections that have been verified by the contractor for each location involving the construction wholly or partially in the original ground.
   ii. Layout of walls, detailed design calculations and drawings, material specifications and construction methodology including quality control and quality assurance of different components.
   iii. Earthwork requirements and results of tests conducted on selected fill material.
   iv. Details of drainage systems and any other facilities.
   v. Test results of soil reinforcing structural element from manufacturers/ suppliers.
   vi. Test results of various materials from an independent laboratory in India or abroad.

vii. Detail sub-soil investigation report including field and laboratory test results in complete.

viii. Any other information required in the plans or special provisions or requested by the Engineer.

16.2 ELIGIBILITY CRITERIA

The agency should provide authenticated details of licensing and collaboration arrangement with the principals, where relevant for prior approval.

Reinforced soil structure being a specialized technology, the approved agency shall furnish design, drawings, method statement, QA plan etc., through contractor for approval by the engineer and make his own arrangements to secure the supplies and services needed.

16.3 DESIGN:

The specialized agency shall have in-house design capability & organization shall be ISO9001:2008 certified.

The design shall ensure internal and external stability of the reinforced soil wall, meeting the requirements of BS 8006. For external and internal stability analysis under seismic loading US Federal Highway Administration (FHWA) design guidelines (FHWA-NHI-00-043) shall be followed.

The approved agency shall submit details of technology, its design principles, durability and details of its adoption on at least one Project in India, as a published literature in Indian Journal. (The detailed design has to be got approved from the consultant before the execution of this work).

16.4 Design Loads

The following loads shall also be considered while designing the Reinforced Soil Wall structures apart from all applicable loads for its tendered use

For Walls

Traffic Live load surcharge : 2.4 T/m2

ii.) Dead load surcharge : 1.2 T/m2 or higher as per design

iii.) Traffic impact load on crash barrier: 7.5kN/m for pullout resistance, 30 kN/m for tensile strength

iv.) Seismic loads as per maximum acceleration expected at site. (zone factor of Table 16, IRC-6:2017).

16.5 EARTH FILL

a) The fill material in reinforced soil zone shall not contain fines (passing 75 micron sieve) more than 15%. Co-efficient of uniformity (Cu) of the backfill shall be greater 2 and the

peak angle of internal friction of back fill tested as per IS: 2720 (Part 13), by conducting a drained direct shear test should be greater than or equal to 30□. For design, effective cohesion of backfill shall be taken as zero.

b) The plasticity index shall not exceed 6. The backfill shall also be free from organic or otherwise deleterious materials so as not to cause corrosion of the soil reinforcement and the facia panels
c) Where metallic soil reinforcing elements is proposed to be used, the fill material shall confirm to following electrochemical requirements:
d) The electrical resistivity of fill material shall be more than 3000 ohm-cm or more determined based on standard test and materials with resistivity less than 1000 ohm-cm are unsuitable and shall not be used.
e) Materials with resistivity between 5000 & 1000 ohm-cm are acceptable provided that in water extracted from soil-water mix, the content of chlorides does not exceed 100 ppm, the content of Sulphate does not exceed 200 ppm, and the pH value is in the range of >5<10.
f) The foundation soil's electrochemical requirements should also meet the above criteria. If not, special consideration will be given to the design of reinforcing element and facing material.
g) The above criteria applicable only for metal strip reinforcement.
h) The select backfill shall be compacted to ensure achieving peak angle of friction not lower than 30°. For design, effective cohesion of backfill shall be taken as zero.
i) The compacted layer should not be more than 200mm thick. The compaction of backfill material shall be 97% of maximum dry density obtained from modified Proctor compaction test performed as per IS 2720 (Part-8).

16.6 REINFORCING ELEMENTS

Only high adherence hot dip galvanised steel can be used for reinforcing the select fill as per the specification given in Section 3100 of MoRT&H (Fifth Revision).

a) Hot Dip Galvanised Soil Reinforcing Strips & Tie Strips

All metallic components buried in soil shall be made of electrolytically compatible materials. The minimum width of the individual steel strip must be 40mm and minimum thickness must be 5 mm. Tie strips and High Adherence Reinforcing (HAR) steel strips shall be hot rolled. Their physical and mechanical properties shall conform to European norms BS EN 10025 S 235 JR or S 355 JR grade or equivalent grades as per BIS code.

Reinforcing and tie strips shall be cut to the lengths and tolerances shown on approved drawings. Holes for bolts shall be punched in the locations shown. They shall be carefully inspected to ensure they are true to size and free from defects that may impair their strength or durability. The connections and reinforcing elements shall be manufactured at ISO 9001-2008 certified facility.

The minimum galvanization protection on reinforcing steel strips and steel components shall be 1000 gm/sq.m (140 microns) on all faces. Sacrificial thickness as recommended in BS: 8006 shall be considered on each surface exposed to corrosion.

The manufacturer shall provide the test results of all physical and mechanical properties of metallic reinforcement for every 15 MT or as required by Engineer.

b) Connection

Connection between the facia and the reinforcing element shall be using galvanised steel loops & toggles bars of appropriate diameter designed as per relevant Indian Standards. If polymeric connections are used or any components of connections are made of polymeric material, the agency shall provide the results of tests carried out on the connection to establish the connection strength between the facia and reinforcing elements from independent accredited body or government agency /college as per the requirement of BS 8006.

c) Handling & Storage of Reinforcing Elements

i. Reinforcing elements shall not be subjected to rough handling, shock loading or dropping from a height.
ii. Reinforcing elements shall be stored in such a manner to eliminate the possibility of any damage and shall be clearly labelled to identify items with different dimensions and properties.
iii. Nylon, rope or padded slings shall be used for lifting galvanized reinforcing elements; bundles of reinforcement shall be lifted with a strong back or with multiple supports to prevent abrasion or excessive bending.
iv. Polymeric reinforcing elements shall be properly stored and protected from precipitation, extended ultraviolet radiation, direct sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperature in excess of 50°C, and any other environmental condition that may damage the physical property values.

16.7 FACIA UNITS

The facia units, which help to maintain a vertical face of the reinforced soil structure, avoid erosion of the fill and provide aesthetic appearance to the reinforced soil, shall be of the pre-cast reinforced concrete panels. The concrete panel height shall not be less than 1.5m.

a) Pre-cast Reinforced Concrete Panels

The pre-cast concrete facing units shall be a discrete panel having maximum longitudinal, transversal and rotational flexibility to cater high static and dynamic loads, and ground movements. Area of concrete panel shall not be less than 3 Sq.m.

Pre-cast concrete facing elements shall conform to the details and dimensions shown on the approved drawing. Concrete shall be of M-35 grade and shall conform to the requirements as specified in section 1700 "Structural Concrete" of MORT&H Specifications.

The nominal thickness of the panel shall be 18 cm including facing textures and design.

Reinforcement in panels shall be designed for the connections with soil reinforcing structural elements and shall be placed as shown on the drawing and shall conform to the requirements specified in Section 1600 of the MORT&H Specifications.

b) Tolerance

All elements shall be manufactured within the following tolerances:

I. All dimensions within: ± 5mm
II. Evenness of the front face: ± 5 mm over 1500mm
III. Diagonals: maximum ±10mm.
IV. Thickness: ± 2 mm

c) Handling, Storage and Transporting

All elements shall be handled, stored and transported in such manner as to eliminate the danger of chipping, cracks, fracture and excessive bending stresses. Elements in storage shall be supported on firm blocks to be located adjacent to the connection to avoid bending.

d) Acceptability

Acceptability of the precast elements shall be determined on the basis of compression tests on concrete cubes taken during precasting, as per MORT&H Specifications.

e) Rejection

Elements shall be subject to rejection in case of failure to meet any of the requirements specified above. In addition, defects, which indicate imperfect molding, or defects indicating honeycombed or open textured concrete, shall be sufficient cause for rejection.

16.8 DRAINAGE MATERIAL, BEARING PADS AND JOINT FILLERS

a) The drainage provision shall be strictly followed as per the approved working drawing. The retained fill shall have a suitably designed drainage bay and associated drainage system to allow for free drainage of the reinforced fill. The minimum drainage gallery width just behind the facing units shall be 600mm with well – graded crushed aggregate (materials as per Clause 2504.2.2 of MoRT&H - Fifth Revision).
b) The main collection drainpipe just behind the precast facing, if used, shall be a minimum of 150mm in diameter. The secondary collection drain pipes should be sloped a minimum of two percent to provide gravity flow into the main collection drainpipe. Drainage laterals shall be spaced at a maximum 15 meters spacing along the wall face. The drainage collection pipe shall be a perforated or slotted, PVC or corrugated HDPE pipe. The drainage pipes shall be wrapped with geotextile.
c) A gap of not less than 15 mm shall be maintained all around the facing units after erection. Bearing pads for horizontal joints between panels shall be made of elastomer with vulcanised EPDM. Fillers of vertical joints between panels shall be flexible open/ close cell polyurethane foam strips or non-woven fabric strips (the latter used as joint cover instead of filter) as approved by Engineer.

16.9 CONSTRUCTION REQUIREMENTS

The construction of Reinforced Soil Structures shall be carried out in accordance with the specifications and in conformity with the lines, grades, design and dimensions shown on the approved drawings.

a) Excavation

The plan area of the of Reinforced Soil Structures shall be excavated in accordance with the requirements of General and Special Specifications and in reasonably close conformity to the limits and to the lines and grades during construction stages as shown on the approved drawings. The contractor shall take precautions to minimise over- excavation. Excavation support, if required shall be designed by the Contractor.

b) Foundation Preparation

The foundation for Reinforced Soil Structures shall be graded level for width equal to or exceeding the length of reinforcing geosynthetics. Prior to wall construction, the foundation shall be compacted with a smooth wheeled roller. The depth of foundation below the finished ground level shall not be less than 1m.In case rock is met above founding level, the depth of embedment shall be adjusted as per ground condition.

c) Ground Improvement

Where foundation soil is found to be unsuitable, either removal and replacement technique or ground improvement is required to be carried out, as required by the Engineer. The need for ground improvement, design and ground improvement methodology shall be verified and approved by the Engineer prior to construction.

Suitable ground improvement technique shall be identified based on the results of subsoil exploration. Foundation preparatory works and foundation treatment/ improvement shall be treated as integral part of the reinforced soil structure and accordingly Contractor shall arrange for detailed sub-soil investigation works and employ his resources to design and construct the foundation/ ground improvement treatment, wherever necessary to satisfy the requirements of reinforced soil structure. The design check and validation for foundation treatment/ ground improvement and the methodology shall be verified and approved by the Engineer prior to construction.

d) Levelling Concrete

A levelling concrete pad shall be provided under the walls. Concrete shall have a minimum grade M-15. Maximum size of aggregates shall be 20mm and the pad shall be cured for at least 48 hours before placement of panels.

e) Erection

i. Reinforcing elements shall be installed at the proper elevation and orientation as shown in approved drawings or as directed by the Engineer. The reinforcement

strips shall be placed normal to the face of the wall unless otherwise shown on the drawings.

ii. Pre-cast Concrete Facia Panels

Pre-cast concrete panels shall be placed vertically with the aid of a light crane. For erection, panels shall be handled by means of lifting devices set into the upper edge of the panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the drawings as backfill placement proceeds.

Panels may be provided with an initial inward batter as specified by the agency or as given in the drawings. Initial inward batter is required to counter the outward tilt that will occur as the wall height is built up and also due to construction process.

As fill materials is placed behind a panel, the panels shall be maintained in positions by means of temporary wooden wedges placed in the joint at the junction of the two adjacent top rows of panels during construction. As construction proceeds and a fourth row are erected, the lowest row of wedges can be removed and so on.

External bracing may also be needed for the initial lift. However, bracings shall be placed in an area not more than 1.5m wide beyond the outer face of panels.

Vertical tolerances (plumbness) and horizontal alignment tolerance shall not exceed 25mm when measured along a 3 m straight edge. The maximum allowable offset in any panel joint shall be 25mm.

f) Reinforced Soil Backfill Placement

The reinforcing elements shall be laid free from all kinks, damage and displacement during deposition, spreading, levelling and compaction of the fill. The program of filling shall be such that no construction plant runs directly on the reinforcement. It shall be ensured that the exposure of soil reinforcement to ultraviolet rays is minimal and should be covered with fill within one day of placement.

All construction plant having a mass exceeding 1000 kg shall be kept at least 1.5m away from the face of wall. In this area (up to 1.5m from the face of slope or wall), the following compaction plant shall be used.

Vibratory roller having a weight per meter width of roll not exceeding 1300 kg with total weight not exceeding 1000 kg.

Vibratory plate compactor of maximum weight 1000 kg.

Vibro tamper having a weight not exceeding 75 kg.

During construction, the retained material beyond the reinforcement at the rear of the structure shall be maintained at the same level as reinforced fill. The entire works related to compaction should be carried out generally in a direction parallel to the facing. Fill placement methods near the facing shall ensure that no voids exist below the reinforcing elements.

At the end of each day's operations, the contractor shall shape the last level of backfill as to permit run-off rainwater away from the wall face.

g) Drainage Material Placement

Drainage material shall be placed to finished thickness and widths shown on the construction plans or as modified by the Engineer. During placement and compaction of drainage material, care must be taken to ensure that there is no contamination with undesirable materials. Vertical layers of drainage material shall be brought up at the same level as the adjoining fill material.

Drainage collection pipes shall be installed to maintain gravity flow of water outside of the reinforced soil zone. The drainage collection pipe should discharge into a storm sewer, manhole or along a slope at an elevation lower than the lowest point of the pipe within the aggregate drain.

16.10 DESIGN, WORKING DRAWING & DETAILING

The scope of work shall also cover the supply of detailed design, engineering submission of working drawings by the specialized agency for reinforced soil works. The designs and drawings shall be got approved from the Engineer and/or its representative before execution of work.

16.11 INSPECTION

Engineer and/or the representative shall verify the materials supplied and quality of work to ensure that all the requirements of the specifications are satisfactorily met with. This includes all submittals and proper installation of the system.

The reinforced soil structure system supplier shall provide one qualified and experienced representative at site on full time basis during the entire working phase to ensure that the quality of the works performed by the Contractor is in accordance with the specifications and to assist the Contractor regarding proper wall installation.

16.12 QUALITY CONTROL AND TESTING OF MATERIALS

Testing shall be done as stated elsewhere in this specification on all materials required for reinforced soil structure construction. The tests shall be done from a reputed independent agency or at the manufacturer's facility under the presence of Engineer or his representative as and when required. All tests and testing certificates shall be submitted to the Engineer at least 7 working days prior to use of any material. Tests on materials before and during construction shall not be limited to the following types.

16.13 For steel reinforcing elements

a) Tensile strength testing one for every lot.
b) Test on Galvanization one for every lot.
c) Size of the steel reinforcement (length, width and thickness) for every lot.
d) Testing at manufacturer's facility witnessed by Engineer's representative to verify the test results.

e) Determination of interaction coefficient by pullout test, maximum once in project, if the values used in the project are not as per code of practices, otherwise at owners cost.

f) The following particulars of the proposed steel reinforcing elements and connections shall be submitted to the Engineer
   i. Literature on the proposed reinforcing element and connection.
   ii. Copies of valid quality assurance certificate such as ISO 9001 or equivalent certifying the quality system for the manufacturing unit of the reinforcing elements, connections and galvanisation plant.
   iii. A certificate showing the manufacturer's name, the date and place of manufacture and showing that the reinforcing element complies with the requirements stated in the contract and including the results of tests specified in the contract or as specified by the Engineer.

16.14 For fill material

a) At source approval, the borrow area shall be divided into grid of 25m c/c (or closer if variability is high) as per Clause. No. 903.2 of MORT&H specifications and trial pit shall be taken to full depth in each grid. These trial pits should be logged and plotted for proper identification of suitable source of fill material. Following tests on representative samples shall be carried out
   i. Grain size analysis - 2 tests per 3000 cu.m of fill.
   ii. Plasticity test – 2 tests per 3000 cu.m of fill
   iii. Shear test for □Peak as per IS 2720 (Part 13) drained direct shear test – one test for every 3000 Cu.m of fill material.
   iv. Modified Procter test as per IS: 2720 (Part-8) – 2 tests per 3000 cu.m of fill material.
   v. Electrochemical properties of soil if steel reinforcing elements are used – 1 test per 3000 Cu.m of fill material.

b) **During construction**
   i. Grain size analysis for every 3000 Cu.m of fill
   ii. Shear test for Ø Peak as per IS 2720 (Part 13) drained direct shear test for every 10,000 Cu.m of fill if the grain size analysis matches with the tests that were carried out during source approval or else one test per 3000 Cu.m of fill material.
   iii. Modified Procter test as per IS:2720 (Part-8) – 2 tests per 10,000 Cu.m of fill material if the grain size analysis matches with the tests that were carried out during source approval or else two test per 3000 cu.m of fill material.
   iv. Electrochemical properties of soil if steel reinforcing elements are used – 1 test per 10000 cu.m of fill material.
   v. Density of each compacted layer (>95% of MDD) at frequency as per clause 903.2.2 – one set of 10 tests in every 500 sq.m.

c) The following particulars of the proposed fill material shall be submitted to the Engineer for approval
   i. Statement identifying each source of supply and showing that sufficient suitable material is available for the works.

ii. For material from borrow areas, a plan showing the location and extent of each proposed borrow area, and the location, depth and test results for each sample obtained.

iii. Certificates from a laboratory approved by the Engineer which shows that each material proposed for use complies with the requirements of the Contract and has been tested in accordance with the appropriate test methods given in this Specification.

d) On receipt of the above particulars, the Engineer may require the Contractor to carry out additional sampling and testing to demonstrate that the properties of the proposed sources of fill will meet the requirements of the Contract.

16.15 MEASUREMENT FOR PAYMENTS

a) The measurement for Reinforced soil structures shall be as follows

i. The measurement shall be for the total face area of each face of Reinforced Soil wall in square meters measured from top of foundation levelling pad to bottom of crash barrier.

ii. Measurement of backfill placement and compacting for the reinforced soil wall shall be in cubic meters of compacted soil.

iii. For crash barrier and friction slab measurement for concrete shall be in cubic meters and reinforcement steel in metric tonnes as per respective time of BOQ.

b) The payment for excavation, foundation concrete, reinforcing element, fastners, filter media, drainage layer, drainpipe, coping beam and other accessories shall not be measured separately. It is deemed to have been included in the facia material rates for the project.

16.16 RATE

a) The overall rate for reinforced soil shall include detailed engineering including designs, drawings, all specified quality control tests, approval from Engineer, furnishing, fabricating and providing all materials for the walls including fascia panels, reinforcing elements and all its accessories, excavation and foundation construction; setting out and erection of wall materials

including fascia panels with all joint fillers/ materials, reinforcement etc., supplying and placing of drainage works, filter medium and filter fabric, foundation pad including any supplementary arrangement to receive the first panel and capping beam etc. Cost involved for any field investigation and sub-soil exploration as directed by the Engineer to determine the extent of ground improvement shall be borne by the Contractor. The rate shall include the cost of labour, plant/ machinery, material storage and handling expenses, as required for all the above activities for completing the works.

The rate shall also cover the cost of all materials, castings, curing, and quality control tests, stacking, transporting and placing of facia. Cost of joints, all necessary temporary formwork, scaffolding and all lifts and leads complete as per approved design/ drawing of the specialised firm shall also be included.

The rate shall also include material cost, all transportation costs and storage of the same as per special provisions for reinforcement element. The rate shall also include cost of quality control tests, lying of the reinforcing elements including all overlaps, jointing or stitching, heat bonding or extension and jointing them with reinforcing elements of concrete discrete panels along with all accessories.

The rate also shall include all items of excavation, concrete, reinforcing steel, formwork, curing etc for foundation and capping beam.

The rate shall also cover providing, placing and compacting drainage aggregate, filter medium including drainage collection pipe, filter fabric and conducting quality control tests etc for drainage.

The rate shall also include patentee charges (if any) and supervision by the specialised supplier (manufacturer / agency).

i. The rate for soil fill shall include selection, supply, placing, compaction, and quality control tests etc. for approved earth fill. The rate shall also include the cost of labour, plant/ machinery, transportation for all leads and lifts etc. as required for the completion of the works, dressing and levelling of slopes, including special measures for edge reinforcement in accordance with the drawings.
ii. The rate for crash barrier and friction slab shall include the cost of all materials, labour, plant/ machinery, transportation for all leads and lifts etc. as required for completing the work.

16.17 APPROVED LIST OF MANUFACTURER'S/SUPPLIER'S FOR RE STRUCTURE

a) MaccaferriLtd.
b) Reinforced Earth India
c) AMIL

SECTION L

17 EXPANSION JOINTS

Expansion joints shall be constructed according to the details shown on the drawings.

The position of all bolts cast into concrete and holes drilled in plates shall be accurately determined from templates.

Vehicular traffic shall not be allowed over the expansion joints after its construction for such period as may be determined by the Engineer-in-charge.

17.1 SPECIFICATION FOR UNITARY STRIP/SEAL EXPANSION JOINTS

a) Strip seal expansion joint should be designed to cater for a total movement of 80mm or as specified in tender / drawings. The joints offered shall have 25% extra movement capacity to be confirmed by the manufacturer.
b) Manufacture and Quality Assurance of the strip seal expansion joint must be in conformity with ISO: 9001 and valid certification of manufacturer's product as per ISO: 9001 to be enclosed with tender. The ISO quality assurance will cover from raw materials upto finished products at the manufacturer's works before being dispatched for installation at site.
c) The components of strip seal expansion joint viz. edge beam, anchorage and the strip seals shall generally conform to MORT&H Specification for Road & Bridge Works, latest Revision, Subsection 2607 and IRC Specification as called for. However, the main edge beam section must be hot rolled steel section as per C1.2607.1 of MOST Specification for Road & Bridge Works. Cold formed, closed loops and welded plate sections will not be accepted.
d) Only 3rd Generation: Lock Seal type" elastomeric sealing elements for 100% water tightness and 'Fail Safe' locking system to be used. The supplier has to provide strip seal which closes fully during contraction so that deposit of dirt and debris and other accumulated particles can be squeezed out of the joints ensuring self-cleaning effect which is of utmost importance from the functional and maintenance point of view of Indian traffic condition having all ranges of traffic / vehicles / transported materials by truck etc. The edge beam shall be anchored to the deck by close loop anchorage system and the minimum diameter of the loops will be 20mm and minimum thickness of the edge beam will be 12mm and also minimum thickness of the anchor plate will be 15mm.
e) Necessary sand blasting / zinc spraying / epoxy painting etc. to be ensured also.
f) A categorical confirmation from the tenderer is required stating that all components of the strip seal expansion joints will be manufactured at their principal workshop/supplied by the System Supplier in their workshop in accordance with the QAP/Drawing etc. of the principal manufacturer, with whom the system supplier must have a technical collaboration.
g) Detailed testing procedure starting from the raw materials to finished joints at every stage of manufacture is to be furnished by the principal manufacturer for items which will be manufactured at their factory and by the licence system manufactured at their workshop

before final assembly and dispatch. DCS&D's inspection of raw materials as per specifications to be carried out for a small extra length (say 200mm) of the expansion joints, for which no extra payment will be made. DC&SD's inspection and certification of each joint is also mandatory without any extra cost. CIDCO representative may also inspect and carry out sample test in manufacturer's premises and all costs to be borne by the contractor.

h) The detailed installation drawing / installation procedure has to be submitted within 45 days of award of the work and the contractor shall coordinate in such a manner that the design and drawing are approved by the competent authority within 30 days of their submission.

i) In order to establish the procurement of strip seal expansion joints in full or part from the foreign based collaborator / principal manufacturer the following documents are to be submitted by the system supplier in India.
   i. Detailed order copy (un priced) placed on the foreign based manufacturer.
   ii. Bill of lading, certificate of origin and other necessary shipping documents.

j) 8.9 The supplier shall furnish the complete installation drawing showing the block out and gaps to be kept during casting of the deck for installation of the expansion joint at a later date. Supervision of installation by foreign principal's expert, free of cost, at least for first 2 joints to be confirmed by the tenderer. For all the joints, installation to be carried out under supervision of manufacturer's expert representative.

k) 10 years warranty on materials and workmanship and on finished product to be provided by the manufacturer / system supplied.

17.2 FABRICATION

17.3 OPEN JOINTS

Open joints shall be constructed at the locations shown on the drawings using a wood strip, metal plate, or other suitable material which is subsequently removed. When removing the material, care shall be exercised to avoid chipping or breaking the corners of the concrete. The edge of the concrete, at the joints shall be edge finished. Reinforcement shall not extend across on open joint.

17.4 FILLED JOINTS

The filler material shall conform to relevant clause of IRC when preformed filler is shown on the drawings the filler shall be placed in correct position before concrete is placed against the filler. The filler material shall form part of the joint and while concreting the slab, care shall be taken to prevent the former from being displaced. After the work it completed the exposed face of the joint shall be cleaned of all loose material attaching to it.

17.5 STEEL WORK

Steel, plates, angles, or other structural shapes provided in the expansion joints shall confirm to the provisions in section 1900 of IRC and shall be accurately shaped to the section of

corner to deck and shall be hot dip galvanized after fabrication positive methods shall be employed in placing the assemblies, to keep them in correct position during the placing of concrete. Care shall be taken to avoid impairment of the clearance in any manner.

17.6 FILLER MATERIAL AT EXPANSION JOINTS

The material used for filling expansion joint shall be bitumen impregnated felt, elastomer or any other suitable material as specified on the drawings. Impregnated felt shall conform to the requirements of IS: 1838 and shall be got approved from the Engineer-in-charge. The joint filler shall consist of large pieces and assembly of small pieces to make up the required size shall be avoided.

17.7 MODE OF MEASUREMENTS

Expansion joints would be measured in running meter for providing and fixing in position as per detailed drawings and particular specifications.

17.8 ITEM TO INCLUDE

The expansion joints shall be of highest standard and shall be purchased from one or two selected manufacturers approved by engineer-in-charge. The rate is to include providing, fabricating, installing, filling the filler material etc. complete as per detailed drawings and particular specifications and shall also include testing of materials and fabricated joints as instructed by Engineer. Rate shall also include surface preparation and cost of neoprene/elastomeric sheet etc. complete.

17.9 APPROVED LIST OF MANUFACTURER'S/SUPPLIER'S

a) Sanfield India Pvt. Ltd.
b) Megaba India
c) J. sons and co.

PART B

AMMENDMENTS / MODIFICATIONS / ADDITIONS TO EXISTING CLAUSES OF GENERAL TECHNICAL SPECIFICATION.

SECTION 100 GENERAL

CLAUSE 102 DEFINITIONS

(Addition) The following abbreviations shall be added in this Clause:

"KIIFB": Kerala Infrastructure Investment Fund Board.

CLAUSE 105.1 Scope of Work

The work to be carried out under the Contract shall consist of the various items as generally described in the tender document under the heading "Scope of Work".

CLAUSE 107 CONTRACT DRAWINGS

107.2 The drawings provided in the tender are the drawings showing proposal of the Employer. Since the offers are invited on the basis of Contractor's own design, the drawings submitted by the Contractor along with his tender shall be treated as Contract drawings subject to conditions laid down in the Contract. The Contractor should visualise the nature and type of work contemplated and ensure that price quoted by him have due consideration of qualitative and quantitative variations, as may be found at the site and complexities of work involved during actual execution/construction.

107.3 Within 15 days of the receipt of work order the Contractor shall submit a programme of submission of designs as per the stipulations made in the design criteria. The programme of submission of designs of various components shall be consistent with the programme of work prepared by the Contractor and approved by the Employer.

Detailed design calculations and working drawings of all the components including launching scheme shall be submitted well in advance of execution, accordance with the above programme. The designs and drawings shall be submitted progressively. If computer is used for design or analysis, the contractor shall submit with design, the detailed description of method of analysis with explanatory notes and manually done sample calculations for adequate number of typical cases. The Computer Software as submitted will be tested by

comparison with solutions as worked examples.

Drawings and designs shall be in metric units. Calculations shall be neat and clear and supplemental by full explanatory notes and sketches wherever required. The drawings of initial submission and final approval shall be stenciled and in A-1 size only.

If during the scrutiny of detailed design calculations and drawings including temporary arrangements for launching, any changes therein are found necessary in the opinion of Engineer, they shall be incorporated without altering the lump-sum price quoted. It will be entirely the responsibility of the contractor to submit properly prepared designs & drawings in good time to enable the competent authority to approve them in time. Schedule of reinforcement and the rate of reinforcement per cum of concrete quantity (and also percentage with respect to gross cross sectional area of the component) should also be shown on each drawing.

Ten sets at approved working drawing including one set on reproduction tracing film and 5 sets of approved design calculations shall then supplied by the contractor which will be formally authenticated by the Engineer (5 copies of drawings and one set of design calculations for field officers, two sets to be returned to the Contractor and three to be retained by Engineer). These drawings shall be submitted in approved plastic folders and calculations in approved plastic files free of cost.

107.4 After completion of each stage of work, 3 sets of record plans and one set of final design calculations based on the work actually executed shall be supplied by the Contractor in bound volumes to the Engineer.

Approval to drawings and designs by the Engineer, shall not in any way relieve the Contractor of his responsibility for the correctness, soundness, stability and safety of the structure.

The approved drawings and design calculations of the bridge shall be the property of the Employer.

CLAUSE 108 SITE INFORMATION

CLAUSE 108.4 This clause shall read as follows:

(Substitution) “Identification of quarry sites and borrow areas shall be the responsibility of the Contractor. Materials procured from quarry sites and borrow areas identified by Contractor and to be used in Works must comply with the requirements of quality as stipulated in the Technical Specification for particular items of work.”

CLAUSE 110 PUBLIC UTILITIES

(Substitution) Replace whole of this clause with the following:

Clause 110.1 The contractor shall be responsible to coordinate with service provider / concerned authorities for shifting of utilities and removal of encroachments etc. and making the site unencumbered from the project construction area required for completion of work. This shall include initial and frequent follow-up meetings / actions / discussion with each involved service provider / concerned authorities. The contractor will not be entitled to any additional compensation for the delay in shifting of utilities and removal of encroachments by the service provider / concerned authorities.

The information contained in the Bid Documents concerning the public utility services such as water, sewer, power transmission lines, telephone lines and oil/gas pipelines, OFC cables, etc. may not be exhaustive, and it shall be the responsibility of the Contractor to ascertain the utilities that are likely to be affected by the works through site investigations and collection of information from the concerned utility owners.

The contractor's alternative proposal shall be such that the shifting of utilities is not required. If during the course of execution the known utilities are encountered at substantially different locations than those shown on drawings or some unidentified utilities are encountered then the contractor shall modify the structural arrangement to avoid them for which extra payment shall be made as per the Contract Conditions.

Clause 110.3 Any utility likely to be affected by Contractor's work should be brought to the notice of the Engineer and such work shall be undertaken only after getting written clearance from the Engineer.

Clause 110.4 The Contractor may be required to carry out certain works for and on behalf of the various bodies and the Contractor shall also provide, with the prior approval of the Engineer, such assistance to the various bodies as may be authorized by the Engineer.

Clause 111.13 Dust Control During Construction

(Addition) The Contractor shall make adequate provision, including frequent spraying of water, to mitigate dust nuisance from on-site equipment during the construction of the works.

Clause 111.14 Sanitation

(Addition) The Contractor shall make adequate sanitation facilities for labour and Contractor's camp, including provision of lavatories, sewage disposal, and solid waste collection and disposal.

Clause 112.4 Traffic Safety and Control

(Modification/ Addition) Last line of Para 5 shall be read as under:

"The sign shall be of approved designs and of retro-reflectory type."

Add the following paragraph at the end of the clause:

"Before commencement of any construction, the Contractor shall prepare and submit details of the arrangements he proposes to make for passing / diverting traffic during construction, design of barricades, signs, markings, lights, flags etc. and get the same approved by the Engineer."

CLAUSE 121 FIELD LABORATORY

Clause 121.2 Description

(Modification / Addition / Substitution) Replace the words "shown in drawings" in the first sentence of first paragraph of this Clause with the words "per provisions indicated in this clause and at a location approved by the Engineer."

Add the words "including uninterrupted power supply" to the second sentence of first paragraph.

Delete the first sentence of second paragraph and substitute the following:

"The floor space required for the field laboratory shall be not less than 40 sq. metres"

Delete the fourth sentence of second paragraph shall be read as under.

"A good furnished office accommodation shall be provided to the Supervision Team as per the direction of the Engineer."

Add the following at the end of this Clause:

"There shall also be provided a concrete paved area, for storing samples adjacent to the laboratory, of about 300 sqft and another 200 sq. ft. shall be suitably roofed with open sides giving protection against sun and rain.

Within 14 (fourteen) days of the commencement date, the Contractor

shall prepare and submit a layout plan and details of the laboratory building and make/supplier of the equipment to the Engineer for his approval.

The field laboratory to be provided under the Contract shall be ready and finished and fully equipped condition not later than 2 months after the receipt of Notice to Commence Work, and the field laboratory with all equipment/instrument shall be to the entire satisfaction of the Engineer. During the period specified, the laboratory tests shall be performed in another laboratory proposed by the Contractor and approved by the Engineer."

Clause 121.3 Laboratory Equipment

(Substitution) This Clause shall read as under:

The following items of laboratory equipment as a minimum shall be provided in the field laboratory:

The equipment and instruments shall be new and shall be quality certified by Bureau of Indian Standards (BIS).

S.No	Sub No.	Item, Specifications	Nos. Required
		A: General	
(i)		Balance	
	(a)	7 kg to 10 kg capacity semi –self indicating Electronic Type –Accuracy 1 gm	2
	(b)	500gm. capacity semi-self-indicating Electronic Type Accuracy 0.01 gm	1
	(c)	Pan balance 10 kg capacity – Accuracy 0.5 gm	6
	(d)	Platform Scale – 300 kg capacity - Accuracy 1 Kg.	1
(ii)		Ovens – Electrically operated, thermostatically controlled	
	(a)	From 100oC to 220^{0}C – Sensitivity 0.5^{0}C	1
(iii)		Sieves, as per IS 460-1962	

	(a)	IS Sieves 450 mm internal dia. of sieve sets as per BIS of required sieve sizes complete with lid and pan	2 set
	(b)	IS sieve 200 mm internal dia. (brass frame and steel or brass wire cloth mesh) consisting of sieve sets of required sieve sizes complete with lid and pan	2 set
(iv)		Sieve shaker capable of taking 200 mm and 450 mm dia. Sieves electrically operated with time switch assembly (As per BIS)	1
(v)		200 tonnes compression testing machine	1
(vi)		Stop watches 1/5 sec. Accuracy	1
(vii)		Glassware comprising of Beakers, Pipettes, dishes, measuring cylinders (100 to 1000 cc capacity) glass rods and funnels, glass thermometers range 0oC to 100oC and metallic thermometers range 300oC	6 each
(viii)		Hot plates 200 mm dia (1500 watt)	2
(ix)		Enamel trays	
	(a)	600 mm x 450 mm x 50 mm	10
	(b)	450 mm x 300 mm x 40 mm	10
	(c)	300 mm x 250 mm x 40 mm	6
	(d)	Circular plates 250mm dia	6
(x)		Water, Sulphate & Chloride testing Kit	1
(xi)		First aid box	1
		B: For Cement, Cement Concrete and Materials	
(i)		**Water still**	1
(ii)		Vicat needle apparatus for setting time with plungers,as per IS.269-1967	1
(iii)		Moulds 150mmx150 mm x150mm cubical for compressive strength	60

(iv)		Concrete permeability apparatus as per DIN 1048.	1
(v)		High frequency mortar cube vibrator for cement testing	1
(vi)		Concrete mixer power driven, 1 cu ft capacity	1
(vii)		Variable frequency and amplitude vibrating table size 1 metre x 1 metre, as per the relevant British Standard	1
(viii)		Flakiness & Elongation test apparatus	1
(ix)		Aggregate impact test apparatus as per IS 2386 (Part 4) 1963	1
(x)		Los Angeles abrasion apparatus as per IS. 2386 (Part 4) 1963	1
(xi)		Flow table as per IS 712-1973	1
(xii)	(a)	Equipment for slump test	1
	(b)	Compaction factor test equipment	1
(xiii)		Equipment for determination of specific gravity for fine and coarse aggregate as per IS 2386 (Part 3) 1963	2
(xiv)		Needle vibrator with needle shaft etc. complete	1 set
(xv)		Air entrainment meter	1
(xvi)		0.5 Cft, 1 Cft cylinder for checking bulk density of aggregate with tamping rod	1
(xvii)		Soundness testing apparatus for cement	1

Note:

a) The laboratory set-up must be complete including a set of reference standards, adequately staffed and operational to the satisfaction of the Engineer before commencement of the works.

i. Following survey instruments shall be made available exclusively for the checking by the Engineer during the tenure of the contract

Auto level	2 Nos
Total station	1 set
Aluminium staff	4 Nos

Clause 121.5 Maintenance

(Substitution) This Clause shall read as under:

"The Contractor shall arrange to maintain the field laboratory including sample store yards in a satisfactory manner until the issue of Taking over Certificate for the complete work. Maintenance includes all activities described in Clause 120.4 and maintenance of equipment and running of the same including chemicals and consumables."

1000 **MATERIALS**

1009.3 Reinforcement /Untensioned Steel IS: 1786 -1985

a) All reinforcement shall be only TMT Bars (Fe 500 or equivalent) and diameter of reinforcement for all types of permanent structure should not be less than 10 mm. Also TMT steel of any brand from TISCO/ TATA, SAIL & VIZAG steel will be acceptable.
b) Cutting, bending of all reinforcement shall be with bar bending/cutting machine only.
c) Binding wire shall be galvanized M. S. wire of minimum 8 gauge.

1500 FORM WORK

1502 The form work used shall be of steel plate made of MS sheets of 10 gauge (3.15 mm) thick minimum and 50 x 500 x 6 Angles. Marine ply wood properly stiffened, such as DOKA/PERI type form work shall be preferred. Form work shall be desired preferably without use of tie bolts. Large and uniform sized panels with minimum number of joints shall be used for pier, pier caps and superstructure.

Clause 1503.2 Add the following at the end of this Clause :

"For distribution of load and load transfer to the ground through staging, an appropriately designed base plate must be provided which shall rest on firm sub-stratum."

CLAUSE 1505 FORMED SURFACE AND FINISH

(Substitute clause) Substitute the following clause in place of the existing clause:

Formed & Unformed Surface Finishes

The surface finishes for formed and unformed surfaces are classified and defined as below. Surface irregularities permitted for the various classes of finishes are termed either 'abrupt' or 'gradual'. Fins or offsets caused by displaced or misplaced form sheeting, lining or form

sections, by loose knots in form lumber or by otherwise defective form lumber are considered abrupt irregularities. All other cases are described as gradual irregularities. Gradual irregularities will be measured with a template consisting of a straight edge for plans surfaces or its equivalent for curved surfaces. The length of template for testing gradual irregularities on formed surfaces shall be 1.5 m in length, the permissible gradual irregularities being measured over this length of the template.

Finish F3 shall describe formed surfaces.

Finish U3 shall describe unformed surfaces.

Class F3 Finish

Class F3 finish shall be formed by specially designed close jointed rigid forms having lining of high quality form plywood. The surface irregularities shall be limited to nil for abrupt irregularities and 3 mm for gradual irregularities. Class F3 finish may be obtained from class F2 finish by carefully removing all abrupt irregularities including fins and projections by rubbing/grinding. If steel forms are used they shall have steel sheet backing faced with plywood.

In addition, finish F3 shall include filling air holes with mortar and treatment of the entire surface with sack rubbed finish. It shall also include clean-up of loose and adhering debris. For a sack rubbed finish, the surface shall be prepared within two days after of removal of the forms. The surface shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one part cement to one and one half parts by volume of fine (I.S. No. 16 mesh) sand. Only sufficient mixing water to give the mortar a workable consistency shall be used. The mortar shall then be rubbed over the surface with a fine burlap or linen cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with clean burlap such that all air holes etc. are filled and the entire surface presents a uniform appearance without air holes, irregularities etc.

List of Approved Shuttering Fabricator

i. Pranav Construction Systems Pvt.Ltd., Mumbai.
ii. Maruti Steel Fab, Pune.
iii. Bharat Engineering Works, Varanasi.

Fabricator will be approved by ENGINEER and RBDCK/KIIFB

Class U1 Finish

This is the screeded finish used on surfaces over which other finishes such as wearing coats etc. are to be placed. It is also the first step in the formation of U2 and U3 finishes. The finishing operation consists of

levelling and screeding the concrete to produce an even and uniform surface so that the gradual irregularities are not greater than 5 mm. Surplus concrete should be removed immediately after consolidation by striking it off with a sawing motion of a straight edge or template across a wooden or metal strip that has been set as guide. Unless the drawings specify a horizontal surface or show the slope required, the tops of narrow surfaces, such as stair treads, walls, curbs and parapets shall be sloped approximately 10 mm per 300 mm width. Surfaces to be covered with concrete topping, terrazzo, and similar surfaces shall be smooth screeded and levelled to produce even surfaces, irregularities not exceeding 5mm.

Class U2 Finish This is a floated finish used on all outdoor unformed surfaces not prominently exposed to view such as tops of piers etc. The floating may be done by hand or power driven equipment. It should not however be started until some stiffening has taken place in the surface concrete and the moisture film or 'shine' has disappeared. The floating should work the concrete no more than is necessary to produce a surface that is free from screed marks. All joints and edges should be finished with edging tools. It shall include the repair of gradual irregularities exceeding 5 mm. All abrupt irregularities shall also be repaired unless a roughened texture is specified.

Class U3 Finish This is a trovelled finish used on all surfaces exposed to view at close quarters such as tops of parapets and kerbs etc. Steel trovelling should not be started until after the moisture film and 'shine' have completely disappeared from the floated surface and the concrete has hardened enough to prevent an excess of fine material and water from being worked to the surface. Excessive trovelling, especially if started too soon, tends to produce crazing and lack of durability. Too long a delay will result in a surface too hard for proper finishing. Steel trovelling should be performed with a firm pressure that will flatten and smooth the sandy surface left by floating. Trovelling should produce a dense, uniform surface free of blemishes, ripples and trovel marks. It shall include the repair of all abrupt irregularities and the repair of gradual irregularities exceeding 5 mm. It shall also include finishing the joints and the edges of concrete with edging tools.

CLAUSE 1509 RE-USE OF FORMWORK

(Substitution) This Clause shall read as under:

"After forms are stripped, all materials shall be examined for any damage and damaged pieces, if any, shall be removed either as rejected or for rectification if possible. The materials found fit to be

reused shall be thoroughly cleaned. Holes bored through sheathing for form ties shall be plugged by driving in common corks or foamed plastics. Patching plaster may also be used to fill small holes. After cleaning and before re-fixing, each formwork shall be got approved from the Engineer.

Form work and staging shall be so used as to ensure quality of the exposed surface. If in the opinion of the Engineer, any particular panel/member has become unsatisfactory for use at any stage, the same will be rejected and removed from site."

CLAUSE 1510 The formwork for piers shall be provided such that concreting of piers above adjoining road level upto pier cap shall be done for full height in one pour. Form Work shall be properly designed considering concrete as liquid of density 2.5 t/m3. The formwork shall be such that it either requires no supports or supports do not protrude outside permissible working area and provided within the carriageway.

Pier shuttering shall be such that it is possible to erect it in maximum two pieces with the help of crane in very short time.

CLAUSE 1600 **STEEL REINFORCEMENT (UNTENSIONED)**

Only TMT FE500 Steel shall be used and diameter of reinforcement for all types of permanent structure should not be less than 10 mm. Also TMT steel of any brand from TISCO/ TATA, SAIL & VIZAG steel will be acceptable. Cutting, bending of all reinforcement shall be with bar bending/cutting machine only.

Binding wire shall be galvanized M. S. wire of minimum 8 gauge.

SECTION 1700 STRUCTURAL CONCRETE

The work shall consist of form work and placing of concrete. All concrete shall be ready mixed concrete/ concrete produced from mini mobile batching plant. All concrete shall satisfy the permeability criteria. Chlorides &sulphates contents shall be within limits.

CLAUSE 1702 MATERIALS

No creek sand shall be allowed in concreting. Only crushed sand and or river sand from approved source shall be allowed. The suspicious aggregates shall be dealt in accordance with IS 2386 (Part VII) for alkali aggregate reactivity.

CLAUSE 1704 PROPORTIONING OF CONCRETE

(Addition) Add the following at the end of this clause:

"In proportioning concrete, the quantity of both cement and aggregate shall be determined by weight. Where the weight of cement is determined by accepting the manufacturer's weight per bag, a reasonable number of bags shall be weighed separately to check the net weight. Where cement is weighed form bulk stock at site and not by bag, it shall be weighed separately from the aggregates. Water shall either be measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean and serviceable condition. Their accuracy shall be periodically checked.

It is most important to keep the specified water-cement ratio constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined as frequently as possible; frequency for a given job being determined by the Engineer according to the weather conditions. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. The determination of moisture content in the aggregates shall be done as per IS: 2386 (Part III). Suitable adjustments shall also be made in the weight of aggregates to allow for the variation in weight of aggregates due to variation in their moisture content."

CLAUSE 1705 ADMIXTURES

(Substitution) Calcium Chloride shall not be used. Workability aids, retarding agents may be used if permitted by the Engineer.

This Clause shall read as under:

"Duly tested admixtures/additives conforming to IS: 6925 and IS: 9103 (without replacement of cement) may be used subject to satisfactory proven use, with the approval of the Engineer. Admixtures generating Hydrogen or Nitrogen and containing chlorides, nitrates, sulphides, sulphates and any other material liable to affect the steel or concrete shall not be permitted.

The general requirements, physical and chemical requirements shall be as per Clause 1012.

CLAUSE 1707 EQUIPMENT

The Equipment for production, Transportation and compaction of concrete shall be as under:

a) For Production of concrete
   For all concrete work - batching and mixing Plant fully automatic with electronic controls and approved by the Engineer.
b) For concrete Transportation - Transit truck mixer, concrete

distributor booms, cranes.

SECTION 1800 PRESTRESSING

The work shall be carried as per the provisions made in relevant clauses of MORTH and IRC: 18-2000.

CLAUSE 2600 EXPANSION JOINTS

The Expansion Joints shall be strip seal /modular strip seal as per requirement and shall conform to latest MORTH specifications and shall be procured only from manufacturers approved by Engineer. Anchorage to the Expansion Joint rail shall be provided by using plates and loops. STUD Anchors shall not be accepted.

PART-C:

General Technical Specifications

The General Technical Specifications shall be the “SPECIFICATIONS FOR ROAD AND BRIDGE WORKS” (fifth Revision, April 2013) issued by the Ministry of Road Transport and Highways (formerly the Ministry of Surface Transport) Government of India, and published by the Indian Roads Congress.

Where reference is made in the Contract to specific standards codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards as on date of tender and codes in effect shall apply, unless otherwise expressly stated in the contract. Where such standards and codes are national, or relate to a particular country or region, other internationally recognized standards which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Engineer’s prior review and written approval. Difference between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer’s approval. In the event the engineer determines that such proposed deviations do not ensure substantially equal performance, the Contractor shall comply with the standards specified in the documents.

ANNEXURE - I

18 SPECIFICATIONS & STANDARDS FOR CONSTRUCTION

18.1 Specifications & Standards

All materials, works and construction operations shall conform to the Guidelines for Planning and Design for Roads & Highway Projects Funded By KIIFB, referred to as the Manual, and MORTH Specifications for Road & Bridge works. Where the specification for a work is not given, good industry practise shall be adopted to the satisfaction of the Authority's Engineer.

18.2 Deviation from the specifications and standards:

a) The terms "Concessionaire", "Independent Engineer" and "Concession Agreement" used in the manual shall be deemed to be substituted by the terms "Contractor", "Engineer" and "Agreement" respectively.
b) Notwithstanding anything to the contrary contained in paragraph 1 above, the following specifications and standards shall apply to the project highway and for purpose of his agreement the aforesaid specifications and standards shall be deemed to be amended to the next set forth below:

Note1: Deviation from the aforesaid Specifications and standards shall be listed out here. Such deviations shall be specified only if they are considered essential in view of project specific requirements

19 ADDITIONAL INFORMATION

19.1 Additional design data is as under

a) Seismic importance factor is 1.5
b) Design speed = 80 kmph.
c) SBC of highly weathered rock shall be 100t/m^2
d) Design mean velocity for water current is 3m/s.

19.2 Founding levels are as under: As shown in Tender drawings and defined in scope of work

The founding levels given are only for the purpose of receiving offers at par. Contractor will have to take confirmatory bores at each locations of pier/abutment. Design shall be based on these findings. Final founding levels shall be decided at site and +/- variation in foundations shall be paid on the basis of rates quoted for extra / rebate as per Volume III.

19.3 Liner levels are as under

Minimum 8 mm thick M.S. liners shall be provided for all piles below pile cap and up to scour level.

PART D

20 DESIGN CRITERIA FOR TENDERER'S DESIGN

20.1 DESCRIPTION OF WORK AND OBLIGATORY PROVISIONS FOR ALTERNATIVE PROPOSALS

20.1.1 Alignment and location

Alignment and location of the "**CABLE STAYED BRIDGE ACROSS PONNANI ESTUARY WITH APPROACHES IN COASTAL HIGHWAY IN MALAPPURAM DISTRICT OF KERALA, UNDER EPC MODE**" shall be as shown in the Authority tender drawings.

20.1.2 The Type and Geometry of Bridge across River Bharathappuzha

a) The Main Bridge shall be of Cable Stayed Bridge and the span configuration and Geometry shall be as specified in the Authority Drawings outer shape of deck and pylon shall be as per authority drawings.
b) The total length of the Bridge between inner faces of dirt walls shall not be less than that provided in the relevant Authority drawings.
c) The minimum vertical and horizontal clearances shall be as shown in the relevant authority drawing.
d) The Tourism facilities proposed on the deck and below deck shall be followed as shown in Authority Drawings.

20.1.3 Road Level on the Proper Bridge & Roadway Particulars

a) The RTL's of the bridge at abutments must be same as shown in the Authority drawings.
b) Roadway particulars and carriageway widths shall be as per authority drawing attached to the bid document.
c) The vertical geometry of the finished surface of deck slab and wearing course shall be in the form of a smooth curve. The design of curves shall be got approved from the Engineer. The design speed on curve shall be as stipulated in Annexure - 1. Super-elevation, camber & widening on curves shall be suitably provided.
d) The geometric feature of the bridge has been indicated in the Tender drawings. While the geometric details are obligatory, the successful tenderer shall furnish geometric design for the bridges as per relevant IRC provisions especially IRC: 92 "Guide lines for the design of inter changes in urban areas".

20.1.4 Supplementary data for design shall be as per Annexure-I.

20.2 GENERAL REQUIREMENTS

In order that the Tenderer's design shall generally satisfy the following requirements: -

a) It shall ensure soundness of the structure, its durability and architectural beauty as a whole in harmony with the surroundings.
b) It shall ensure speedy construction and lead to appreciable economy.
c) It shall be accompanied by preliminary but fairly detailed drawings and detailed description of work and specification of materials and items. If called upon, Tenderer shall furnish any additional information necessary for appreciation and comparison with other alternative proposals received from other tenderers.
d) At the time of detailed design the contractor shall not deviate from the basic scheme proposed by him for the purpose of tender.
e) Bidders may carry out the Geotechnical investigation at their own cost.

20.3 RESTRICTIONS ON TYPE OF STRUCTURES

The following types of structural arrangements shall not be permitted:

a) Abutments resting on approach embankments.
b) A design in which stability of one or more span is endangered due to failure of some other span or spans.
c) Superstructure with joints at the tip of long cantilevers with hinges, gap slab, short suspended spans, hammerhead structures to reduce the spans, etc.
d) Structures with steel composite super structure.
e) (a) Piers in the form of multiple columns with isolated/separate footings resting on yielding type strata.
(b) Piers in the form of multiple columns not connected with continuous diaphragms.
f) Two girder slab system for superstructure.
g) Hollow/ cellular pier/foundation.
h) Any structural system with shape / profile / arrangement different from that shown in the tender drawings unless specific alternative have been expressively accepted.
i) Minimum C/C between expansion joint shall be 120m.

20.4 SPECIFICATIONS FOR DESIGN AND CODES TO BE FOLLOWED

a) The design of structural components shall conform to the criteria laid down in the latest editions including amendments/ corrigendum etc. of the following codes of Practice and Standard specifications published up to one month prior to date of submission of the tender and subject to the departures stipulated in these tender documents.
i. (A) Latest version of I.R.C. Standard Specifications and Codes of Practice for Road Bridges.
ii. (B) For any item not covered by A above, specification for Road and Bridge works published by I.R.C. for Ministry of Road Transport & Highways, Government of India
iii. (C) For items not covered by any of the A&B above, relevant provisions of IS codes of practice.
iv. (D) For any item not covered by A, B &C above, the relevant provisions from BS and AASHTO Codes of Practice.

v. (E) For items not covered by any of the above Standards and Specifications sound Engineering practice and provisions in the Authority design and provisions of relevant Codes of other nation shall be referred. In this regard decision of the Engineer shall be final and binding.

20.5 DESIGN LOADS

The design loads shall generally be as per provisions of latest IRC: 6, except specified below.

20.5.1 **Loads**

a) Loads from service facilities

Electrical cables	1 kN/R.M./per cable duct on either side
Telephone cables	1 kN/R.M./per cable duct on either side
Public amenities	Permanent loads as per actual
	Transient loads 5 kN/m^2

20.5.2 **Wind Forces**

Wind forces shall be considered in the following two ways. The design shall be governed by the one producing the worst effect.

a) Full wind force at right angles to the superstructure.
b) 65 % of wind force as calculated in (a) above acting perpendicular to the superstructure and 35 % acting in traffic direction.

20.5.3 **Temperature-Range**

a) For design of structure to account for temperature shall be as per clause 215.3 of IRC 6-2017
b) The superstructure shall also be designed for temperature differential across the deck depth as per IRC: 6. for calculation of thermal forces effect of 'E' value of concrete should be taken as 50 % of the instantaneous value so as to account for effects of creep on thermal strains.
c) One span dislodged condition in approach viaduct shall also be checked. For this condition live load of one lane of Class ‘A’ per 2 Lanes with impact shall be adopted on span in position. When coupled with wind/seismic force the same shall be checked as per load combination nos. VIII and IX of table 1 of IRC: 6.

20.6 DURABILITY AND QUALITY ASSURANCE

a) Various design and construction specifications shall be adopted so as to provide a safe, durable and yet an economical structure. The durability and longevity of the structure requires consideration of various factors not only at the design stage but also during

construction. Some of the aspects which shall be considered during design and construction shall be:

i. Increased cover to all reinforcement/HTS Cables
ii. Use of high grade concrete – Minimum grade of concrete in bridge shall be M40 for foundation and substructure and M50 for superstructure.
iii. Use of admixtures to reduce w/c ratio and to improve workability to result in dense concrete.
iv. Protection of HTS cables during storage.
v. Grouting the ducts with minimum w/c ratio using suitable admixture and with controlled temperature of the grout as per IRC: 112.
vi. Grouting the ducts within 72 hours of stressing.
vii. Use of potable water for concreting and curing.
viii. Detailing of reinforcement to ensure proper compaction.
ix. Provision for inspection and replacement of bearings.
x. Mandatory use of steel cutting / bending machine.
xi. Minimum Clear cover to outermost reinforcement shall be as follows
Foundation and all components below
- HTL + 1.5 m Height - 75mm.
- All other components - 50mm.
- HTS duct - 75mm. Or Outer dia. of duct whichever is more.

b) High strength ordinary Portland cement of Grade 43 conforming to I.S. 12269 will also be permitted.
c) The minimum nominal diameter of reinforcement shall be 10 mm.
d) Low relaxation high tensile steel strands conforming to IS: 14268 shall only be used.
e) A high standard of quality assurance shall be maintained for various items of work. Various measures shall be adopted to ensure good quality of workmanship and maintain quality to the required standard throughout the construction period. For this purpose, one site laboratory equipped with all material testing equipment shall be established at site so that the quality of various construction materials is checked and tested at site and / or in a recognised laboratory to conform to relevant standards. The concrete mix design shall be carried out at site. The materials used in concreting including water shall be tested before each major concreting operation.
f) Regular concrete cubes for strength and cubes or cylinders for impermeability tests shall be cast and tested. Relevant provisions of various standards/sound engineering practices shall be followed for storage of materials, cutting, bending of reinforcement bars, stressing and grouting of cables, mixing/ transporting/placing and compaction of concrete.

20.7 SOIL PROFILE

a) For details refer GAD of existing bridges attached with tenders. It should be expressively understood that these drawings are purely for guidance and are made available on “No commitment” basis.

b) The contractor shall have to take bores by hydraulically operated double tube boring machine at the final location of each pier and abutment for appropriate depth prior to the commencement of the work to ascertain the rock quality/levels at the location of the foundations and this shall form part of the contract and no payments will be made by the authority for boring, soil sampling and testing etc.

i. During execution of the work, the samples from the bore taken at each foundation shall be tested and analysed in the laboratory approved by the authority for establishing design parameters. Tests such as standard penetration test, compression and shear test on undisturbed soil samples, etc., shall be carried out in conformity with the specifications. The Contractor shall submit the entire data to the Engineer along with his own/laboratory recommendations and obtain approval to the design-parameters. Necessary interpretation of the result of tests shall be furnished to the Engineer for scrutiny of design of foundations.

ii. The cost of these test and interpretation of the test results shall be included in the tendered amount. No payment will be made separately for the testing of soil or rock.

iii. While checking the stresses at the base of foundations it shall be ensured that under the worst combination of forces there is no tension except where founded on rock. The SBC at the foundation level shall be verified during construction so as to ensure that the stresses imposed on the foundation strata are within permissible limit. The Contractor shall carry out the said work for such boring, soil sampling and testing, etc. as per schedule of variation. The taking out of samples and carrying out required tests shall be in conformity with the departmental specifications. The Contractor shall then submit the entire data to the Department along with his own/laboratory recommendation and obtain approval to the design parameters. The payment for such boring shall be paid as per PWD GSR.

20.8 FOUNDATIONS

20.8.1 Piers/Abutments

a) For bidding and for the purpose of tender drawing, general foundation levels for the piers & abutment are shown in the authority drawing. Where pier abutment positions differ from the authority drawing, the levels shall be interpolated for the purpose of this clause.

b) Founding levels are indicated in General Arrangement Drawing for guidelines & quoting tender at par.

20.8.2 Pile Foundations

a) The pile foundation shall be designed as per the latest edition of I.R.C 78. The following criteria shall be considered for deciding the length of embedment. The piling shall be done only by hydraulically operated rotary rig.

b) The piles shall be considered as fixed at the founding level with the specified minimum embedment.

c) The design capacity assumed for the piles shall be verified by the initial load testing of test piles in non-working areas, in the vicinity of the bridge site. These piles shall

be tested for 2.5 times the design load and number of such tests shall be one per diameter. Additional one pile per dia., which is actually going to be used for piers and abutments shall be tested for 1.5 times the design load. These tests and the routine tests shall be as per I.R.C 78(Latest edition). Dynamic Load Test for routine test on piles shall be accepted provided correlation with static load test is carried out on initial pile load test.

d) The minimum dia. of piles shall be 1200mm for viaduct piers and 1500mm for pylon and capacity of pile shall be calculated as per provision of IRC:78
e) Annular piles filled or unfilled shall not be accepted.
f) Design with single row of piles shall not be accepted.
g) Minimum 8 mm thick permanent M.S. Liner for piles painted with 3 coats of coal tar epoxy shall be provided for all piles up to refusal.
h) Use of High performance concrete for piles is not permitted.
i) The cost of all above tests shall be borne by the contractor and no extra payment will be made to the contractor.
j) Only bored cast in situ piles bored with hydraulically operated rotary drilling rigs be accepted.

20.9 SUBSTRUCTURE

a) For continuous spans, pier with fixed bearing shall be designed to take all the horizontal forces.

20.9.1 Minimum dimensions

a) Dimension of any element of substructure shall not be less than 300 mm.
b) Dead man anchors or friction slabs shall not be accepted behind abutment for relieving moments.
c) Arrangement for lifting of the superstructure for future replacement of bearings shall be provided in the design of substructure. The positions of jacks shall be distinctly marked on the drawing.

d) The height of pedestals below bearings shall not be more than 300 mm i.e. this height is excluding height /depth of bearings. Shape of pedestals, shall match with that of pier.
e) Slender piers shall be checked for deflection under horizontal and eccentric forces and pier, bearings and expansion joints shall be suitably designed to cater for the same.

20.9.2 Barge Impact

The foundations for all piers in navigational channel shall be designed to cater to barge impact moving in the river for the following conditions

a) A 4000 tonne barge cruising at the speed of 6 knots / hour.
b) Head on collision with the foundation / substructure.

The fenders shall be suitably designed to absorb the impact force due to barge collisions.

The design impact force shall be at least 250 tonnes acting at 1.0 m above H.F.L. / H.T.L. in spite of fenders being provided and bridge structures (foundation / piers, etc.) shall be designed for at least this minimum force.

20.9.3 **Velocity of River water: 3.0m/sec**

20.10 SUPERSTRUCTURE

20.10.1 **General**

a) Deck slab thickness excluding the flange thickness of girders shall not be less than 240 mm and not less than 200 mm at tip of cantilever. Stage construction of deck slab is not allowed.
b) In case of pre-tensioned girders with no cables in webs, the thickness of web shall not be less than 150 mm.
c) Superstructure shall be designed for 20mm differential lifting at bearing Location. This shall be considered as an erection condition.

20.10.2 **Box girders**

a) The Box girder in Cable Stayed Portion shall be as per Authority drawings.
b) In the viaduct Box girder may be adopted wherein Overhangs shall not be more than 2.00m. Span to depth ratio shall not be less than 15. Soffit of Box Girder shall be flat. Vertical curves shall be effected in deck only by adjusting height of webs or thickness of deck slab.
c) Minimum thickness of end diaphragms shall be 500 mm and other diaphragms shall not be less than 300 mm thick. Suitable openings shall be left in diaphragms for access to inside of Box Girder.

20.10.3 **Steel and Composite Bridges**

Steel & composite superstructure shall not be permitted.

20.11 SEGMENTAL CONSTRUCTION

In situ segmental construction shall not be permitted.

20.12 BEARINGS BELOW SUPERSTRUCTURE

a) Only POT/POT-PTFE type of bearings shall be permitted. Suitably designed bearings for uplift, if any, shall be provided.
b) The bearings shall be easily accessible for inspection.
c) Scope for lifting the superstructure for future replacement of bearings shall be provided for in the design of bearing. The scheme of lifting shall be indicated on the drawing to be submitted at the time of tendering.

d) The contact surface of superstructure shall project beyond the edge of the bearing plate by a minimum distance of 150 mm at any location.
e) APPROVED LIST OF MANUFACTURER'S/SUPPLIER'S
    i. Sanfield India Ltd.
    ii. Dynamics Prestress India Pvt. Ltd.
    iii. J. sons and co.
    iv. Tefcon Bearing Pvt. Ltd.

20.13 EXPANSION JOINTS

a) Only strip seal/modular strip joints shall be permitted.
b) Expansion joints shall conform to MORTH specifications.

20.14 RAILINGS AND KERB

a) Crash barrier and median kerb having a typical cross section as shown in Tender drawing shall be provided. Only stainless steel railing shall be provided.

20.15 WATER SPOUTS

Waterspouts as per MORTH Type design No.SD/303 shall be provided. However, the diameter of G. I. pipe shall be 150 mm. These shall be spaced at not more than 5.0 m c/c on either side.

20.16 WEARING COAT

The wearing course on the bridge shall be bituminous concrete of 25mm thick followed by dense bituminous macadam of 40mm thick Waterproofing membrane shall be provided on top of RCC deck. The waterproofing shall be a polymer waterproofing membrane and shall be fast cure acrylic based system for concrete bridge decks. The waterproofing system shall be spray applied and shall include a primer, waterproof membrane, bituminous based hot melt adhesive bond coat and a 2mm aggregate over scatter unless otherwise approved by the Engineer. The waterproofing membrane shall be not less than 3mm thick.

20.17 SPECIFICATIONS FOR SHEATHING DUCT JOINTS

The specifications for sheathing duct shall be as per MORTH specification. HDPE sheathing ducts only shall be used. Metallised sheathing shall not be permitted.

20.18 LOAD TEST

a) In case a structure or a component of structures proposed by the contractor, in the opinion of the Engineer is of unusual nature, then the Engineer shall have the right to call upon the contractor to carryout model testing and / or load testing of the structure or component to prove its suitability. The cost of such test shall be borne equally by the

contractor and the department if the test results are satisfactory. In case the test results are not satisfactory, the total cost of testing shall be entirely borne by the contractor.

b) If required by the Department the Contractor shall have to carry out a load test on any one unit of the superstructure for the design static loads or their equivalent and in a manner as may be decided by the Engineer.

c) If the load test is to be made for any one or more reasons mentioned in above clauses, the cost of the same shall be reimbursable to the contractor at the rate tendered by him, provided the test results thereof are found to be satisfactory.
   i. It shall ensure soundness of the structure, its durability and architectural beauty as a whole in harmony with the surroundings.
   ii. It shall ensure speedy construction and lead to appreciable economy.
   iii. It shall be accompanied by preliminary but fairly detailed drawings and detailed description of work and specification of materials and items. If called upon,
   iv. Tenderer shall furnish any additional information necessary for appreciation and comparison with other alternative proposals received from other tenderers.
   v. At the time of detailed design the contractor shall not deviate from the basic scheme proposed by him for the purpose of tender.

d) In the event of load testing being ordered the contractor shall
   i. Prepare well in time all necessary calculations and details of arrangements for such load testing, e.g. the magnitude of the test load, mode and method of caring out the test, the application of loads, duration of keeping the load, the equipment's to be provided and observations to be made during and after placing the loads in position etc.
   ii. Make all necessary arrangements for observations, centering, equipment's etc., that may be needed for measuring the settlement, deflections etc., required for the test, to the entire satisfaction of the Engineer-in-charge and
   iii. Provide labour and make all observations during the test

e) After the test, the contractor shall submit a report on the results of the tests. The Engineer shall then communicate as to whether the test has been satisfactory or not. Any further tests or reconstruction or strengthening as may be necessary shall be decided.

f) When the tests are declared by the Engineer as having been completed, the contractor shall remove all loading which might still be on the bridge as well as in the surroundings.

g) Only design load is to be super imposed for prestressed concrete superstructure.

20.19 INSPECTION PLATFORM

Inspection platform in R.C.C shall be provided for inspection & maintenance of bearings at each pier cap. Ladder shall be from superstructure to inspection platform at each location. Width of inspection platform shall be 1.0 m. clear with G.I. Pipe railing of 0.9m height.

Provision of access to top of pylon and to reach cable anchored in pylon shall be made.

20.20 DOCUMENTATION, INSTRUMENTATION

The following items shall be deemed to be included in the Bid submission.

a) All final drawings and Microfilms and Compact Discs of all approved drawings and "as built" drawings and calculations shall be supplied by the Contractor free of cost.
b) Three Compact Disks each of the bridge covering the different phases of construction from start to finish shall be supplied by the Contractor free of cost.
c) A "Maintenance Manual" describing access arrangements, important obligatory precautions from the point of view of structural safety, and procedure for minor and major repairs of each component of the bridge, renewals of finishes and treatments periodically shall be supplied by the Contractor free of cost.
d) A "Quality Assurance Manual" covering designs and drawings, mix-designs, materials, testing, soil and rock properties, statistical quality control, etc. shall be prepared by the Contractor free of cost well before starting the work.
e) A "Construction manual" covering various aspects of construction methods, difficulties faced and how they were overcome during execution etc. shall be supplied by the contractor free of cost at the time of finalization of work.
f) Fixing arrangement for internal and external lighting shall be got approved from competent authority and executed.
g) Health monitoring system for the Cable Stayed Bridge with proper embedment of systems inside the concrete based on the requirement
h) CCTV Camera and monitoring system on the Main Bridge level and the tourism facilities proposed like Cafeteria, Walkway etc.

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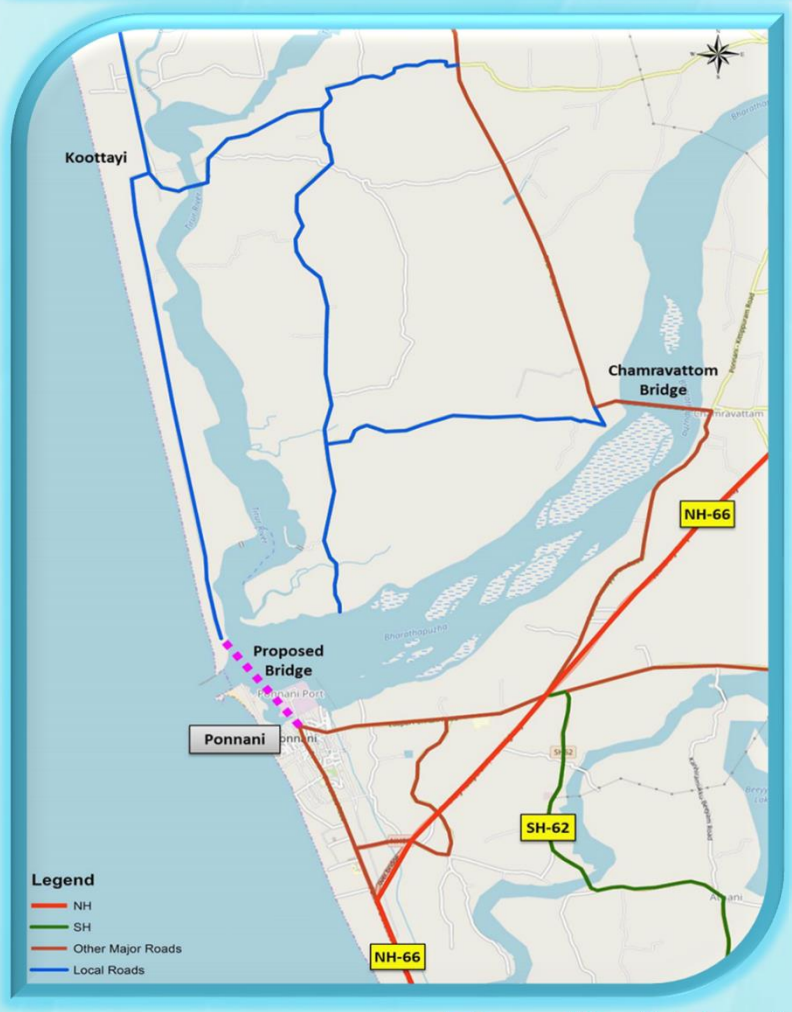
Roads and Bridges Development Corporation of Kerala Limited (RBDCK)

Kerala Infrastructure Investment Fund Board (KIIFB)

Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with Approaches



Detailed Project Report

Volume VI/ VII/VIII : Rate Analysis, Cost Estimate & Bill of Quantities

March 2020

L&T Infra Engineering

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L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

Client: **National Highways Authority of India**

Project:	Feasibility Study and Preparation of DPR for the Construction of Cable Stayed/Suspension Bridge across Ponnani Estuary with approaches	**Project No.:** C1193601
Title:	Detailed Project Report – Volume VI, VII & VIII: Rate Analysis, Cost Estimates & Bill of Quantities	**Document No.:** RP010 / **Rev.:** 0

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Notes:

1.

Revision Details:

Rev.	Date	Details	Prepared Init.	Prepared Sign.	Checked Init.	Checked Sign.	Approved Init.	Approved Sign.
0	12/03/2020	First Submission	VVD		PML		KGN	

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ANNEXURE-2: COST ESTIMATES-AS PER PRICE

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1 Introduction

1.1 Project Background

Roads and Bridges Development Corporation of Kerala Limited (RBDCK) (the "Client/Authority") has been entrusted with the assignment of ***'Design and Construction of a Suspended / Cable Stayed Bridge across Ponnani Estuary in Malappuram District, Kerala'***. In this context, the Client has appointed **L&T Infrastructure Engineering (L&TIEL) (the "Consultant")** for carrying out Feasibility Study, to establish the technical, economic and financial viability of the aforesaid project and to prepare Detailed Project Report.

1.2 The Project Road

The project road starts from Chainage Km 0+000 Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) and ends at Padinjarekara beach. The project alignment crosses Malappuram, Ponnani Harbour, Ponnani Beach Road Ponnani Estuary (mouth of Bharathupuzha River) and Padinjarekara dock. The project corridor alignment is given in **Figure 1-1.**

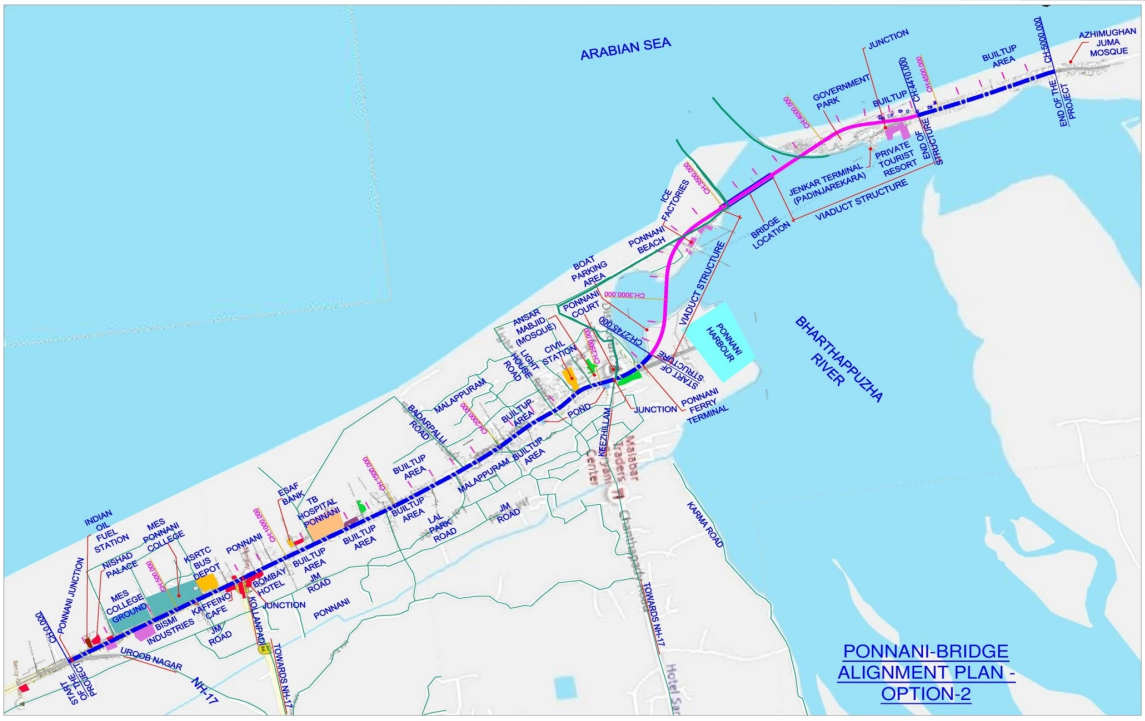

Figure 1-1: The Project Road

2 Rate Analysis

Rate Analysis is a vital input for assessing financial and economic viability of the project. Rate Analysis has been done for two-lane corridor from Ponnani Junction (between Palakkad-Ponnani Road and Panvel-Kochi-Kanyakumari Highway of NH-66) to Padinjarekara beach. This chapter present Rate Analysis of each item for the project. Each component is discussed in the following sections.

Unit rates are applied to the quantities to get the direct cost of construction. Unit rates are arrived after carrying out the rate analysis based on "Standard data book for analysis of rates" published by MoRTH and PRICE software. The various components such as material cost at source, lead charges, labour cost and machinery hire charges are considered for the rate analysis.

The rates and inputs for analysis of unit rates have also been based on “MORTH *Schedule of Rates 2016”* in PRICE software. Appropriate Cost index is applied based on site location.

The detailed Rate analysis from PRICE Software is attached as Annexure-1 to this Volume.

3 Cost Estimates

Cost estimation is a vital input for assessing financial and economic viability of the project. This section presents cost estimation for the development of the project. Total capital cost of the project includes construction of road and structures, Utility relocation and Environmental & Social Costs. Each of these components is discussed in the following sections.

3.1 Methodology

- Quantities of various components are worked out based on preliminary design & engineering.
- To arrive at construction cost, rate analysis was done as per PRICE software which includes cost of an item based on man, material and machinery required for the same item.

3.2 Total Capital Cost of the Project

Detailed Bills of Quantities were prepared based on the preliminary design of all project components and costs worked out using the rates derived. The detailed cost estimate is attached as **Annexure 2** to this volume.

A summary of costs under various heads for the project stretch from Chainage Km 0+000 to Chainage Km 4+800 is presented in **Table 3-1.**

Table 3-1 Total Capital Cost of the Project

S. No.	Bill of Items	Total Amount (In Crore Rupees)
A	**Total Civil Work Cost (Rs. In Cr) as per PRICE (including GST)**	**265.577**
i	Add physical contingency @ 2.8% of total civil work cost	7.436
B	**Total including Physical Contingency of 2.8% (Rs. In Cr) B = A + i**	**273.013**
ii	Add Agency Charges 3% on A	7.967
iii	Add Quality Control 0.25% on A	0.664
iv	Add Road Safety 0.25% on A	0.019
v	5% Maintenance of A	13.279
C	**CENTAGE'S C = ii+iii+iv+v**	**21.929**
D	**Total project cost (Including Cengage's) D = B + C**	**294.942**
vi	Cost of Utility shifting (Rs. In Cr) *	0.500

S. No.	Bill of Items	Total Amount (In Crore Rupees)
vii	Cost of Rehabilitation and Resettlement R&R (Rs. In Cr)*	4.000
viii	Cost of Land Acquisition LA (Rs. In Cr)*	10.000
E	**Total Capital Cost for the Project (Rs. In Cr), E = D + vi+vii+viii**	**309.442**

4 Bill of Quantities

Bill of Quantities has been prepared for the project area. This section presents Bill of quantities for the project. The following Bill of quantities has been prepared.

Road Works

- Site clearance
- Pavement
- Drain
- Intersections
- Road furniture

Structural Works

- Superstructure
- Substructure
- Foundation
- Dismantling of existing structure wherever required.

The bill of quantities/ quantity survey has been prepared in the PRICE software and the same is presented in **Annexure-3** of this Volume.

ANNEXURE-1
(RATE ANALYSIS-AS PER PRICE)

DATA ANALYSIS

PART-A: INVESTIGATIONS AND TESTS

1. Specification Code : 56.2.a

SUBHEAD : 56.0

Investigation Rate

56.2.a Setting up boring at each bore hole locations including carrying all necessary plant, equipment and materials of boring and field tests and collection of samples at each bore hole location.
For machine boring.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		3000.00	
					TOTAL	3000.00	
					Cost of 1.0 Nos hole	3000.00	

Public Works Department
PRICE

2. Specification Code : 56.3.d.1

SUBHEAD : 56.0

Investigation Rate

56.3.d.1 Boring with rotary power drilling equipment inall types of soil having N value less than 50 excluding hard rock soft rock, or medium rock for strata above 30m depth including conducting necessary S.P.T and recovery of undisturbed soil samples at 5m.intervals.
For ordinary soil.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		1100.00	
					TOTAL	1100.00	
					Cost of 1.0 metre	1100.00	

3. Specification Code : 56.1.a

SUBHEAD : 56.0

Investigation Rate

56.1.a Mobilization including transportation of all necessary plan and equipment's and materials of boring field testing and sampling and demobilization after completing the work
For machine boring

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		15798.00	
					TOTAL	15798.00	
					Cost of 1.0 set	15798.00	

4. Specification Code : 56.3.d.2

Public Works Department
PRICE

SUBHEAD : 56.0

Investigation Rate

56.3.d.2 Boring with rotary power drilling equipment inall types of soil having N value less than 50 excluding hard rock soft rock, or medium rock for strata above 30m depth including conducting necessary S.P.T and recovery of undisturbed soil samples at 5m.intervals.
For under water.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		1500.00	
					TOTAL	1500.00	
					Cost of 1.0 metre	1500.00	

5. Specification Code : 56.8

SUBHEAD : 56.0

Investigation Rate

56.8 Recovering disturbed samples and preserving the same in air tight sample containers including waxing labelling packing storing including cost of containers as per IS Code.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		63.00	
					TOTAL	63.00	
					Cost of 1.0 each	63.00	

6. Specification Code : 56.9.1

Public Works Department
PRICE

SUBHEAD : 56.0

Investigation Rate

56.9.1 Erecting platform over 2 nos of 2nd Class Boat USING Mango wood planks of of not less than 30 mm thick, Mango wood joists of 100mm x 70mm at 60cm intervals including labour and hire of all materials and dismantling the platform after completion of work etc complete excluding hire of boats (A Platform of Minimum size 6.00m x 5.00m will be required)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		494.80	
					TOTAL	494.80	
					Cost of 1.0 sqm	494.80	

7. Specification Code : 56.10

SUBHEAD : 56.0

Investigation Rate

56.10 Hire charges for providing 2 nos of 2nd Class boat with boatman for erecting the platform over which the boring plant is to be erected, and 1 no of 2nd Class boat with 1 boatman for conveying the departmental staff and labour engaged from the banks to platform and back etc.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	0						
0000				0.0		2087.00	
					TOTAL	2087.00	
					Cost of 1.0 Day	2087.00	

8. Specification Code : od35465/2019_2020

od35465/2019_2020 : Lateral load testing of single pile in accordance with IS Code of practice IS : 2911 (Part IV) for determining safe allowable lateral load on pile:Above 50 tonne and upto 100 tonne capacity pile.

Public Works Department
PRICE

Code	Description	Unit	Quantity	Rate	Amount
7253	Lateral load testing of single pile in accordance with IS : 2911 part - IV for detemining safe allowable lateral load on pile. Above 50 tonne capacity	per test	1.0	23600.0	23600.0
				TOTAL	23600.00
				cost for one per test	23600.0
				say	23600.0
				Add Overhead @ 25.0%	5900.00
				Add Contractors Profit @ 10.0%	2950.00
				SAY	32450.00
				Cost index **31.06 %**	10078.96
				Total with Cost index	42528.97
				Say	42528.97

9. Specification Code : od35466/2019_2020

od35466/2019_2020 : Vertical load testing of piles in accordance with IS 2911(Part IV) including installation of loading platform and preparation of pile head or construction of test cap and dismantling of test cap after test etc. complete as per specification & the direction of engineer -in-Charge.
Pile capacity = 350 tonne
Initial test

Code	Description	Unit	Quantity	Rate	Amount
MR	Rate as per item number 20.6.2.1 of SH: Pile Work	per test	16.5	46808.45	772339.43 ( )
MR	Rate as per item number 20.6.1.1 of SH: Pile Work	per test	-16.5	38561.8	-636269.7 ()
MR	Rate as per item number 20.6.1.1 of SH: Pile Work	per test	1.0	38561.8	38561.8 ()
				TOTAL	174631.53
				cost for one per test	174631.53
				say	174631.53
				Add Overhead @ 25.0%	43657.88
				Add Contractors Profit @ 10.0%	21828.94
				SAY	240118.35
				Cost index **31.06 %**	0.00
				Total with Cost index	240118.35
				Say	240118.35

Public Works Department
PRICE

10. Specification Code : od35467/2019_2020

od35467/2019_2020 : Vertical load testing of piles in accordance with IS 2911(Part IV) including installation of loading platform and preparation of pile head or construction of test cap and dismantling of test cap after test etc. complete as per specification & the direction of engineer -in-Charge.
Pile Capacity = 350 tonne
Routine test

Code	Description	Unit	Quantity	Rate	Amount
MR	Rate as per item number 20.6.2.2 of SH: Pile Work	per test	9.5	23000.0	218500.0 ()
MR	Rate as per item number 20.6.1.2 of SH: Pile Work	per test	-9.5	15000.0	-142500.0 ()
MR	Rate as per item number 20.6.1.2 of SH: Pile Work	per test	1.0	15000.0	15000.0 ()
				TOTAL	91000.00

cost for one per test	91000.0
say	91000.0

Add Overhead @ 25.0%	22750.00
Add Contractors Profit @ 10.0%	11375.00
SAY	125125.00
Cost index **31.06 %**	0.00
Total with Cost index	125125.00
Say	125125.00

PART-B: FOR FOUNDATIONS

1. Specification Code : 12.25.3

SUBHEAD : 12.0

Foundations

12.25.3 Bored cast-in-situ M35 grade R.C.C. Pile Using Batching Plant, Transit Mixer and Concrete Pump excluding Reinforcement complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m.
Pile diameter-1200 mm

Public Works Department
PRICE

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1100 & 1700	Unit = meter Taking output = 9 m a) Materials					
12.11.C.4.2		Rate as per item Number of SH: Foundations PCC Grade M35 b) Machinery(for boring and construction)	cum	10.17	4940.52	50245.09	
P&M-036		Pilling Rig with Bantonite Pump Hire and running charges of hydraulic piling rig with power unit and complete accessories including shifting from one bore location to another.	hour	6.0	5504.00	33024.00	MR235

P&M-013		Cranes (c) 3 tonnes for lowering reinforcement cage	hour	0.5	358.00	179.00	MR212
P&M-017		Front End loader 1 cum bucket capacity	hour	0.5	812.00	406.00	MR216
P&M-048		Tipper - 5 cum capacity for disposal of muck from pile bore hole	hour	0.5	312.00	156.00	MR247
M-071		Bentonite c) Labour	kg	385.0	3.10	1193.50	
L-12		Mate	Day	0.18	407.00	73.26	
L-13		Mazdoor	Day	4.5	368.00	1656.00	

TOTAL	86932.85
Cost of 9.0 metre	86932.85
Cost of 1 metre	9659.21

Add Overhead @ 25.0%	2414.80
Add Contractors Profit @ 10.0%	1207.40
Cost index **31.06%**	2369.35
Total with Cost index	15650.77
Say	15650.77

Public Works Department
PRICE

2. Specification Code : 12.38.D.2

SUBHEAD : 12.0

FOUNDATIONS

12.38.D.2 Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical Specification
R C C Grade M35 - Using Batching plant, Transit Mixer and Concrete pump

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = cum Taking output = 15 cum a) Material					

	1100,1500 &1700						
M-081		Cement	tonne	6.33	5792.24	36664.88	
M-004		Coarse sand at mixing Plant	cum	6.75	1303.77	8800.45	
M-053		Aggregates 20mm nominal size	cum	8.1	1403.77	11370.54	
M-051		10mm nominal size b) Labour	cum	5.4	1403.77	7580.36	
L-12		Mate	Day	0.16	407.00	65.12	
L-10		Mason (IInd class)	Day	0.38	448.00	170.24	
L-13		Mazdoor for connecting	Day	2.5	368.00	920.00	
L-13		Mazdoor for breaking pile head, bending bars, cleaning etc. c) Machinery	Day	1.0	368.00	368.00	
P&M-002		Batching and Mixing Plant	hour	0.75	2249.00	1686.75	MR201
P&M-018		Generator (a) 125 KVA	hour	0.75	702.00	526.50	MR217
P&M-017		Front End loader 1 cum bucket capacity	hour	0.75	812.00	609.00	MR216
P&M-049		Transit Mixer 4.0/4.5 cum	hour	2.0	938.00	1876.00	MR248
P&M-007		Concrete Pump of 45 & 30cum capacity	hour	0.75	258.00	193.50	MR206
		Formwork @ 4 per cent on cost of concrete			(B+C+D+E+F+G+H+I+J+K+L+M+N)*4/100	2833.25	

Cost of 15.0 cum	73664.55
Cost of 1 cum	4910.97

Public Works Department
PRICE

Add Overhead @ 25.0%	1227.74
Add Contractors Profit @ 10.0%	613.87
Cost index **31.06%**	1952.50
Total with Cost index	8705.09
Say	8705.09

3. Specification Code : 12.1.2.B

SUBHEAD : 12.0

Foundations

12.1.2.B Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material.
Ordinary Rock (not requiring blasting) - Depth up to 3 m - Mechanical Means

Public Works Department
PRICE

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	304	Mechanical Means Unit = cum Taking output= 180 cum a) Laour					
L-12		Mate	Day	0.24	407.00	97.68	
L-13		Mazdoor b) Machinery	Day	6.0	368.00	2208.00	
P&M-026		Hydraulic Excavator of 1 cum bucket	hour	6.0	1312.00	7872.00	MR225
					TOTAL	10177.68	
					Cost of 180.0 cum	10177.68	
					Cost of 1 cum	56.54	

Note In case of rock, foundation beyond 3 m is not dug and hence not included

Add Overhead @ 25.0%	14.13
Add Contractors Profit @ 10.0%	7.06

Cost index **31.06%**	5.47
Total with Cost index	83.21
Say	83.21

4. Specification Code : od35618/2019_2020

od35618/2019_2020 : Bored cast-in-situ M40 grade R.C.C. Pile Using Batching Plant, Transit Mixer and Concrete Pump excluding Reinforcement complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m.
Pile diameter-1800 mm

Code	Description	Unit	Quantity	Rate	Amount
14.1E.2	Rate as per item number 14.1E.2 of SH: Super-Structure	cum	22.9022	4803.14	110002.47 ( )
P&M-036	Pilling Rig with Bantonite Pump	hour	6.0	5504.0	33024.0 ()
P&M-013	Cranes (c) 3 tonnes	hour	0.5	358.0	179.0 ()
P&M-017	Front End loader 1 cum bucket capacity	hour	0.6	812.0	487.2 ()
P&M-048	Tipper - 5 cum	hour	0.6	312.0	187.2 ()
M-071	Bentonite	kg	450.0	3.1	1395.0 ()
L-12	Mate	Day	0.3	407.0	122.1 ()
L-13	Mazdoor	Day	6.0	368.0	2208.0 ()
				TOTAL	147604.97
				cost for 9.0 metre	147604.97
				cost for one metre	16400.55
				say	16400.55
				Add Overhead @ 25.0%	4100.13
				Add Contractors Profit @ 10.0%	2050.06
				SAY	22550.75
				Cost index **31.06 %**	5050.76
				Total with Cost index	27601.52
				Say	27601.52

Public Works Department
PRICE

5. Specification Code : od35322/2019_2020

od35322/2019_2020 : Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical SpecificationR C C Grade M40 - Using Batching plant, Transit Mixer and Concrete pump

Code	Description	Unit	Quantity	Rate	Amount
14.1E.2	Rate as per item number 14.1E.2 of SH: Super-Structure	cum	1.0	4803.14	4803.14 ()

14.1E.2	Rate as per item number 14.1E.2 of SH: Super-Structure	cum	0.04	4803.14	192.13 ()
				TOTAL	4995.27
				cost for one cum	4995.27
				say	4995.27
				Add Overhead @ 25.0%	1248.81
				Add Contractors Profit @ 10.0%	624.40
				SAY	6868.49
				Cost index **31.06 %**	1991.98
				Total with Cost index	8860.48
				Say	8860.48

6. Specification Code : od35806/2019_2020

od35806/2019_2020 : Providing Steel Liner 6 mm thick for Piles including Fabricating and Setting out as per Detailed Drawing.

Public Works Department

PRICE

Code	Description	Unit	Quantity	Rate	Amount
M-179	Structural Steel	tonne	1.05	37842.24	39734.35
L-12	Mate	Day	1.24	407.0	504.68
L-08	Fitter	Day	6.0	487.0	2922.0
L-01	Blacksmith (IInd class)	Day	5.0	448.0	2240.0
L-02	Blacksmith	Day	5.0	487.0	2435.0
L-13	Mazdoor	Day	10.0	368.0	3680.0
	Electrodes, cutting gas and other consumables @ 5 per cent		0.0	***null***	1986.72
				TOTAL	53502.75
				cost for one MT	53502.75
				say	53502.75
				Add Overhead @ 25.0%	13375.68
				Add Contractors Profit @ 10.0%	6687.84

SAY	73566.28

Cost index **31.06 %**	22849.68
Total with Cost index	96415.97
Say	96415.97

7. Specification Code : od35818/2019_2020

od35818/2019_2020 : Providing Steel Liner 12mm thick for Piles including Fabricating and Setting out as per Detailed Drawing.

Code	Description	Unit	Quantity	Rate	Amount
M-179	Structural Steel	tonne	1.05	37842.24	39734.35 0
L-12	Mate	Day	1.24	407.0	504.68 0
L-08	Fitter	Day	6.0	487.0	2922.0 0
L-01	Blacksmith (IInd class)	Day	5.0	448.0	2240.0 0
L-02	Blacksmith	Day	5.0	487.0	2435.0 0
L-13	Mazdoor	Day	10.0	368.0	3680.0 0
	Electrodes, cutting gas and other consumables @ 5 per cent	0.0			1986.72 0
				TOTAL	53502.75
				cost for one MT	53502.75
				say	53502.75
				Add Overhead @ 25.0%	13375.68
				Add Contractors Profit @ 10.0%	6687.84
				SAY	73566.28
				Cost index **31.06 %**	22849.68
				Total with Cost index	96415.97
				Say	96415.97

Public Works Department
PRICE

8. Specification Code : 12.39

SUBHEAD : 12.0

Foundations

12.39 Providing and laying of PCC M15 leveling course 100 mm thick below the pile cap

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1100 & 1700	Unit : cum Taking output = 15 a) Material					
M-081		Cement	tonne	4.13	5792.24	23921.95	
M-005		Coarse sand at Site	cum	6.75	1303.77	8800.45	
M-055		Aggregate 40mm nominal size	cum	8.1	1362.79	11038.60	
M-053		Aggregates 20mm nominal size	cum	4.05	1403.77	5685.27	
M-051		10mm nominal size b) Labour	cum	1.35	1403.77	1895.09	
L-12		Mate	Day	0.86	407.00	350.02	
L-10		Mason (IInd class)	Day	1.5	448.00	672.00	
L-13		Mazdoor c) Machinery	Day	20.0	368.00	7360.00	
P&M-009		Concrete Mixer (cap 0.4/0.28 cum)	hour	6.0	234.00	1404.00	MR208
P&M-079		Generator 33 KVA	hour	6.0	374.00	2244.00	MR278

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PRICE

TOTAL	63371.38
Cost of 15.0 cum	63371.38
Cost of 1 cum	4224.76

Add Overhead @ 25.0%	1056.19
Add Contractors Profit @ 10.0%	528.09
Cost index **31.06%**	1700.42
Total with Cost index	7509.47
Say	7509.47

9. Specification Code : od35355/2019_2020

od35355/2019_2020 : Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Foundations

Code	Description	Unit	Quantity	Rate	Amount

M-082	Cold twisted bars (HYSD Bars)	tonne	1.33081	37392.24	49761.85 ()

M-072	Binding wire	kg	6.0	48.09	288.54 ()
L-12	Mate	Day	0.4	407.0	162.8 ()
L-02	Blacksmith	Day	2.0	487.0	974.0 ()
L-13	Mazdoor	Day	6.0	368.0	2208.0 ()
				TOTAL	53395.19
				cost for 1.05 MT	53395.19
				cost for one MT	50852.57
				say	50852.57
				Add Overhead @ 25.0%	12713.14
				Add Contractors Profit @ 10.0%	6356.57
				SAY	69922.28
				Cost index **31.06 %**	21717.86
				Total with Cost index	91640.15
				Say	91640.15

PART-C: FOR SUBSTRUCTURE

Public Works Department

1. Specification Code : 13.5.H.r.2

PRICE

SUBHEAD : 13.0

SUB-STRUCTURE

13.5.H.r.2 Plain/Reinforced cement concrete in sub-structure complete as per drawing and Technical Specifications
RCC Grade M35 - With Batching Plant, Transit Mixer and Concrete Pump - Height above 10m

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1500,1700 & 2200						
12.8.H.2		Rate as per item Number of SH: Foundations - RCC Grade M35	cum	1.0	4682.94	4682.94	
		Add 13 per cent for Formwork			A*13/100	608.782	

		Add 3 per cent to cater for extra lift			A*3/100	140.488	

Cost of 1.0 cum	5432.21
Cost of 1 cum	5432.21

Note

The basic components of this analysis are the same as those of items 12.8 (A to H). The only changes are as under:

a) Ramps/Stairs: Extra expenditure on structures which are more than 5 m high @ 2 per cent of cost for height upto 10 m and 4 per cent for heights above 10 m will be involved for approaching the work spot by providing higher ramp/stair case for use by the working parties.

b) The above mentioned percentages have been suitably modified for different categories as cost for various categories varies, whereas effort for access for same height will be similar. As the cost of richer concrete is comparatively more, the percentage to be added has been reduced to maintain the same cost for extra efforts.

Add Overhead @ 25.0%	1358.05
Add Contractors Profit @ 10.0%	679.02
Cost index **31.06%**	2162.27
Total with Cost index	9631.56
Say	9631.56

Public Works Department
PRICE

2. Specification Code : od35328/2019_2020

od35328/2019_2020 : Plain/Reinforced cement concrete in Substructure complete as per drawing and Technical Specififcations RCC Grade M50- Using concrete mixer for Heights above 10m

Code	Description	Unit	Quantity	Rate	Amount
14.1.G.1	Rate as per item number 14.1.G.1 of SH: Super-Structure	cum	1.0	5159.79	5159.79 ()
14.1.G.1	Rate as per item number 14.1.G.1 of SH: Super-Structure	cum	0.13	5159.79	670.77 ()
14.1.G.1	Rate as per item number 14.1.G.1 of SH: Super-Structure	cum	0.03	5159.79	154.79 ()
				TOTAL	5985.35
				cost for one cum	5985.36
				say	5985.36
				Add Overhead @ 25.0%	1496.34

Add Contractors Profit @ 10.0%	748.17
SAY	8229.86

Cost index **31.06 %**	2398.50
Total with Cost index	10628.38
Say	10628.38

3. Specification Code : od35346/2019_2020

od35346/2019_2020 : Plain/Reinforced cement concrete in substructrue complete as per drawing and Technical Specifications RCC Grade M55-Using concrete mixer for heights above 10m

Code	Description	Unit	Quantity	Rate	Amount
14.1.H.1	Rate as per item number 14.1.H.1 of SH: Super-Structure	cum	1.0	5392.74	5392.74 ()
14.1.H.1	Rate as per item number 14.1.H.1 of SH: Super-Structure	cum	0.13	5392.74	701.06 ()
14.1.H.1	Rate as per item number 14.1.H.1 of SH: Super-Structure	cum	0.03	5392.74	161.78 ()
				TOTAL	6255.58
				cost for one cum	6255.58
				say	6255.58
				Add Overhead @ 25.0%	1563.89
				Add Contractors Profit @ 10.0%	781.94
				SAY	8601.42
				Cost index **31.06 %**	2513.91
				Total with Cost index	11115.34
				Say	11115.34

Public Works Department
PRICE

4. Specification Code : od35357/2019_2020

od35357/2019_2020 : Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Substructure

Code	Description	Unit	Quantity	Rate	Amount
M-082	Cold twisted bars (HYSD Bars)	tonne	1.33081	37392.24	49761.85 ()
M-072	Binding wire	kg	6.0	48.09	288.54 ()
L-12	Mate	Day	0.34	407.0	138.38 ()

L-02	Blacksmith	Day	2.0	487.0	974.0 0

L-13	Mazdoor	Day	6.5	368.0	2392.0 0
				TOTAL	53554.77
				cost for one MT	53554.77
				say	53554.77
				Add Overhead @ 25.0%	13388.69
				Add Contractors Profit @ 10.0%	6694.34
				SAY	73637.80
				Cost index **31.06 %**	22871.90
				Total with Cost index	96509.71
				Say	96509.71

5. Specification Code : 13.13

SUBHEAD : 13.0

SUB-STRUCTURE

13.13 Supplying, fitting and fixing in position true to line and level sliding plate bearing with PTFE surface sliding on stainless steel complete including all accessories as per drawing and Technical Specifications and BS: 5400, section 9.1 & 9.2 (for PTFE) and clause 2004 of MoRTH Specifications.

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PRICE

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit: one tonne capacity Considering a 80 tonne capacity bearing for this analysis a) Labour					
	2000 & 2200						
L-12		Mate	Day	0.06	407.00	24.42	
L-13		Mazdoor	Day	1.0	368.00	368.00	
L-15		Mazdoor/Dresser/Sinker (skilled) b) Material	Day	0.5	407.00	203.50	

M-069		Bearing (PTFE sliding plate bearing assembly of 80 tonnes)	no	1.0	1.00	1.00	MR109
		Add 1 per cent of cost of bearing assembly for foundation anchorage bolts, lifting arrangements, grease and other consumables.			A*1/100	0.01	

Cost of 80.0 tonne	596.80
Cost of 1 tonne	7.46

Add Overhead @ 25.0%	1.86
Add Contractors Profit @ 10.0%	0.93
Cost index **31.06%**	3.18
Total with Cost index	13.44
Say	13.44

Public Works Department

6. Specification Code : od35406/2019_2020

PRICE

od35406/2019_2020 : Supplying, fitting and fixing in position true to line and level sliding plate bearing with PTFE surface sliding on stainless steel complete including all accessories as per drawing and Technical Specifications -for Spherical Bearings

Code	Description	Unit	Quantity	Rate	Amount
L-12	Mate	Day	0.06	407.0	24.42 ()
L-13	Mazdoor	Day	1.0	368.0	368.0 ()
L-15	Mazdoor/Dresser/Sinker (skilled)	Day	0.5	407.0	203.5 ()
M-069	Bearing (PTFE sliding plate bearing assembly of 80 tonnes)	no	393.0	1.0	393.0 ()
	Add 1 per cent of cost of bearing assembly for foundation anchorage bolts, lifting arrangements, grease and other consumables.	0.0			0.01 ( )
				TOTAL	988.93

cost for 80.0 tonne	988.93
cost for one tonne	12.36
say	12.36

Add Overhead @ 25.0%	3.09
Add Contractors Profit @ 10.0%	1.54
SAY	16.99
Cost index **31.06 %**	3.16
Total with Cost index	20.16
Say	20.16

PART-D: FOR SUPERSTRUCTURE

1. Specification Code : 14.1F.2.C

SUBHEAD : 14.0

SUPER-STRUCTURE

14.1F.2.C "Furnishing and Placing PSC Grade M45 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification.
For T-beam & slab including launching of precast girders by launching truss upto 40 m span - Height above 10m

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Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1500,1600 & 1700						
14.1.F.1		Rate as per item Number of SH: Super-Structure	cum	1.0	5011.19	5011.19	
		Formwork and staging 31% of Labour, Material, Machinery of 14.1.F.1			B*31/100	1553.47	
					Cost of 1.0 cum	6564.66	

Note Formwork and staging 31% of Labour, Material, Machinery of 14.1.F.1

Add Overhead @ 25.0%	1641.16

Add Contractors Profit @ 10.0%	820.58

Cost index **31.06%**	2625.52
Total with Cost index	11651.93
Say	11651.93

2. Specification Code : 14.1G.1.C

SUBHEAD : 14.0

SUPER-STRUCTURE

14.1G.1.C "Furnishing and Placing PSC Grade M50 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification.
For cast-in-situ box girder, segmental construction and balanced cantilever- Height above 10m

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1500,1600 & 1700						
14.1.G.1		Rate as per item Number of SH: Super-Structure	cum	1.0	5159.79	5159.79	
		Formwork and staging 55% of Labour, Material, Machinery of 14.1.A.1			B*55/100	2837.88	
					Cost of 1.0 cum	7997.67	

Note 1.Where ever concrete is carried out using batching plant, transit mixer, concrete pump, admixers conforming IS: 9103 @ 0.4 per cent of weight of cement may be added for achieving desired slump of concrete.2. Cement provided for various components of the super structure is for estimating purpose only. Actual quantity of cement will be as per approved mix design. Similarly, the provision for coarse and fine aggregates is for estimating purpose and the exact quantity shall be as per the mix design.3. The items like needle and surface vibrators are part of minor T & P which is already covered under the overhead charges. As such these items have not been added separately in the rate analysis.

Add Overhead @ 25.0%	1999.41
Add Contractors Profit @ 10.0%	999.70
Cost index **31.06%**	3204.90

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Total with Cost index	14201.70
Say	14201.70

3. Specification Code : od35428/2019_2020

od35428/2019_2020 : Furnishing and Placing PSC Grade M60 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification.For cast-in-situ box girder, segmental construction and balanced cantilever- Height above 10m

Code	Description	Unit	Quantity	Rate	Amount
MR	Cost of Hire charges of land	cum	1.0	44.13	44.13 ()
MR	Handling of segments in the casting yard, i/c loading and unloading the segments in the trailor and transporting to the site of work.	cum	1.0	643.98	643.98 ()
MR	Cost of crane at site for unloading of segments and placing then in position as and when required.	cum	1.0	47.29	47.29 ()
MR	Cost of launching girder i/c temporary prestressing M-rods, and jacks etc.	cum	1.0	1096.63	1096.63 ()
MR	Using fosrock PC-20 epoxy	cum	1.0	509.0	509.0 ()
MR	Labour for lifting, erection of segment straightening/alignment of segment, temporary pre-stressing and applying epoxy paint etc.	cum	1.0	494.01	494.01 ()
MR	Stiching wings of segments including shuttering at 10m height, bolts, safety net etc.	cum	1.0	126.65	126.65 ()
14.1.H.1	Rate as per item number 14.1.H.1 of SH: Super-Structure	cum	1.3	5392.74	7010.56 ()
				TOTAL	9972.25
				cost for one cum	9972.25
				say	9972.25
				Add Overhead @ 25.0%	2493.06
				Add Contractors Profit @ 10.0%	1246.53
				SAY	13711.84
				Cost index **31.06 %**	2817.31
				Total with Cost index	16529.16
				Say	16529.16

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4. Specification Code : od35438/2019_2020

od35438/2019_2020 : Supply, Fitting and Placing HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Superstructure

Code	Description	Unit	Quantity	Rate	Amount
M-082	Cold twisted bars (HYSD Bars)	tonne	1.33081	37392.24	49761.85 *()*
M-072	Binding wire	kg	8.0	48.09	384.72 *()*
L-12	Mate	Day	0.44	407.0	179.08 *()*
L-02	Blacksmith	Day	3.0	487.0	1461.0 *()*
L-13	Mazdoor	Day	8.0	368.0	2944.0 *()*
				TOTAL	54730.65
				cost for one MT	54730.65
				say	54730.65
				Add Overhead @ 25.0%	13682.66
				Add Contractors Profit @ 10.0%	6841.33
				SAY	75254.64
				Cost index **31.06 %**	23374.09
				Total with Cost index	98628.74
				Say	98628.74

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5. Specification Code : 14.3

SUBHEAD : 14.0

SUPER-STRUCTURE

14.3 High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as per drawing and Technical Specifications

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = 1 MT Taking output = 0.377 MT Details of cost for 12T13 strand 40 m long cable (weight = 0.377 MT) a) Material					
	1800						

M-119		HTS Strand @ 9.42 kg/m including 2 per cent for wastage and extra length for jacking	tonne	0.39	58000.00	22620.00	MR134
M-165		Sheathing duct ID 66 mm along with 5 per cent extra length 40 x 1.05 = 42 m.	metre	42.0	180.00	7560.00	MR163
M-257		Tube anchorage set complete with bearing plate, permanent wedges etc	each	2.0	2900.00	5800.00	MR437
M-081		Cement b) Labour i) For making and fixing cables, anchorages	tonne	0.125	5792.24	724.03	
		Add 0.50 per cent cost of material for Spacers, Insulation tape and miscellaneous items			(B+C+D+E)*0.5/100	183.52	
L-12		Mate	Day	0.16	407.00	65.12	
L-02		Blacksmith	Day	1.0	487.00	487.00	
L-13		Mazdoor ii) For prestressing	Day	3.0	368.00	1104.00	
L-12		Mate	Day	0.05	407.00	20.35	
L-08		Fitter	Day	0.25	487.00	121.75	
L-13		Mazdoor iii) For grouting	Day	1.0	368.00	368.00	
L-12		Mate	Day	0.05	407.00	20.35	
L-11		Mason (1st class)	Day	0.25	487.00	121.75	
L-13		Mazdoor c) Machinery	Day	1.0	368.00	368.00	

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P&M-040		Prestressing Jack with Pump & access	hour	2.5	130.00	325.00	MR239
M-111		Grouting pump with agitator	hour	1.0	714.00	714.00	MR126
P&M-079		Generator 33 KVA	hour	3.5	374.00	1309.00	MR278

Cost of 0.377 MT	41911.87
Cost of 1 MT	111172.07

Note Cost of HT steel has been taken for delivery at site. Hence carriage has not been considered.

Add Overhead @ 25.0%	27793.01
Add Contractors Profit @ 10.0%	13896.50
Cost index **31.06%**	3856.10
Total with Cost index	156717.70
Say	156717.70

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6. Specification Code : od35429/2019_2020

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od35429/2019_2020 : Providing/fabricating and stressing of stay cables, threading them (i.e. cutting, pulling, pushing and placing) , placing them in proper profiles including anchorages, bearing plates, wedges,recess filling etc.complete as per detailed drawings and approved specifications, grouting the cables approved equivalent as per the specifications, all complete including the cost of all labour, machinery and materials and hardware etc, as per the specifications and directions of the Engineer-in-charge.

Code	Description	Unit	Quantity	Rate	Amount
14.3	Rate as per item number 14.3 of SH: Super-Structure	MT	10.0	111172.07	1111720.7 ( )
				TOTAL	1111720.70
				cost for one MT	1111720.8
				say	1111720.8
				Add Overhead @ 25.0%	277930.20
				Add Contractors Profit @ 10.0%	138965.10
				SAY	1528616.10

Cost index **31.06 %**	38561.07
Total with Cost index	1567177.17
Say	1567177.17

7. Specification Code : 14.22

SUBHEAD : 14.0

SUPER-STRUCTURE

14.22 Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Running meter Taking output = 12 m a) Labour					
	2607						
L-12		Mate	Day	0.05	407.00	20.35	
L-13		Mazdoor	Day	1.0	368.00	368.00	
L-15		Mazdoor/Dresser/Sinker (skilled) b) Material	Day	0.25	407.00	101.75	
M-178		Strip seal expansion join comprising of edge beams, anchorage, strip seal element and complete accessories as per approved specifications and drawings.	metre	12.0	7500.00	90000.00	MR174
		Add 5 per cent of cost of material for anchorage reinforcement, welding and other incidentals.			B*5/100	4500.0	
					Cost of 12.0 metre	94990.08	

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Cost of 1 metre	7915.84

Note 1. The installation shall be done by the manufacturer or his authorised representative to the satisfaction of the Engineer. 2. The concreting for joining the expansion joint assembly with the deck has not been included in this analysis as the same is catered in the quantities of RCC deck.

Add Overhead @ 25.0%	1978.96
Add Contractors Profit @ 10.0%	989.48
Cost index **31.06%**	17.44
Total with Cost index	10901.72
Say	10901.72

8. Specification Code : od35430/2019_2020

od35430/2019_2020 : Providing and laying of a modular strip box seal expansion joint catering to a horizontal movement beyond 210 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer /supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.

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Code	Description	Unit	Quantity	Rate	Amount
L-12	Mate	Day	0.07	407.0	28.49 0
L-13	Mazdoor	Day	1.25	368.0	460.0 0
L-15	Mazdoor/Dresser/Sinker (skilled)	Day	0.5	407.0	203.5 0
MR	Modular strip/box seal expansion joint beyond 210mm	metre	12.0	237571.37	2850856.44 0
				TOTAL	2851548.43
				cost for 12.0 metre	2851548.43
				cost for one metre	237629.05
				say	237629.05
				Add Overhead @ 25.0%	59407.26
				Add Contractors Profit @ 10.0%	29703.63
				SAY	326739.94
				Cost index **31.06 %**	24.62
				Total with Cost index	326764.57

Say	326764.57

9. Specification Code : od35431/2019_2020

od35431/2019_2020 : Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified

Code	Description	Unit	Quantity	Rate	Amount
14.1E.1.2.A	Rate as per item number 14.1E.1.2.A of SH: Super-Structure	cum	3.0	6600.04	19800.12 ()
L-12	Mate	Day	0.04	407.0	16.28 ()
L-13	Mazdoor Material	Day	1.0	368.0	368.0 ()
M-082	Cold twisted bars (HYSD Bars)	tonne	0.28	37392.24	10469.83 ()
M-144	Pre-moulded asphalt filler board	sqm	0.32	350.0	112.0 ()
				TOTAL	30766.23
				cost for 10.0 metre	30766.23
				cost for one metre	3076.62
				say	3076.62
				Add Overhead @ 25.0%	769.15
				Add Contractors Profit @ 10.0%	384.57
				SAY	4230.35
				Cost index **31.06 %**	1270.21
				Total with Cost index	5500.57
				Say	5500.57

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10. Specification Code : 14.9

SUBHEAD : 14.0

SUPER-STRUCTURE

14.9 Drainage Spouts complete as per drawing and Technical specification

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = 1 No. Taking output = 1 No. a) Material					
	2705						
M-229		Corrosion resistant Structural steel including 5 per cent wastage	kg	4.0	37.84	151.36	
M-244		G.I Pipe - 100 m dia	metre	6.0	460.00	2760.00	MR189
M-110		Gl Bolt 10mm dia	no	6.0	11.00	66.00	
M-101		Galvanised MS flat clamp b) Labour for fabrication	each	2.0	35.00	70.00	MR118
L-12		Mate	Day	0.02	407.00	8.14	
L-02		Blacksmith	Day	0.02	487.00	9.74	
L-13		Mazdoor For fixing in position	Day	0.02	368.00	7.36	
L-12		Mate	Day	0.01	407.00	4.07	
L-11		Mason (1st class)	Day	0.01	487.00	4.87	
L-13		Mazdoor	Day	0.2	368.00	73.60	
		Add @ 5 per cent of cost of material and labour for electrodes, cutting gas, sealant, anti-corrosive bituminous paint, mild steel grating etc.			(B+C+D+E+F+G+H+I+J+K)*5/100	157.757	

Cost of 1.0 no	3312.90
Cost of each	3312.90

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Note

1. In case of viaducts in urban areas, the drainage spouts should be connected with suitably located pipelines to discharge the surface run-off to drains provided at ground level.2. In case of bridges, sufficient length of G.I Pipe shall be provided to ensure that there is no splashing of water from the drainage spout on the structure.

Add Overhead @ 25.0%	828.22
Add Contractors Profit @ 10.0%	414.11
Cost index **31.06%**	145.80
Total with Cost index	4701.04
Say	4701.04

11. Specification Code : od35437/2019_2020

od35437/2019_2020 :null Providing and Fixing PVC pipes 110mm OD(6kg/cm2) Down water pipe complete as drawing and Technical Specification

Code	Description	Unit	Quantity	Rate	Amount
MR54	PVC pipe 110 mm outer dia 6kgf/cm2	metre	1.0	211.0	211.0
				TOTAL	211.00
				cost for one metre	211.0
				say	211.0
				Add Overhead @ 25.0%	52.75
				Add Contractors Profit @ 10.0%	26.37
				SAY	290.12
				Cost index **31.06 %**	0.00
				Total with Cost index	290.13
				Say	290.13

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12. Specification Code : 14.16

SUBHEAD : 14.0

Super-Structure

14.16 Providing and applying 2 coats of water based cement paint to unplastered concrete surface after cleaning the surface of dirt, dust, oil, grease, efflorescence and applying paint @ of 1 litre for 2 sqm.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	800	Unit: sqm Taking output = 10 sqm a) Labour					
L-12		Mate	Day	0.01	407.00	4.07	
L-18		Painter 1 class	Day	0.25	448.00	112.00	
L-15		Mazdoor/Dresser/Sinker (skilled) b) Material	Day	0.25	407.00	101.75	
M-190		Water based cement paint	Litre	5.0	200.00	1000.00	
					TOTAL	1217.82	
					Cost of 10.0 sqm	1217.82	
					Cost of 1 sqm	121.78	

Add Overhead @ 25.0%	30.44
Add Contractors Profit @ 10.0%	15.22
Cost index **31.06%**	52.00
Total with Cost index	219.46
Say	219.46

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13. Specification Code : 5.6.2.b.1

SUBHEAD : 5.0

BASES AND SURFACE COURSES

5.6.2.b.1

Providing and laying bituminous concrete with 100-120 TPH hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder (NRMB) @ 5.4 per cent of mix and filler with Anti stripping additive (Zycosoil) material 1.0 kg per 1 tonne of bitumen, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects For Grading -II (13.2 mm Nominal size).

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = cum Taking output = 191 cum (450 tonnes) a) Labour					
	507						
L-12		Mate	Day	0.84	407.00	341.88	
L-13		Mazdoor working with HMP, mechanical broom, paver, roller, asphalt cutter and assistance for setting out lines, levels and layout of construction	Day	14.0	368.00	5152.00	
L-15		Mazdoor/Dresser/Sinker (skilled) for checking line & levels b) Machinery	Day	5.0	407.00	2035.00	
P&M-021		Hotmix Plant - 120 TPH capacity	hour	6.0	23579.00	141474.00	MR220
P&M-034		Paver Finisher Hydrostatic with sensor control 100 TPH	hour	6.0	2694.00	16164.00	MR402
P&M-081		Generator 250 KVA	hour	6.0	702.00	4212.00	MR280
P&M-017		Front End loader 1 cum bucket capacity	hour	6.0	812.00	4872.00	MR216
P&M-058		Truck 5.5 cum per 10 tonnes	tonne km	450.0	3.00	1350.00	MR257
		Add 10 per cent of cost of carriage to cover cost of loading and unloading			B*10/100	135.0	
P&M-044		Smooth Wheeled Roller 8 tonne -10 tonnes for initial break down rolling.	hour	3.9	464.00	1809.60	MR243
P&M-059		Vibratory Roller 8 tonne for intermediate rolling.	hour	3.9	1553.00	6056.70	MR258

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P&M-045		Tandem Road Roller c) Material i) Bitumen Total weight of mix = 450 tonnes Weight of bitumen =450 x 5.4 /100 = 24.30 tonnes	hour	3.9	1152.00	4492.80	MR244
M-402		Bitumen (NRMB) @ 5.4 per cent of weight of mix modified grade	tonne	24.3	42130.00	1023759.00	MR102
M-197		carriage code of Bitumen	tonne	24.3	103.77	2521.61	
M-409		Anti Stripping Additive(Zycosoil) materials ii) Aggregate Weight of aggregate = 450 -24.30 = 427.50 tonnes Taking density of aggregate = 1.5 ton/cum Volume of aggregate = 427.5/1.5 = 283.80 cum	kg	24.3	1717.50	41735.25	MR167
M-044B		Aggregates 13.2 mm to 10 mm 30 per cent	cum	85.14	1403.77	119516.98	
M-040D		Aggregates 10 mm to 5 mm 25 per cent	cum	70.95	1403.77	99597.48	
M-208		5 mm and below 43 per cent	cum	122.034	1353.77	165205.97	
M-203		Filler @ 2 per cent of weight of aggregates.	cum	5.676	968.77	5498.74	

Cost of 191.0 cum	1645929.13
Cost of 1 cum	8617.43

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Note

*1. Although the rollers are required only for 3 hours as per norms of output, but the same have to be available at site for six hours as the hot mix plant and paver will take six hours for mixing and paving the output of 450 tonnes considered in this analysis. To cater for the idle period of these rollers, their usage rates have been multiplied by a factor of 0.652.Quantity of Bitumen has been taken for analysis purpose. The actual quantity will depend upon job mix formula.3. Labour for traffic control, watch and ward and other miscellaneous duties at site including sundries have been included in administrative overheads of the contractor.4. In case BC is laid over freshly laid tack coat, provision of mechanical broom and 2 mazdoors shall be deleted as the same has been included in the cost of tack coat.5. The individual density for each size of aggregates to be used for construction i.e. 37.5-25 mm, 25-10 mm etc. should be found in the laboratory and accordingly the quantities should be ammended for use in field. The average density of 1.5 tonne/cum is only a reference density in this Data Book.6. The individual percentage of aggregates should be calculated from the total weight of dry aggregates i.e.. excluding the weight of bitumen. The weight of filler will also be 2 per cent by weight of dry aggregates.

Add Overhead @ 25.0%	2154.35
Add Contractors Profit @ 10.0%	1077.17
Cost index **31.06%**	894.10
Total with Cost index	12743.07
Say	12743.07

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14. Specification Code : 14.10

SUBHEAD : 14.0

Super-Structure

14.10 PCC M15 Grade leveling course below approach slab complete as per drawing and Technical specification.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	2700	Unit = 1 cum Taking output = 1 cum Material					
12.8.A		Rate as per item Number of SH: Foundations excluding formworks	cum	1.0	4228.66	4228.66	

TOTAL	4228.66
Cost of 1.0 cum	4228.66

Add Overhead @ 25.0%	1057.16
Add Contractors Profit @ 10.0%	528.58
Cost index **31.06%**	1702.09
Total with Cost index	7516.50
Say	7516.50

15. Specification Code : 14.11

SUBHEAD : 14.0

SUPER-STRUCTURE

14.11 Reinforced cement concrete approach slab including reinforcement and formwork complete as per drawing and Technical specification.

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Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = 1 cum Taking output = 1 cum a) Material					
	1500,1600,1700,2704						
12.8.G.2		Rate as per item Number of SH: Foundations Cement concrete M30 Grade by using batching plant, excluding formwork	cum	1.0	4594.12	4594.12	
		Add 2 per cent for formwork			B*2/100	91.8824	
14.2		Rate as per item Number of SH: Super-Structure HYSD bar reinforcement	MT	0.05	44230.65	2211.53	
					Cost of 1.0 cum	6897.53	

Cost of 1 cum	6897.53

Note The grade of reinforced cement concrete may be adopted as M30 for severe conditions and M25 for moderate conditions.

Add Overhead @ 25.0%	1724.38
Add Contractors Profit @ 10.0%	862.19
Cost index **31.06%**	2807.10
Total with Cost index	12291.21
Say	12291.21

16. Specification Code : 55.26

SUBHEAD : 55.0

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55.26 Providing and applying elastic, elastomeric membrane forming system with anticarbonation and breathing properties. The system should be based on solvent free acrylic polymers with selected mineral fillers and should be ultra-violet resistant, crack bridging type, carbonation resistant, breathable, enviornment friendly, water proofing coating. For anticarbonation, equivalent air layer thickness denoted as R or SD CO2 grater than 50 m and for breathability equivalent air layer thickness denoted as SD H2O shall be less than 4 m for vapour transmitting barrier. The system consists of one coat primer @ 75- 100 g/m2. The consumption of main polymer coating to give film thickness of 200-225 microns (Solid contents- 70%+ -3%) should be approximately. 400-450 g/m2 per two coats depending upon the method of application (either by roller or brush) and surface smoothness of the concrete. The total dry film thickness of the coating system should be minimum 200 microns for the above system. Polymer coating should be in suitable approved shades, including cost of materials, cleaning, chipping and removing the dirt particles of the concrete slab with wire brush and water,labour charges for filling the bug holes, cracks, joints etc with one component polymer modified fine repair and cosmetic mortar, labour for applying the above coating, scaffolding charges,etc. complete as per IRC SP:80 Clause 6.5.1 and Clause 2808 in the Specifications Book for Roads & Bridges published by the Ministry during April 2013.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Details of cost for Painting 10 sqm					
	0						

M-435		Acrylic polymer paint	kilogram	4.5	450.00	2025.00	MR622
M-436		Acrylic polymer primer Labour for scrapping , one coat primer and two coat painting (work in risky condition)	kilogram	1.0	200.00	200.00	MR623
L-18		Painter 1 class	Day	2.0	448.00	896.00	
L-13		Mazdoor	Day	1.2	368.00	441.60	
L-12		Mate	Day	0.12	407.00	48.84	
		Add for scaffolding @ 40 per cent of material cost and labour charges			(B+C+D+E +F)*40/100	1444.58	
		Add @ 5 per cent cost of labour and materials to prepare the surface by filling minuts roughness on the surface before laying 2 coats of painting.			(B+C+D+E +F)*5/100	180.572	

Public Works Department
PRICE

Cost of 10.0 sqm	5236.60
Cost of 1 sqm	523.66

Add Overhead @ 25.0%	130.91
Add Contractors Profit @ 10.0%	65.45
Cost index **31.06%**	85.85
Total with Cost index	805.89
Say	805.89

PART-E: RE WALL PORTION

1. Specification Code : 7.5.2

SUBHEAD : 7.0

GEOSYNTHETICS AND REINFORCED RAINS

7.5.2 Assembling, joining and laying of reinforcing facing elements of RCC for Reinforced Earth Structures

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = sqm Taking output = 75 sqm a) Labour					
	3105						
L-12		Mate	Day	0.18	407.00	73.26	
L-13		Mazdoor	Day	3.0	368.00	1104.00	
L-15		Mazdoor/Dresser/Sinker (skilled) b) Machinery	Day	1.5	407.00	610.50	
P&M-013		Cranes (c) 3 tonnes c) Material	hour	6.0	358.00	2148.00	MR212
12.8.H.1		Rate as per item Number of SH: Foundations	cum	13.5	5100.32	68854.32	
13.6		Rate as per item Number of SH: Sub-Structure	MT	0.38	43054.77	16360.81	
		Add 2 per cent of cost of facia pannels, for all necessary temporary form work, scaffolding and provision of loops/lugs for lifting of pannels and joining the reinforcing elements.			(B+C)*2/100	1704.3	
					Cost of 75.0 sqm	90855.00	
					Cost of 1 sqm	1211.40	

Public Works Department
PRICE

Note

1.The specification and construction details to be adopted shall be as per section 3100 of MoRTH Specification.2.Drainage arrangement shall be made as per approved design and drawings.3.The quantity of filler media shall be calculated as per approved design and specifications and shall be priced separately.The rate for same to be adopted from chapter 15.4.Excavation for foundation including foundation concrete and groove in the foundation for seating of bottom most facia panel and capping beam to be calculated as per design and priced separately. The rates for excavation and foundation concrete shall be taken from the chapter 12 & 13 in bridge section.5.The earth fill to be retained is not included in this analysis. The same is to be worked out and provided separately complete as per clause 305.6.For compaction of Earthwork, attention is invited to clause 3105.5 of MoRTH Specification.7.Length of reinforcing strips will vary with the height of wall and will be as per approved design and drawings.8.The type of reinforcing elements to be adopted shall be as per approved design and specifications.9.The market rate for supply of reinforcing elements and their accessories are to be ascertained from reputed firms in the field of earth reinforcement.10.The earth fill material shall be clean, free draining, granular with high friction and low cohesion, non-corrosive, coarse grained with not 10 per cent of particles passing 75 micron sieve, free of any deleterious matter, chlorides, salts, acids, alkalies, mineral oil, fungus and microbes and shall be of specified PH value.11.Capping beam is to be priced separately as per approved design. The rate for cement concrete shall be taken from the chapter of sub-structure in bridge section.12.The cost of reinforced earth retaining wall shall include following:(I) Excavation for foundation including backfilling.(ii) Foundation concrete as per approved design.(iii) Cost of facial pannels and their erection .(iv) Cost of reinforcing elements including their fixing and joining with the facial pannels.(v) Drainage arrangement including filter media as per approved design and drawings.13. The compacted earth filling to be retained shall form part of embankment.

Public Works Department
PRICE

Add Overhead @ 25.0%	302.85
Add Contractors Profit @ 10.0%	151.42
Cost index **31.06%**	486.05
Total with Cost index	2151.73
Say	2151.73

2. Specification Code : 12.1.2.B

SUBHEAD : 12.0

Foundations

12.1.2.B

Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material.

Ordinary Rock (not requiring blasting) - Depth up to 3 m - Mechanical Means

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	304	Mechanical Means Unit = cum Taking output= 180 cum a) Laour					
L-12		Mate	Day	0.24	407.00	97.68	
L-13		Mazdoor b) Machinery	Day	6.0	368.00	2208.00	
P&M-026		Hydraulic Excavator of 1 cum bucket	hour	6.0	1312.00	7872.00	MR225

TOTAL	10177.68
Cost of 180.0 cum	10177.68
Cost of 1 cum	56.54

Note In case of rock, foundation beyond 3 m is not dug and hence not included

Add Overhead @ 25.0%	14.13
Add Contractors Profit @ 10.0%	7.06
Cost index **31.06%**	5.47
Total with Cost index	83.21
Say	83.21

Public Works Department
PRICE

3. Specification Code : 13.5.B

SUBHEAD : 13.0

SUB-STRUCTURE

13.5.B Plain/Reinforced Cement Concrete in sub-structure complete as per drawing and Technical Specifications
PCC Grade M20 - Height upto 5m

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1500,1700 & 2200						

12.8.B		Rate as per item Number of SH: Foundations PCC M20	cm	1.0	4633.77	4633.77	
		Add 10 per cent of cost of material, labour and machinery (a b c) for Formwork			A*10/100	463.377	

Cost of 1.0 cum	5097.15
Cost of 1 cum	5097.15

Note

The basic components of this analysis are the same as those of items 12.8 (A to H). The only changes are as under:

a) Ramps/Stairs: Extra expenditure on structures which are more than 5 m high @ 2 per cent of cost for height upto 10 m and 4 per cent for heights above 10 m will be involved for approaching the work spot by providing higher ramp/stair case for use by the working parties.

b) The above mentioned percentages have been suitably modified for different categories as cost for various categories varies, whereas effort for access for same height will be similar. As the cost of richer concrete is comparatively more, the percentage to be added has been reduced to maintain the same cost for extra efforts.

Public Works Department
PRICE

Add Overhead @ 25.0%	1274.28
Add Contractors Profit @ 10.0%	637.14
Cost index **31.06%**	2062.61
Total with Cost index	9071.20
Say	9071.20

4. Specification Code : 13.5.A

SUBHEAD : 13.0

SUB-STRUCTURE

13.5.A Plain/Reinforced cement concrete in sub-structure complete as per drawing and Technical Specifications
PCC Grade M15 - Height upto 5m

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1500,1700 & 2200						
12.8.A		Rate as per item Number of SH: Foundations PCC Grade M15	cum	1.0	4228.66	4228.66	
		Add 10 per cent of cost of material, labour and machinery (a b c) for Formwork			A*10/100	422.866	

Cost of 1.0 cum	4651.53
Cost of 1 cum	4651.53

Note

The basic components of this analysis are the same as those of items 12.8 (A to H). The only changes are as under:

a) Ramps/Stairs: Extra expenditure on structures which are more than 5 m high @ 2 per cent of cost for height upto 10 m and 4 per cent for heights above 10 m will be involved for approaching the work spot by providing higher ramp/stair case for use by the working parties.

b) The above mentioned percentages have been suitably modified for different categories as cost for various categories varies, whereas effort for access for same height will be similar. As the cost of richer concrete is comparatively more, the percentage to be added has been reduced to maintain the same cost for extra efforts.

Public Works Department PRICE

Add Overhead @ 25.0%	1162.88
Add Contractors Profit @ 10.0%	581.44
Cost index **31.06%**	1872.30
Total with Cost index	8268.15
Say	8268.15

5. Specification Code : od35459/2019_2020

od35459/2019_2020 : Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified

Code	Description	Unit	Quantity	Rate	Amount
14.1E.1.2.A	Rate as per item number 14.1E.1.2.A of SH: Super-Structure	cum	3.0	6600.04	19800.12 ()
L-12	Mate	Day	0.04	407.0	16.28 ()
L-13	Mazdoor Material	Day	1.0	368.0	368.0 ()
M-082	Cold twisted bars (HYSD Bars)	tonne	0.28	37392.24	10469.83 ()
M-144	Pre-moulded asphalt filler board	sqm	0.32	350.0	112.0 ()
				TOTAL	30766.23
				cost for 10.0 metre	30766.23
				cost for one metre	3076.62
				say	3076.62
				Add Overhead @ 25.0%	769.15
				Add Contractors Profit @ 10.0%	384.57
				SAY	4230.35
				Cost index **31.06 %**	1270.21
				Total with Cost index	5500.57
				Say	5500.57

Public Works Department
PRICE

6. Specification Code : od35461/2019_2020

od35461/2019_2020 : Reinforced cement concrete friction slab including reinforcement and formwork complete as per drawing and Technical specification.

Code	Description	Unit	Quantity	Rate	Amount
14.1.E.1	Rate as per item number 14.1.E.1 of SH: Super-Structure	cum	1.0	5280.03	5280.03 (B)
14.1.E.1	Rate as per item number 14.1.E.1 of SH: Super-Structure	cum	0.02	5280.03	105.6 ()

14.2	Rate as per item number 14.2 of SH: Super-Structure	MT	0.08	44230.65	3538.45 ()

TOTAL	8924.08
cost for one cum	8924.08
say	8924.08
Add Overhead @ 25.0%	2231.02
Add Contractors Profit @ 10.0%	1115.51
SAY	12270.61
Cost index **31.06 %**	3705.31
Total with Cost index	15975.92
Say	15975.92

PART-F: PROJECT AMENITIES & STRUCTURAL HEALTH MONITORING SYSTEMS

1. Specification Code : od35468/2019_2020

od35468/2019_2020 : Providing Touring Amenities like Cafeteria, Elevator/Lifts, ramps etc at main bridge portion

Code	Description	Unit	Quantity	Rate	Amount
MR	Providing Touring Amenities like Cafeteria, Elevator/Lifts, ramps etc at main bridge portion	L.S	1.0	1.090909091E7	1.090909091E7
				TOTAL	10909090.91
				cost for one L.S	1.0909091E7
				say	1.0909091E7
				Add Overhead @ 25.0%	2727272.75
				Add Contractors Profit @ 10.0%	1363636.37
				SAY	15000000.12
				Cost index **31.06 %**	0.00
				Total with Cost index	15000000.13

Public Works Department PRICE

Say	15000000.13

2. Specification Code : od36035/2019_2020

od36035/2019_2020 : Installing Structural Health Monitoring systems at Cable stayed/ extradosed bridge portions to monitor the structural behaviour of the bridge.

Code	Description	Unit	Quantity	Rate	Amount
MR	Equipment cost for Structural health monitoring system	L.S	1.0	1.454545455E7	1.454545455E7
				TOTAL	14545454.55
				cost for one L.S	1.4545455E7
				say	1.4545455E7
				Add Overhead @ 25.0%	3636363.75
				Add Contractors Profit @ 10.0%	1818181.87
				SAY	20000000.62
				Cost index **31.06 %**	0.00
				Total with Cost index	20000000.63
				Say	20000000.63

Public Works Department
PRICE

PART-G: SITE CLEARANCE

1. Specification Code : 2.3.2.A

SUBHEAD : 2.0

Site Clearence

2.3.2.A Clearing and grubbing road land including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, up to a lead of 1000 metres including removal and disposal of top organic soil not exceeding 150 mm in thickness
In area of light jungle - By Mechanical Means

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	201	Unit=Hectare Taking output=1 Hectare a) Labour					
L-12		Mate	Day	0.16	407.00	65.12	
L-13		Mazdoor b) Machinery	Day	4.0	368.00	1472.00	
P&M-014		Dozer D - 80 - A 12 with attachment for removal of trees & stumps	hour	10.0	3748.00	37480.00	MR213
P&M-053		Tractor - trolley	hour	1.0	365.00	365.00	MR252
					TOTAL	39382.12	
					Cost of 1.0 Hecter	39382.12	

Public Works Department
PRICE

Add Overhead @ 25.0%	9845.53
Add Contractors Profit @ 10.0%	4922.76
Cost index **31.06%**	656.46
Total with Cost index	54806.88
Say	54806.88

2. Specification Code : 2.10.B

SUBHEAD : 2.0

Site Clearence

2.10.B Dismantling of kilometre stone including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and back filling of pit Dismantling of Ordinary KM Stone including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and back filling of pit

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	202	Unit=Each Taking output=one KM stone a) Labour					
L-12		Mate	Day	0.02	407.00	8.14	
L-13		Mazdoor b) Machinery	Day	0.5	368.00	184.00	
P&M-053		Tractor	hour	0.1	365.00	36.50	MR252
					TOTAL	228.64	
					Cost of 1.0 each	228.64	
					Cost of 1 each	228.64	

Public Works Department
PRICE

Add Overhead @ 25.0%	57.16
Add Contractors Profit @ 10.0%	28.57
Cost index **31.06%**	82.05
Total with Cost index	396.44
Say	396.44

3. Specification Code : 2.5.2.A

SUBHEAD : 2.0

Site Clearence

2.5.2.A Dismantling of flexible pavements and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately
Bituminous course - By Mechanical Means

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.

	202	Unit=cum Taking output=1 cum a) Labour					
L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor b) Machinery	Day	0.3	368.00	110.40	
P&M-053		Tractor	hour	0.38	365.00	138.70	MR252
P&M-055		Tractor with Ripper	hour	0.017	393.00	6.68	MR254

TOTAL	259.85
Cost of 1.0 cum	259.85

Add Overhead @ 25.0%	64.96
Add Contractors Profit @ 10.0%	32.48
Cost index **31.06%**	48.88
Total with Cost index	406.18
Say	406.18

Public Works Department
PRICE

4. Specification Code : 2.5.1.B

SUBHEAD : 2.0

Site Clearence

2.5.1.B Dismantling of flexible pavements and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately
Granular courses - By Manual Means

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	202	Unit=cum Taking output=1 cum a) Labour					
L-12		Mate	Day	0.04	407.00	16.28	
L-13		Mazdoor b) Machinery	Day	1.0	368.00	368.00	
P&M-053		Tractor	hour	0.33	365.00	120.45	MR252

TOTAL	504.73
Cost of 1.0 cum	504.73

Add Overhead @ 25.0%	126.18
Add Contractors Profit @ 10.0%	63.09
Cost index **31.06%**	164.11
Total with Cost index	858.12
Say	858.12

PART-H: PAVEMENT BILL

1. Specification Code : 4.1.A.2

SUBHEAD : 4.0

SUB-BASES,BASES AND SHOULDERS

4.1.A.2 Construction of granular sub-base by providing graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401
Grading-II - Plant Mix Method

Public Works Department
PRICE

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = cum Taking output = 225 cum (450 tonne) a) Labour					
	401						
L-12		Mate	Day	0.4	407.00	162.80	
L-15		Mazdoor/Dresser/Sinker (skilled)	Day	2.0	407.00	814.00	
L-13		Mazdoor b) Machinery	Day	8.0	368.00	2944.00	

P&M-101		Wet mix plant @75 tonne capacity per hour	hour	6.0	1213.00	7278.00	MR383
P&M-018		Generator (a) 125 KVA	hour	6.0	702.00	4212.00	MR217
P&M-060		Water Tanker 6 KL capacity 5 km lead with one trip per hour	hour	4.5	250.00	1125.00	MR259
P&M-017		Front End loader 1 cum bucket capacity	hour	6.0	812.00	4872.00	MR216
P&M-102		Tipper 10 tonne	tonne km	450.0	3.00	1350.00	MR384
		Add 10 per cent of cost of carriage to cover loading and unloading			A*10/100	135.0	
P&M-106		Motor Grader 110HP@ 50 cum per hour	hour	6.0	2413.00	14478.00	MR389
P&M-059		Vibratory Roller 8 tonne c) Material Granular sub-base Material as per table 400-1 For Grading-II Material	hour	6.0	1553.00	9318.00	MR258
M-015		26.5 mm to 9.5 mm @ 35 per cent	cum	100.8	1383.77	139484.02	
M-017		9.5 mm to 2.36 mm @ 25 per cent	cum	72.0	1343.77	96751.44	
M-020		2.36 mm below @ 40 per cent	cum	115.2	1303.77	150194.30	
M-189		Water	Kilo litre	27.0	13.00	351.00	MR177

Cost of 225.0 cum	433469.25
Cost of 1 cum	1926.53

Public Works Department
PRICE

Add Overhead @ 25.0%	481.63
Add Contractors Profit @ 10.0%	240.81
Cost index **31.06%**	740.92
Total with Cost index	3389.91
Say	3389.91

2. Specification Code : 4.12

SUBHEAD : 4.0

SUB-BASES,BASES AND SHOULDERS

4.12 Providing, laying, spreading and compacting graded stone aggregate to Wet Mix Macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub- base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.

Public Works Department PRICE

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit=cum Taking output=225 cum (495 tonnes) Labour					
	406						
L-12		Mate	Day	0.48	407.00	195.36	
L-15		Mazdoor/Dresser/Sinker (skilled)	Day	2.0	407.00	814.00	
L-13		Mazdoor Machinery	Day	10.0	368.00	3680.00	
P&M-094		Wet Mix plant 75 TPH capacity	hour	6.6	1213.00	8005.80	MR293
P&M-018		Generator (a) 125 KVA	hour	6.0	702.00	4212.00	MR217

P&M-017		Front End loader 1 cum bucket capacity	hour	6.0	812.00	4872.00	MR216
P&M-035		Paver Finisher Mechanical 100TPH	hour	6.0	983.00	5898.00	MR234
P&M-059		Vibratory Roller 8 tonne	hour	3.9	1553.00	6056.70	MR258
P&M-060		Water Tanker 6 KL capacity	hour	3.0	250.00	750.00	MR259
P&M-058		Truck 5.5 cum per 10 tonnes	tonne km	495.0	3.00	1485.00	MR257
		Add 10 percent of cost of carriage to cover cost of loading and unloading Material (Table 400-13)			A*10/100	148.5	
M-034		Aggregate 45mm to 22.4mm @ 30 per cent	cum	89.1	1349.22	120215.50	
M-031		Aggregate 22.4mm to 2.36mm @ 40 per cent	cum	118.8	1303.77	154887.88	
M-022		2.36 mm & below @ 30 per cent	cum	89.1	1136.27	101241.66	
M-189		Water	Kilo litre	18.0	13.00	234.00	MR177

Public Works Department
PRICE

Cost of 225.0 cum	412697.25
Cost of 1 cum	1834.21

Note

1. Though vibratory roller is required only for 3 hours as per norms, the same is required to be available at site for 6 hours to match with other machines. The usage rates of vibratory roller may be multiplied with a factor of 0.652. As three wheeled smooth steel rollers are commonly in use, the same has been provided as an alternative which can be used if the thickness of individual layer does not exceed 100 mm..

Add Overhead @ 25.0%	458.55
Add Contractors Profit @ 10.0%	229.27
Cost index **31.06%**	723.24
Total with Cost index	3245.29
Say	3245.29

3. Specification Code : 3.18

SUBHEAD : 3.0

EARTH WORK,EROSION CONTROL AND DRAINAGE

3.18 Construction of sub-grade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = cum Taking output = 100 cum a) Labour					
	305						
L-12		Mate	Day	0.04	407.00	16.28	
L-13		Mazdoor b) Machinery	Day	1.0	368.00	368.00	
P&M-026		Hydraulic Excavator of 1 cum bucket @ 60 cum per hour	hour	1.67	1312.00	2191.04	MR225
P&M-102		Tipper 10 tonne capacity	tonne km	175.0	3.00	525.00	MR384
		Add 10 per cent of cost of carriage to cover cost of loading and unloading			A*10/100	52.5	
P&M-014		Dozer D - 80 - A 12 @ 200 cum per hour	hour	0.5	3748.00	1874.00	MR213
P&M-140		Motor Grader for grading @ 50 cum per hour	hour	2.0	2413.00	4826.00	MR471
P&M-060		Water Tanker with 6 km lead	hour	4.0	250.00	1000.00	MR259
P&M-059		Vibratory Roller 8 tonne @ 80 cum per hour c) Material	hour	1.25	1553.00	1941.25	MR258

Public Works Department PRICE

M-189		Water	Kilo litre	24.0	13.00	312.00	MR177
M-092		Compensation for earth taken from private land	cum	100.0	159.71	15971.00	

Cost of 100.0 cum	29077.00
Cost of 1 cum	290.77

Add Overhead @ 25.0%	72.69
Add Contractors Profit @ 10.0%	36.34
Cost index **31.06%**	69.84
Total with Cost index	469.66
Say	469.66

4. Specification Code : 5.1.a

SUBHEAD : 5.0

Bases and Surface courses

Public Works Department PRICE

5.1.a Providing and applying primer coat with bitumen emulsion (SS) on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.70 - 1.0 kg/sqm using mechanical means.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	502	Unit = sqm Taking output = 3500 sqm a) Labour					
L-12		Mate	Day	0.08	407.00	32.56	
L-13		Mazdoor b) Machinery	Day	2.0	368.00	736.00	
P&M-031		Mechanical Broom Hydraulic @ 1250 sqm per hour	hour	2.8	358.00	1002.40	MR230
P&M-001		Air Compressor	hour	2.8	322.00	901.60	MR200

P&M-004		Bitumen Pressure Distributor @ 1750 sqm per hour	hour	2.0	1080.00	2160.00	MR203
P&M-060		Water Tanker 6 KL capacity @ 1 trip per hour c) Material	hour	1.0	250.00	250.00	MR259
M-404		Bitumen Emulsion (SS) @ 0.7 kg per sqm	tonne	2.45	56059.00	137344.55	MR123
M-197		carriage code of Bitumen	tonne	2.45	103.77	254.24	
M-189		Water	Kilo litre	6.0	13.00	78.00	MR177

TOTAL	142759.35
Cost of 3500.0 sqm	142759.35
Cost of 1 sqm	40.79

Note Bitumen primer has been provided @ 0.70 kg per sqm as per clause 502.8. Payment shall be made with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to in clause No. 502.4.3.

Add Overhead @ 25.0%	10.19
Add Contractors Profit @ 10.0%	5.09
Cost index **31.06%**	0.12
Total with Cost index	56.21
Say	56.21

Public Works Department
PRICE

5. Specification Code : 5.2.a

SUBHEAD : 5.0

Bases and Surface courses

5.2.a Providing and applying tack coat with bitumen emulsion(RS) using emulsion pressure distributor at the rate of 0.20 - 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.

	503	Unit = sqm Taking output = 3500 sqm a) Labour					
L-12		Mate	Day	0.08	407.00	32.56	
L-13		Mazdoor b) Manchinery	Day	2.0	368.00	736.00	
P&M-031		Mechanical Broom Hydraulic @ 1250 sqm per hour	hour	2.8	358.00	1002.40	MR230
P&M-001		Air Compressor 250cfm	hour	2.8	322.00	901.60	MR200
P&M-016		Emulsion Pressure Distributor c) Material	hour	2.0	806.00	1612.00	MR215
M-403		Bitumen Emulsion (RS) @ 0.2 kgper sqm	tonne	0.7	33330.00	23331.00	MR121
M-197		carriage code of Bitumen	tonne	0.7	103.77	72.64	

TOTAL	27688.20
Cost of 3500.0 sqm	27688.20
Cost of 1 sqm	7.91

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Note

1. Bitumen emulsion has been provided @ 0.20 kg per sqm as per clause 503.8. Payment shall be made with adjustment, plus or minus, for the variation between this quantity and actual quantity approved by the Engineer after preliminary trials referred to in clause No. 503.4.3
2. An output of 3500 sqm has been considered in case of prime coat and tack coat which can be covered by bituminous courses on the same day.

Add Overhead @ 25.0%	1.97
Add Contractors Profit @ 10.0%	0.98
Cost index **31.06%**	0.10
Total with Cost index	10.98
Say	10.98

6. Specification Code : 5.4.1

SUBHEAD : 5.0

BASES AND SURFACE COURSES

5.4.1 Providing and laying dense bituminous macadam with 80-100 TPH HMP producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder (VG 30) @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects.
Grading - I (37.5 mm Nominal Size)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = cum Taking output = 195 cum (450 tonnes) a) Labour					
	505						
L-12		Mate	Day	0.84	407.00	341.88	
L-13		Mazdoor working with HMP, mechanical broom, paver, roller, asphalt cutter and assistance for setting out lines, levels and layout of construction	Day	14.0	368.00	5152.00	
L-15		Mazdoor/Dresser/Sinker (skilled) for checking line & levels b) Machinery	Day	5.0	407.00	2035.00	
P&M-022		Hotmix Plant - 100 TPH capacity @ 75 tonne per hour	hour	6.0	17438.00	104628.00	MR221
P&M-034		Paver Finisher Hydrostatic with sensor control 100 TPH @ 75 cum per hour	hour	6.0	2694.00	16164.00	MR402
P&M-081		Generator 250 KVA	hour	6.0	702.00	4212.00	MR280

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P&M-017		Front End loader 1 cum bucket capacity	hour	6.0	812.00	4872.00	MR216
P&M-102		Tipper 10 tonne	tonne km	450.0	3.00	1350.00	MR384
		Add 10 per cent of cost of carriage to cover cost of loading and unloading.			B*10/100	135.0	
P&M-044		Smooth Wheeled Roller 8 tonne for initial break down rolling.	hour	3.9	464.00	1809.60	MR243
P&M-059		Vibratory Roller 8 tonne for intermediate rolling.	hour	3.9	1553.00	6056.70	MR258
P&M-045		Tandem Road Roller Finish rolling with 6-8 tonnes smooth wheeled tandem roller. c) Materials i. Bitumen Total weight of mix = 450 tonnes Weight of bitumen = 450 x 4.0/100= 18.0 tonne	hour	3.9	1152.00	4492.80	MR244
M-401		Bitumen VG-30 @ 4.0 per cent of weight of mix	tonne	18.0	35170.00	633060.00	MR101
M-197		carriage code of Bitumen ii. Aggregate Weight of aggregate = 450 - 18.0 = 432.0 tonnes Taking density of aggregate = 1.5 ton/cum Volume of aggregate = 432/1.5 = 288 cum	tonne	18.0	103.77	1867.86	
M-049		Aggregates 37.5 mm to 25 mm 22 per cent	cum	63.36	1353.77	85774.87	
M-265		25 - 10 mm 13 per cent	cum	37.44	1303.77	48813.15	
M-266		10 - 4.75 mm 19 per cent	cum	54.72	1278.77	69974.29	

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PRICE

M-206		4.75 mm and below 44 per cent	cum	126.72	1353.77	171549.73	
M-203		Filler @ 2 per cent of weight of aggregates.	cum	5.76	968.77	5580.12	

Cost of 195.0 cum	1167868.65
Cost of 1 cum	5989.07

Note

1. Although the roller are required only for 3 hours as per norms of output, but the same have to be available at site for six hours as the hot mix plant and paver will take six hours for mixing and paving the output of 450 tonnes considered in this analysis. To cater for the idle period of these rollers, their usage rates have been multiplied by a factor of 0.65.
2.Quantity of Bitumen has been taken for analysis purpose. The actual quantity will depend upon job mix formula.
3. Labour for traffic control, watch and ward and other miscellaneous duties at site including sundries have been included in administrative overheads of the contractor.
4. In case DBM is laid over freshly laid tack coat, provision of mechanical broom and 2 mazdoors shall be deleted as the same has been included in the cost of tack coat.
5. The individual density for each size of aggregates to be used for construction I.e. 37.5-25 mm, 25-10 mm etc. should be found in the laboratory and accordingly the quantities should be ammended for use in field. The average density of 1.5 tonne/cum is only a reference density in this Data Book.
6. The individual percentage of aggregates should be calculated from the total weight of dry aggregates i.e.. excluding the weight of bitumen. The weight of filler will also be 2 per cent by weight of dry aggregates.

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Add Overhead @ 25.0%	1497.26
Add Contractors Profit @ 10.0%	748.63
Cost index **31.06%**	856.53
Total with Cost index	9091.50
Say	9091.50

7. Specification Code : 5.6.1.a

SUBHEAD : 5.0

BASES AND SURFACE COURSES

5.6.1.a Providing and laying bituminous concrete with 80-100 TPH hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder(NRMB) @ 5.2 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects
For Grading - I (19 mm nominal size)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = cum Taking output = 191 cum (450 tonnes) a) Labour					
	507						
L-12		Mate	Day	0.84	407.00	341.88	
L-13		Mazdoor working with HMP, mechanical broom, paver, roller, asphalt cutter and assistance for setting out lines, levels and layout of construction	Day	14.0	368.00	5152.00	
L-15		Mazdoor/Dresser/Sinker (skilled) mazdoor for checking line & levels b) Machinery	Day	5.0	407.00	2035.00	
P&M-022		Hotmix Plant - 100 TPH capacity @ 75 tonne per hour	hour	6.0	17438.00	104628.00	MR221
P&M-105		Paver finisher hydrostactic with sensor control @ 75 cum per hour	hour	6.0	2694.00	16164.00	MR388
P&M-081		Generator 250 KVA	hour	6.0	702.00	4212.00	MR280
P&M-017		Front End loader 1 cum bucket capacity	hour	6.0	812.00	4872.00	MR216

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P&M-102		Tipper 10 tonne capacity	tonne km	450.0	3.00	1350.00	MR384
		Add 10 per cent of cost of carriage to cover cost of loading and unloadin			B*10/100	135.0	
P&M-044		Smooth Wheeled Roller 8 tonne for initial break down rolling.	hour	3.9	464.00	1809.60	MR243
P&M-059		Vibratory Roller 8 tonne for intermediate rolling.	hour	3.9	1553.00	6056.70	MR258
P&M-045		Tandem Road Roller Finish rolling with 6-8 tonnes smooth wheeled tandem roller. c) Material i) Bitumen Total weight of mix = 450 tonnes Weight of bitumen (450x5.2/100) = 23.4 tonnes	hour	3.9	1152.00	4492.80	MR244
M-402		Bitumen (NRMB) @ 5.2 per cent of weight of mix	tonne	23.4	42130.00	985842.00	MR102
M-197		carriage code of Bitumen ii) Aggregate Weight of aggregate = 450 -23.40 = 426.60 tonnes Taking density of aggregate = 1.5 ton/cum Volume of aggregate = 284.4 cum	tonne	23.4	103.77	2428.22	
M-045		Aggregate 20mm to 10mm 35 Percent	cum	99.54	1403.77	139731.27	
M-040D		Aggregates 10 mm to 5 mm 23 Percent	cum	65.412	1403.77	91823.40	
M-208		5 mm and below 40 Percent	cum	113.76	1353.77	154004.88	
M-203		Filler @ 2 per cent of weight of aggregates.	cum	5.688	968.77	5510.36	

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Cost of 191.0 cum	1530589.96
Cost of 1 cum	8013.56

Note

1. Although the rollers are required only for 3 hours as per norms of output, but the same have to be available at site for six hours as the hot mix plant and paver will take six hours for mixing and paving the output of 450 tonnes considered in this analysis. To cater for the idle period of these rollers, their usage rates have been multiplied by a factor of 0.65
2.Quantity of Bitumen has been taken for analysis purpose. The actual quantity will depend upon job mix formula.
3. Labour for traffic control, watch and ward and other miscellaneous duties at site including sundries have been included in administrative overheads of the contractor.
4. The individual density for each size of aggregates to be used for construction i.e. 37.5-25 mm, 25-10 mm etc. should be found in the laboratory and accordingly the quantities should be ammended for use in field. The average density of 1.5 tonne/cum is only a reference density in this Data Book.
5. The individual percentage of aggregates should be calculated from the total weight of dry aggregates i.e.. excluding the weight of bitumen. The weight of filler will also be 2 per cent by weight of dry aggregates.

Add Overhead @ 25.0%	2003.39
Add Contractors Profit @ 10.0%	1001.69
Cost index **31.06%**	896.69
Total with Cost index	11915.34
Say	11915.34

Public Works Department
PRICE

PART-I: ROAD FURNITURE

1. Specification Code : 8.14.1

SUBHEAD : 8.0

Traffic signs,Markings & Other Road Appurtenances

8.14.1 Reinforced cement concrete M15 grade Kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc.
5th Kilometre stone (precast)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	804	Unit = Nos. Taking output = 6 Nos.					

12.8.A.1		Rate as per item Number of SH: Foundations M-15 grade of concrete	cum	2.35	4397.81	10334.85	
13.6		Rate as per item Number of SH: Sub-Structure Steel reinforcement @ 5 kg per sqm	MT	0.02208	43054.77	950.65	
3.13.1.A		Rate as per item Number of SH: Earth Work,Erosion Control and Drainage Excavation in soil for foundation	cum	1.68	307.42	516.47	
8.8		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting two coats on concrete surface	sqm	9.85	61.49	605.68	
8.3.2		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Lettering on km post (average 30 letters of 10 cm height each) Transportation and fixing f) Labour	Cm ht per letter	1800.0	0.54	972.00	
L-12		Mate	Day	0.26	407.00	105.82	
L-11		Mason (1st class)	Day	0.6	487.00	292.20	
L-13		Mazdoor g) Machinery	Day	6.0	368.00	2208.00	
P&M-053		Tractor	hour	6.0	365.00	2190.00	MR252

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TOTAL	18175.67
Cost of 6.0 each	18175.67
Cost of 1 each	3029.28

Add Overhead @ 25.0%	757.32
Add Contractors Profit @ 10.0%	378.66
Cost index **31.06%**	1095.54

Total with Cost index	5260.80
Say	5260.80

2. Specification Code : 8.14.2

SUBHEAD : 8.0

Traffic signs,Markings & Other Road Appurtenances

8.14.2 Reinforces cement concrete M 15 grade Kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc
Ordinary kilometer stone (precast)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	804	Unit = Nos. Taking output = 14 Nos.					
12.8.A.1		Rate as per item Number of SH: Foundations M-15 grade of concrete	cum	3.77	4397.81	16579.74	
13.6		Rate as per item Number of SH: Sub-Structure Steel reinforcement @ 5 kg per sqm	MT	0.02632	43054.77	1133.20	
3.13.1.A		Rate as per item Number of SH: Earth Work,Erosion Control and Drainage Excavation in soil for foundation	cum	2.77	307.42	851.55	
8.8		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting two coats on concrete surface	sqm	11.41	61.49	701.60	

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8.3.2		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Lettering on km post (average 12 letters of 10 cm height each) Transportation and fixing Labour	Cm ht per letter	1680.0	0.54	907.20	
L-12		Mate	Day	0.32	407.00	130.24	
L-11		Mason (1st class)	Day	1.0	487.00	487.00	
L-13		Mazdoor Machinery	Day	7.0	368.00	2576.00	
P&M-053		Tractor	hour	6.0	365.00	2190.00	MR252

TOTAL	25556.53
Cost of 14.0 each	25556.53
Cost of 1 each	1825.47

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Add Overhead @ 25.0%	456.36
Add Contractors Profit @ 10.0%	228.18
Cost index **31.06%**	683.71
Total with Cost index	3193.74
Say	3193.74

3. Specification Code : 8.14.3

SUBHEAD : 8.0

Traffic signs,Markings & Other Road Appurtenances

8.14.3 Reinforced cement concrete M15 grade Hectometer stone of standard design as per IRC-8-1980, fixing in position including painting and printing etc
Hectometer stone (precast)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	804	Unit = Nos. Taking output = 33 Nos.					
12.8.A.1		Rate as per item Number of SH: Foundations M-15 grade of concrete	cum	1.58	4397.81	6948.54	
13.6		Rate as per item Number of SH: Sub-Structure Steel reinforcement @ 5 kg per sqm	MT	0.066	43054.77	2841.61	
3.13.1.A		Rate as per item Number of SH: Earth Work,Erosion Control and Drainage Excavation in soil for foundation	cum	1.39	307.42	427.31	
8.8		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting two coats on concrete surface	sqm	6.27	61.49	385.54	
8.3.2		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Lettering on km post (average 1 letter of 10 cm height each) Transportation and fixing f) Labour	Cm ht per letter	330.0	0.54	178.20	
L-12		Mate	Day	0.34	407.00	138.38	
L-11		Mason (1st class)	Day	1.5	487.00	730.50	
L-13		Mazdoor g) Machinery	Day	7.0	368.00	2576.00	
P&M-053		Tractor	hour	6.0	365.00	2190.00	MR252

TOTAL	16416.08
Cost of 33.0 no	16416.08
Cost of each	497.46

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Note The rate for excavation, cement concrete, steel reinforcement, painting and lettering may be taken from respective chapters.

Add Overhead @ 25.0%	124.36
Add Contractors Profit @ 10.0%	62.18
Cost index **31.06%**	178.93
Total with Cost index	862.94
Say	862.94

4. Specification Code : 8.16

SUBHEAD : 8.0

Traffic signs,Markings & Other Road Appurtenances

8.16 Reinforced cement concrete M-15 grade boundary pillars of standard design as per IRC:25-19767, fixed in position including finishing and lettering but excluding painting .

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	806	Unit = Each Taking output = 57 Nos.					
12.8.A.1		Rate as per item Number of SH: Foundations M-15 grade of the boundary stone	cum	1.25	4397.81	5497.26	
13.6		Rate as per item Number of SH: Sub-Structure Steel reinforcement	MT	0.0798	43054.77	3435.77	
3.13.1.A		Rate as per item Number of SH: Earth Work,Erosion Control and Drainage Excavation in soil	cum	10.72	307.42	3295.54	

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8.3.2		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Lettering, each 10 cm high Transportation and fixing Labour	Cm ht per letter	2280.0	0.54	1231.20	
L-12		Mate	Day	0.57	407.00	231.99	
L-13		Mazdoor Machinery	Day	14.25	368.00	5244.00	
P&M-053		Tractor Material	hour	6.0	365.00	2190.00	MR252
M-008		Gravel/Quarry spall at Site	cum	11.97	822.08	9840.30	

TOTAL	30966.06
Cost of 57.0 no	30966.06
Cost of each	543.26

Note In case of soft ground, a proper foundation may be provided as per approved design. In case foundation is required to be provided, the items of excavation and foundation concrete are required to be measured and paid separately.

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Add Overhead @ 25.0%	135.81
Add Contractors Profit @ 10.0%	67.90
Cost index **31.06%**	213.23
Total with Cost index	960.22
Say	960.22

5. Specification Code : 8.11.1

SUBHEAD : 8.0

Traffic signs,Markings & Other Road Appurtenances

8.11.1 Painting lines, dashes, arrows etc on roads in two coats on new work with ready mixed road marking paint conforming to IS:164 on bituminous surface, including cleaning the surface of all dirt, dust and other foreign matter, demarcation at site and traffic control
Over 10 cm in width

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	803	Unit = sqm Taking output = 10 sqm a) Labour					
L-12		Mate	Day	0.09	407.00	36.63	
L-18		Painter 1 class	Day	0.55	448.00	246.40	
L-13		Mazdoor b) Material	Day	1.55	368.00	570.40	
M-132		Pavement Marking Paint	Litre	1.48	140.00	207.20	
					TOTAL	1060.63	
					Cost of 10.0 sqm	1060.63	
					Cost of 1 sqm	106.06	

Add Overhead @ 25.0%	26.51
Add Contractors Profit @ 10.0%	13.25
Cost index **31.06%**	45.29
Total with Cost index	191.13
Say	191.13

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6. Specification Code : 8.4.3

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.4.3 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.

60 cm circular

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Each Taking output = one traffic sign					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Excavation for foundation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	
8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron & post two coats a) Labour (For fixing at site)	sqm	0.827	63.91	52.85	
L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor b) Material	Day	0.25	368.00	92.00	
M-210		GI pipe 50 mm dia 3.10m long	metre	3.1	220.00	682.00	
M-179		Structural Steel Mild steel angle 25 x 25 x 3 - 2.4m @ 1.10Kg/m	tonne	0.00264	37842.24	99.90	
M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.283	3495.00	989.09	MR419

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		Add 2 per cent of cost of material towards cost of drilling holes, nuts, bolts etc. c) Machinery			(A+B+C)*2/ 100	35.4196	
P&M-053		Tractor	hour	0.01	365.00	3.65	MR252

Cost of 1.0 each	2495.47

Note 1.Rate for excavation, cement concrete M-15 may be taken from respective chapters 2. The depth of foundation and quantity of cement concrete in the foundation are indicative. These may be increased for areas having higher wind velocities like in coastal areas. This is applicable to all road signs and directions boards. 3. Price of Aluminium sheeting is inclusive of cost for lettering.

Add Overhead @ 25.0%	623.86
Add Contractors Profit @ 10.0%	311.93
Cost index **31.06%**	620.86
Total with Cost index	4052.14
Say	4052.14

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7. Specification Code : 8.4.9

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.4.9 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.75 cm circular

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.

		Unit = Each Taking output = one traffic sign					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Excavation for foundation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	
8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron post two coats Labour (For fixing at site)	sqm	0.827	63.91	52.85	
L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor Material	Day	0.25	368.00	92.00	
M-210		GI pipe 50 mm dia	metre	3.1	220.00	682.00	
M-179		Structural Steel	tonne	0.00264	37842.24	99.90	
M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.442	3495.00	1544.79	MR419
		Add 2 per cent of cost of angle iron towards cost of drilling holes, nuts, bolts etc. c) Machinery			(A+B+C)*2/100	46.5338	
P&M-053		Tractor	hour	0.01	365.00	3.65	MR252

	Cost of 1.0 each	3062.29

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Note 1. Rate for excavation, cement concrete M-15 may be taken from respective chapters 2. The depth of foundation and quantity of cement concrete in the foundation are indicative. These may be increased for areas having higher wind velocities like in coastal areas. This is applicable to all road signs and directions boards.3. Price of Aluminium sheeting for cost for lettering.

Add Overhead @ 25.0%	765.57
Add Contractors Profit @ 10.0%	382.78
Cost index **31.06%**	620.86
Total with Cost index	4831.52
Say	4831.52

8. Specification Code : 8.4.10

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

Public Works Department PRICE

8.4.10 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.
90 cm circular

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Each Taking output = one traffic sign					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Excavation for foundation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	

8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron post two coats Labour (For fixing at site)	sqm	0.827	63.91	52.85	
L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor Material	Day	0.25	368.00	92.00	
M-210		GI pipe 50 mm dia	metre	3.1	220.00	682.00	
M-179		Structural Steel	tonne	0.00264	37842.24	99.90	
M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.636	3495.00	2222.82	MR419
		Add 2 per cent of cost of angle iron towards cost of drilling holes, nuts, bolts etc. c) Machinery			(A+B+C)*2/100	60.0944	
P&M-053		Tractor	hour	0.01	365.00	3.65	MR252

Public Works Department
PRICE

Cost of 1.0 each	3753.88

Note

1.Rate for excavation, cement concrete M-15 may be taken from respective chapters 2. The depth of foundation and quantity of cement concrete in the foundation are indicative. These may be increased for areas having higher wind velocities like in coastal areas. This is applicable to all road signs and directions boards.3. Price of Aluminium sheeting is inclusive of cost for lettering.

Add Overhead @ 25.0%	938.47
Add Contractors Profit @ 10.0%	469.23
Cost index **31.06%**	620.86
Total with Cost index	5782.45
Say	5782.45

9. Specification Code : 8.4.2

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.4.2 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.
60 cm equilateral triangle

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Each Taking output = one traffic sign					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Excavation for foundation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	
8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron & post two coats a) Labour (For fixing at site)	sqm	0.827	63.91	52.85	
L-12		Mate	Day	0.01	407.00	4.07	

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L-13		Mazdoor b) Material	Day	0.25	368.00	92.00	
M-210		GI pipe 50 mm dia 3.10 m long	metre	3.1	220.00	682.00	
M-179		Structural Steel Mild steel angle 25 x 25 x 3 - 2.4m @ 1.10Kg/m	tonne	0.00264	37842.24	99.90	
M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.156	3495.00	545.22	MR419
		Add 2 per cent of cost of material towards cost of drilling holes, nuts, bolts etc. c) Machinery			(A+B+C)*2/100	26.5424	
P&M-053		Tractor	hour	0.01	365.00	3.65	MR252

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PRICE

Cost of 1.0 each	2042.73

Note 1.Rate for excavation, cement concrete M-15 may be taken from respective chapters 2. The depth of foundation and quantity of cement concrete in the foundation are indicative. These may be increased for areas having higher wind velocities like in coastal areas. This is applicable to all road signs and directions boards. 3. Price of Aluminium sheeting is inclusive of cost for lettering.

Add Overhead @ 25.0%	510.68
Add Contractors Profit @ 10.0%	255.34
Cost index **31.06%**	620.86
Total with Cost index	3429.62
Say	3429.62

10. Specification Code : 8.4.1

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.4.1 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.
90 cm equilateral triangle

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Each Taking output = one traffic sign					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Excavation for foundation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	
8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron & post two coats a) Labour (For fixing at site)	sqm	0.827	63.91	52.85	
L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor b) Material	Day	0.25	368.00	92.00	
M-210		GI pipe 50 mm dia 3.1 m long	metre	3.1	220.00	682.00	

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M-179		Structural Steel Mild steel angle 25 x 25 x 3 - 2.4m @ 1.10Kg/m	tonne	0.00264	37842.24	99.90	
M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.35	3495.00	1223.25	MR419
		Add 2 per cent of cost of material towards cost of drilling holes, nuts, bolts etc. c) Machinery			(A+B+C)*2/100	40.103	
P&M-053		Tractor	hour	0.01	365.00	3.65	MR252

Cost of 1.0 each	2734.32

Note 1.Rate for excavation, cement concrete M-15 may be taken from respective chapters 2. The depth of foundation and quantity of cement concrete in the foundation are indicative. These may be increased for areas having higher wind velocities like in coastal areas. This is applicable to all road signs and directions boards. 3. Price of Aluminium sheeting is inclusive of cost for lettering.

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Add Overhead @ 25.0%	683.58
Add Contractors Profit @ 10.0%	341.79
Cost index **31.06%**	620.86
Total with Cost index	4380.56
Say	4380.56

11. Specification Code : 8.4.12

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.4.12 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.
50cmx 60 cm rectangular (Single chevron etc.)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Each Taking output = one traffic sign					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Excavation for foundation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	
8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron post two coats Labour (For fixing at site)	sqm	0.827	63.91	52.85	
L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor Material	Day	0.25	368.00	92.00	
M-210		GI pipe 50 mm dia	metre	3.1	220.00	682.00	
M-179		Structural Steel	tonne	0.00264	37842.24	99.90	

Public Works Department
PRICE

M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.3	3495.00	1048.50	MR419
		Add 2 per cent of cost of angle iron towards cost of drilling holes, nuts, bolts etc. c) Machinery			(A+B+C)*2/100	36.608	
P&M-053		Tractor	hour	0.01	365.00	3.65	MR252

Cost of 1.0 each	2556.08

Note 1.Rate for excavation, cement concrete M-15 may be taken from respective chapters 2. The depth of foundation and quantity of cement concrete in the foundation are indicative. These may be increased for areas having higher wind velocities like in coastal areas. This is applicable to all road signs and directions boards.3. Price of Aluminium sheeting is inclusive of cost for lettering.

Add Overhead @ 25.0%	639.02
Add Contractors Profit @ 10.0%	319.51
Cost index **31.06%**	620.86
Total with Cost index	4135.48
Say	4135.48

Public Works Department
PRICE

12. Specification Code : 8.35

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.35 Providing and fixing reflective road studs (Raised Pavement Marker) of ' category A' made out of ASA/HIPS/ABS moulded body with shanks and conforming to ASTM D 4280, strong enough to support a load of more than 13.635 T when tested in accordance with ASTM D 4280, reflective panel confirming to ASTM D 788, and reflectivity conforming to clause 804.4. including installation, drilling, fixing with adhesive etc. with 2 years warranty for the road stud as well as for in field performance as per clause 804.7.3

Road Markers/Road Stud with Lense Reflector :-

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.

		Unit = Nos Taking output = 50Nos a) Labour					
	804						
L-12		Mate	Day	0.04	407.00	16.28	
L-13		Mazdoor b) Material	Day	1.0	368.00	368.00	
M-214		Roads studs 100 x 100 mm fitted with lense reflectors	each	50.0	105.00	5250.00	
		Add 10 per cent of cost of material for fixing and installation.			A*10/100	525.0	

Cost of 50.0 no	6159.50
Cost of each	123.19

Add Overhead @ 25.0%	30.79
Add Contractors Profit @ 10.0%	15.39
Cost index **31.06%**	52.61
Total with Cost index	222.00
Say	222.00

Public Works Department
PRICE

13. Specification Code : 8.23.A

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.23.A Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per clause 811.3

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Running metre Taking output = 4.5 metre length					
	811.3						
L-12		Mate	Day	0.06	407.00	24.42	
L-02		Blacksmith	Day	0.5	487.00	243.50	
L-13		Mazdoor b) Machinery	Day	1.0	368.00	368.00	
P&M-053		Tractor - trolley c) Material	hour	0.1	365.00	36.50	MR252
M-227		Corrugated sheet,3 mm thick "Thrie" beam section railing,4.5 m in length	kg	41.21	52.00	2142.92	
M-179		Structural Steel Channel post 150 x 75 x 5 mm, 2 m long,3 Nos @ 16.4 kg per metre	tonne	0.08856	37842.24	3351.31	
M-179		Structural Steel Spacer 150 x 75 x 5 mm channel 0.546 m long,3 Nos	tonne	0.01624	37842.24	614.56	
M-130		Nuts and bolts	kg	20.0	51.00	1020.00	
M-253		Galvanization cost for structural steel for W Beam	L.S	1.0	437.00	437.00	MR466
		Add 25 per cent of the cost of material for fabrication, nuts, bolts and washers etc.)			(B+C+D+E)*25/100	1782.2	

Cost of 4.5 metre	10020.42
Cost of 1 metre	2226.76

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Note 1. In the case of median crash barrier, 'W' metal beam or thrie beam section should be provided on both sides of the vertical posts fixed in the median. Extra provision for metal beam railing and spacer is required to be made when fixed in the median depending on approved design.

Add Overhead @ 25.0%	556.69
Add Contractors Profit @ 10.0%	278.34
Cost index **31.06%**	906.05
Total with Cost index	3967.85
Say	3967.85

14. Specification Code : od35479/2019_2020

od35479/2019_2020 : Providing and laying factory made chamfered edge Cement Concrete paver blocks infootpath, parks, lawns, drive ways or light traffic parking etc, of required strength, thickness & size/ shape, madeby table vibratory method using PU mould, laid in required colour & pattern over 50mm thick compacted bed ofsand, compacting and proper embedding/laying of inter locking paver blocks into the sand bedding layer throughvibratory compaction by using plate vibrator, filling the joints with sand and cutting of paver blocks as perrequired size and pattern, finishing and sweeping extra sand. complete all as per direction of Engineer-in-Charge. 60mm thick cement concrete paver block of M35 grade with approved colour, design & pattern

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Code	Description	Unit	Quantity	Rate	Amount
7773	Coloured inter locking C.C. paver Block	sqm	10.0	500.0	5000.0 0
0983	Fine sand (zone IV)	cum	0.5	760.0	380.0 0
2261	Fine sand (1 part badarpur sand : 2 parts jamuna sand	cum	0.65	103.77	67.45 0
0123	Mason (brick layer) Ist class	Day	0.5	487.0	243.5 0
0124	Mason (brick layer)2nd class	Day	0.5	448.0	224.0 0
0114	Beldar	Day	1.0	368.0	368.0 0
0115	Coolie	Day	0.5	368.0	184.0 0
9999	Sundries	L.S	25.0	1.73	43.25 0
				TOTAL	6510.20
				cost for 10.0 cum	6510.20
				cost for one cum	651.02
				say	651.02
				Add Overhead @ 25.0%	162.75

Add Contractors Profit @ 10.0%	81.37
SAY	895.15

Cost index **31.06 %**	278.03
Total with Cost index	1173.19
Say	1173.19

15. Specification Code : od35561/2019_2020

od35561/2019_2020 : Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3

Code	Description	Unit	Quantity	Rate	Amount
MR	Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3Delete	no	1.0	920000.0	920000.0
				TOTAL	920000.00
				cost for one no	920000.0
				say	920000.0
				Add Overhead @ 25.0%	230000.00
				Add Contractors Profit @ 10.0%	115000.00
				SAY	1265000.00
				Cost index **31.06 %**	0.00
				Total with Cost index	1265000.00
				Say	1265000.00

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16. Specification Code : od35562/2019_2020

od35562/2019_2020 : Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3

Code	Description	Unit	Quantity	Rate	Amount
MR	Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3	no	1.0	460000.0	460000.0
				TOTAL	460000.00
				cost for one no	460000.0
				say	460000.0
				Add Overhead @ 25.0%	115000.00
				Add Contractors Profit @ 10.0%	57500.00
				SAY	632500.00
				Cost index **31.06 %**	0.00
				Total with Cost index	632500.00
				Say	632500.00

17. Specification Code : od35563/2019_2020

Public Works Department

od35563/2019_2020 : Providing and fixing reflective Solar road studs (Raised Pavement Marker) of ' category A' made out of ASA/HIPS/ABS moulded body with shanks and conforming to ASTM D 4280, strong enough to support a load of more than 13.635 T when tested in accordance with ASTM D 4280, reflective panel confirming to ASTM D 788, and reflectivity conforming to clause 804.4. including installation, drilling, fixing with adhesive etc. with 2 years warranty for the road stud as well as for in field performance as per clause 804.7.3Solar Stud

PRICE

Code	Description	Unit	Quantity	Rate	Amount
MR	Solar Studs	no	1.0	1818.18	1818.18
				TOTAL	1818.18
				cost for one no	1818.18
				say	1818.18
				Add Overhead @ 25.0%	454.54
				Add Contractors Profit @ 10.0%	227.27
				SAY	2499.99
				Cost index **31.06 %**	0.00
				Total with Cost index	2500.00

Say	2500.00

18. Specification Code : od35564/2019_2020

od35564/2019_2020 : High Mast light of pole height 25m

Code	Description	Unit	Quantity	Rate	Amount
MR	High Mast light of pole height 25m	no	1.0	381818.18	381818.18
				TOTAL	381818.18
				cost for one 100 meter	381818.2
				say	381818.2
				Add Overhead @ 25.0%	95454.55
				Add Contractors Profit @ 10.0%	47727.27
				SAY	525000.02
				Cost index **31.06 %**	0.00
				Total with Cost index	525000.03
				Say	525000.03

19. Specification Code : 8.15

Public Works Department
PRICE

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.15 Supplying and installation of delineator (Road way indicators) posts 80- 100cm high above ground level, pained black and white in 15 cm wide strips, fitted with min. 80 x 100 mm rectangular or 75 mm dia circular retro reflectorised panels at the top with minimum visibility of 300m with provisions to prevent edge lifting and vandalisam, and conforming to clause 806 , IRC-79 and the drawings including fixing to ground (The deleniator shall be of approved type as per specification)

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = Each Taking output= 30 Nos. a) Labour					
	806						
L-12		Mate	Day	0.04	407.00	16.28	

L-13		Mazdoor b) Material	Day	1.0	368.00	368.00	
M-091		Delineators from ISI certified firm as per the standard Cost of approved type of delineators from ISI certified firm as per the standard drawing given in IRC - 79	each	30.0	275.00	8250.00	
		Add 10 per cent cost of material for installation			B*10/100	825.0	

Cost of 30.0 each	9459.30
Cost of 1 each	315.31

Note (i) The specification for the post may be modified suitably as per manufactures specification for other approved type posts and cost of material also modified accordingly in such cases.(ii) In case of soft ground, a proper foundation of size 30 x 30 x 45 cm or as required may be provided as per approved design. In case foundation required to be provided, the items of excavation and foundation concrete are required to be measured and included in the estimate.

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Add Overhead @ 25.0%	78.82
Add Contractors Profit @ 10.0%	39.41
Cost index **31.06%**	134.66
Total with Cost index	568.21
Say	568.21

20. Specification Code : 8.29.2

SUBHEAD : 8.0

Traffic signs,Markings & Other Road Appurtenances

8.29.2 Providing and laying of a reinforced cement concrete pipe duct, 300 mm dia, across the road (new construction), extending from drain to drain in cuts and toe of slope to toe of slope in fills, constructing head walls at both ends, providing a minimum fill of granular material over top and sides of RCC pipe as per IRC:98-1997, bedded on a 0.3 m thick layer of granular material free of rock pieces, outer to outer distance of pipe at least half dia of pipe subject to minimum 450 mm in case of double and triple row ducts, joints to be made leak proof, invert level of duct to be above higher than ground level to prevent entry of water and dirt, all as per IRC: 98 - 1997 and approved drawings.

Cable Duct Across the Road - Double row for two utility services

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	suggestive	Unit = Running metre Taking output = 20metres					
12.7.B		Rate as per item Number of SH: Foundations Random Rubble brick/Brick masonry in cement mortar 1:6 for head wall both sides. Labour	cum	3.37	3938.28	13272.00	
L-12		Mate	Day	0.05	407.00	20.35	
L-13		Mazdoor	Day	2.0	368.00	736.00	
L-15		Mazdoor/Dresser/Sinker (skilled) Material	Day	0.25	407.00	101.75	
M-151		RCC Pipe NP 4 heavy duty non pressure pipe 300 mm dia	metre	40.0	1506.80	60272.00	
M-009		Granular Material or hard murrum for GSB works at Site Granular soil with PI less than 6 for bedding and sides of pipe (0.6 x 0.6 x 40 m)	cum	14.4	903.77	13014.29	
M-083		Collar for joints 300mm dia	no	18.0	55.00	990.00	
12.6.B		Rate as per item Number of SH: Foundations Cement mortar 1:2 for joints Machinery	cum	0.04	5440.79	217.63	
P&M-053		Tractor	hour	1.0	365.00	365.00	MR252
					TOTAL	88989.02	
					Cost of 20.0 RM	88989.02	
					Cost of 1 RM	4449.45	

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Add Overhead @ 25.0%	1112.36
Add Contractors Profit @ 10.0%	556.18
Cost index **31.06%**	1892.45
Total with Cost index	8010.45
Say	8010.45

21. Specification Code : 8.5

SUBHEAD : 8.0

TRAFFIC SIGNS,MARKINGS & OTHER ROAD APPURTENANCES

8.5 Providing and fixing of direction and place identification retro-reflectorised sign with 7 years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with area not exceeding 0.9 sqm, with suitable back supporting frame of MS angle 40x40x6 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.

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Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
		Unit = sqm Taking output = 0.9 sqm					
	801						
12.1.A.1		Rate as per item Number of SH: Foundations Earthwork excavation	cum	0.216	134.50	29.05	
12.8.A		Rate as per item Number of SH: Foundations Cement concrete M15 grade	cum	0.12	4228.66	507.44	
8.9.A		Rate as per item Number of SH: Traffic signs,Markings & Other Road Appurtenances Painting angle iron & post two coats a) Labour (For fixing at site)	sqm	1.316	63.91	84.11	

L-12		Mate	Day	0.01	407.00	4.07	
L-13		Mazdoor b) Material	Day	0.2	368.00	73.60	
M-210		GI pipe 50 mm dia 3.4m long	metre	3.4	220.00	748.00	
M-179		Structural Steel Mild steel angle iron 40mm x 40 mm x 6 mm,4.2metres long @ 3.498kg/m	tonne	0.01469	37842.24	555.90	
M-212		Aluminium sheeting fixed with ASTM Type IV retroreflective sheeting	sqm	0.9	3495.00	3145.50	MR419
		Including 2 per cent of material for drilling holes, nuts, bolts, fabrication etc. c) Machinery			(A+B+C)*2/100	88.988	
P&M-053		Tractor	hour	0.02	365.00	7.30	MR252

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Cost of 0.9 sqm	5243.96
Cost of 1 sqm	5826.62

Note i) Rate for excavation, cement concrete M-15 and painting may be taken from respective chapters

Add Overhead @ 25.0%	1456.65
Add Contractors Profit @ 10.0%	728.32
Cost index **31.06%**	948.61
Total with Cost index	8960.22
Say	8960.22

22. Specification Code : od35591/2019_2020

od35591/2019_2020 : Informatory Sign1)Advance Direction Sign2)Reassurance Sign

Code	Description	Unit	Quantity	Rate	Amount
MR	Informatory Sign 1)Advance Direction Sign 2)Reassurance Sign	no	1.0	3693.09	3693.09
				TOTAL	3693.09
				cost for one no	3693.09
				say	3693.09
				Add Overhead @ 25.0%	923.27
				Add Contractors Profit @ 10.0%	461.63
				SAY	5077.99
				Cost index **31.06 %**	0.00
				Total with Cost index	5078.00
				Say	5078.00

23. Specification Code : od35592/2019_2020

od35592/2019_2020 : Facility Information Sign1)Flag Type2)Informatory Sign3)Facility Informatory sign

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Code	Description	Unit	Quantity	Rate	Amount
MR	Facility Information Sign 1)Flag Type 2)Informatory Sign 3)Facility Informatory sign	no	1.0	2436.36	2436.36
				TOTAL	2436.36
				cost for one no	2436.36
				say	2436.36
				Add Overhead @ 25.0%	609.09
				Add Contractors Profit @ 10.0%	304.54
				SAY	3349.99
				Cost index **31.06 %**	-0.01
				Total with Cost index	3350.00

Say	3350.00

24. Specification Code : od35593/2019_2020

od35593/2019_2020 : Informatory Sign1)Flag type Direction Sign

Code	Description	Unit	Quantity	Rate	Amount
MR	Informatory Sign 1)Flag type Direction Sign	no	1.0	2245.82	2245.82
				TOTAL	2245.82
				cost for one no	2245.82
				say	2245.82
				Add Overhead @ 25.0%	561.45
				Add Contractors Profit @ 10.0%	280.72
				SAY	3088.00
				Cost index **31.06 %**	0.00
				Total with Cost index	3088.00
				Say	3088.00

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25. Specification Code : od35594/2019_2020

od35594/2019_2020 : Construction ZoneInformatory Sign

Code	Description	Unit	Quantity	Rate	Amount
MR	Construction Zone Informatory Sign	no	1.0	2690.9	2690.9
				TOTAL	2690.90
				cost for one no	2690.9
				say	2690.9
				Add Overhead @ 25.0%	672.72
				Add Contractors Profit @ 10.0%	336.36
				SAY	3699.98
				Cost index **31.06 %**	0.00
				Total with Cost index	3699.99

Say	3699.99

26. Specification Code : od35595/2019_2020

od35595/2019_2020 : Construction ZoneMandatory Sign

Code	Description	Unit	Quantity	Rate	Amount
MR	Construction Zone Mandatory Sign	no	1.0	3096.72	3096.72
				TOTAL	3096.72
				cost for one no	3096.72
				say	3096.72
				Add Overhead @ 25.0%	774.18
				Add Contractors Profit @ 10.0%	387.09
				SAY	4257.99
				Cost index **31.06 %**	0.00
				Total with Cost index	4257.99
				Say	4257.99

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27. Specification Code : od35596/2019_2020

od35596/2019_2020 : Construction ZoneCautionary sign

Code	Description	Unit	Quantity	Rate	Amount
MR	Construction Zone Cautionary sign	no	1.0	2415.27	2415.27
				TOTAL	2415.27
				cost for one no	2415.27
				say	2415.27
				Add Overhead @ 25.0%	603.81
				Add Contractors Profit @ 10.0%	301.90
				SAY	3320.99
				Cost index **31.06 %**	0.00
				Total with Cost index	3321.00

Say	3321.00

28. Specification Code : od35597/2019_2020

od35597/2019_2020 : Delineators Stickers Provided at the Place of WBCB in the Edge of the Carriageway

Code	Description	Unit	Quantity	Rate	Amount
MR	Delineators Stickers Provided at the Place of WBCB in the Edge of the Carriageway	no	1.0	436.36	436.36
				TOTAL	436.36
				cost for one no	436.36
				say	436.36
				Add Overhead @ 25.0%	109.09
				Add Contractors Profit @ 10.0%	54.54
				SAY	599.99
				Cost index **31.06 %**	0.00
				Total with Cost index	600.00
				Say	600.00

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29. Specification Code : od35600/2019_2020

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od35600/2019_2020 : Providing and erecting Overhead Signs complete as per Drawing and Technical Specification Clause 802Forgiving Delineator Post

Code	Description	Unit	Quantity	Rate	Amount
MR	Providing and erecting Overhead Signs complete as per Drawing and Technical Specification Clause 802 Forgiving Delineator Post	no	1.0	728.72	728.72
				TOTAL	728.72
				cost for one no	728.72
				say	728.72
				Add Overhead @ 25.0%	182.18
				Add Contractors Profit @ 10.0%	91.09
				SAY	1001.99
				Cost index **31.06 %**	-0.01

Total with Cost index	1001.99
Say	1001.99

30. Specification Code : od35601/2019_2020

od35601/2019_2020 : Providing and Fixing retro-reflected road delineators complete as per drawing and technical specification Clause 805One way Hazard Marker

Code	Description	Unit	Quantity	Rate	Amount
MR	Providing and Fixing retro-reflected road delineators complete as per drawing and technical specification Clause 805 One way Hazard Marker	no	1.0	357.09	357.09
				TOTAL	357.09
				cost for one no	357.09
				say	357.09
				Add Overhead @ 25.0%	89.27
				Add Contractors Profit @ 10.0%	44.63
				SAY	490.99
				Cost index **31.06 %**	0.00
				Total with Cost index	491.00
				Say	491.00

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31. Specification Code : od35602/2019_2020

od35602/2019_2020 : Providing and erecting street light mounted on a steel circular hollow pole of standard specifications for street lighting, 9 m high spaced 40 m apart, 1.8 m overhang on both sides if fixed in the median and on one side if fixed on the footpath, fitted with sodium vapour lamp and fixed firmly in concrete foundation.For Fixing in Median

Code	Description	Unit	Quantity	Rate	Amount

MR	Providing and erecting street light mounted on a steel circular hollow pole of standard specifications for street lighting, 9 m high spaced 40 m apart, 1.8 m overhang on both sides if fixed in the median and on one side if fixed on the footpath, fitted with sodium vapour lamp and fixed firmly in concrete foundation. For Fixing in Median	no	1.0	72727.27	72727.27

TOTAL	72727.27
cost for one no	72727.27
say	72727.27
Add Overhead @ 25.0%	18181.81
Add Contractors Profit @ 10.0%	9090.90
SAY	99999.99
Cost index **31.06 %**	-0.01
Total with Cost index	100000.00
Say	100000.00

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Drainage Works

1. Specification Code : od35357/2019_2020

od35357/2019_2020 : Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Substructure

Code	Description	Unit	Quantity	Rate	Amount
M-082	Cold twisted bars (HYSD Bars)	tonne	1.33081	37392.24	49761.85 *()*
M-072	Binding wire	kg	6.0	48.09	288.54 *()*
L-12	Mate	Day	0.34	407.0	138.38 *()*
L-02	Blacksmith	Day	2.0	487.0	974.0 *()*
L-13	Mazdoor	Day	6.5	368.0	2392.0 *()*
				TOTAL	53554.77
				cost for one MT	53554.77
				say	53554.77
				Add Overhead @ 25.0%	13388.69
				Add Contractors Profit @ 10.0%	6694.34

SAY	73637.80

Cost index **31.06 %**	22871.90
Total with Cost index	96509.71
Say	96509.71

2. Specification Code : 13.5.B

SUBHEAD : 13.0

SUB-STRUCTURE

13.5.B Plain/Reinforced Cement Concrete in sub-structure complete as per drawing and Technical Specifications
PCC Grade M20 - Height upto 5m

Morth SOR Code	Ref. to MoRTH Spec.	Description	Unit	Quantity	Rate Rs	Cost Rs	Remarks /Input ref.
	1500,1700 & 2200						
12.8.B		Rate as per item Number of SH: Foundations PCC M20	cm	1.0	4633.77	4633.77	
		Add 10 per cent of cost of material, labour and machinery (a b c) for Formwork			A*10/100	463.377	
					Cost of 1.0 cum	5097.15	
					Cost of 1 cum	5097.15	

Note

The basic components of this analysis are the same as those of items 12.8 (A to H). The only changes are as under:

a) Ramps/Stairs: Extra expenditure on structures which are more than 5 m high @ 2 per cent of cost for height upto 10 m and 4 per cent for heights above 10 m will be involved for approaching the work spot by providing higher ramp/stair case for use by the working parties.

b) The above mentioned percentages have been suitably modified for different categories as cost for various categories varies, whereas effort for access for same height will be similar. As the cost of richer concrete is comparatively more, the percentage to be added has been reduced to maintain the same cost for extra efforts.

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Add Overhead @ 25.0%	1274.28
Add Contractors Profit @ 10.0%	637.14
Cost index **31.06%**	2062.61
Total with Cost index	9071.20
Say	9071.20

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ANNEXURE-2
(COST ESTIMATE-AS PER PRICE)

ABSTRACT OF COST

EST NO : RB/2020/594

Edit Id : 0

GENERAL ABSTRACT

Detailed Project Report for Construction of Cable Stayed Bridge across Ponnani Estuary

(Dsor year: 2016 ,Cost Index Applied for this estimate is 31.06%)

Sl No	Heading Description	Amount
1	**PART-A: INVESTIGATIONS AND TESTS**	**3665296.64**
2	**PART-B: FOR FOUNDATIONS**	**795471076.19**
3	**PART-C: FOR SUBSTRUCTURE**	**271185898.43**
4	**PART-D: FOR SUPERSTRUCTURE**	**1123059758.99**
5	**PART-E: RE WALL PORTION**	**39442211.00**
6	**PART-F: PROJECT AMENITIES & STRUCTURAL HEALTH MONITORING SYSTEMS**	**35000000.76**
7	**PART-G: SITE CLEARANCE**	**5024968.66**
8	**PART-H: PAVEMENT BILL**	**48613653.99**
9	**PART-I: ROAD FURNITURE**	**29228995.44**
10	**Drainage Works**	**20531715.39**
	Total	**2371223575.49**
	Provision for GST payments (in %) @	**12.0%**
	Amount reserved for GST payments	**284546829.06**
	Total	**2655770404.55**
	Lumpsum for roundoff	**0.00**
	TOTAL	**2655770404.55**
	Rounded Total	**Rs 2,65,57,70,405**
Rupees Two Hundred Sixty Five Crore Fifty Seven Lakh Seventy Thousand Four Hundred and Five only		

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SPECIFICATION AND SCHEDULE OF QUANTITIES

ABSTRACT ESTIMATE

Detailed Project Report for Construction of Cable Stayed Bridge across Ponnani Estuary

(Dsor year: 2016 ,Cost Index Applied for this estimate is 31.06%)

1 PART-A: INVESTIGATIONS AND TESTS		
1	56.2.a Setting up boring at each bore hole locations including carrying all necessary plant, equipment and materials of boring and field tests and collection of samples at each bore hole location. For machine boring.	
	Net Total Quantity	39.0 Nos hole
	Say 39.0 Nos hole @ Rs.3000.0	**117000.00**
2	56.3.d.1 Boring with rotary power drilling equipment in all types of soil having N value less than 50 excluding hard rock soft rock, or medium rock for strata above 30m depth including conducting necessary S.P.T and recovery of undisturbed soil samples at 5m.intervals. For ordinary soil.	
	Net Total Quantity	1750.0 metre
	Say 1750.0 metre @ Rs.1100.0	**1925000.00**
3	56.1.a Mobilization including transportation of all necessary plan and equipment's and materials of boring field testing and sampling and demobilization after completing the work For machine boring	
	Net Total Quantity	2.0 set
	Say 2.0 set @ Rs.15798.0	**31596.00**
4	56.3.d.2 Boring with rotary power drilling equipment in all types of soil having N value less than 50 excluding hard rock soft rock, or medium rock for strata above 30m depth including conducting necessary S.P.T and recovery of undisturbed soil samples at 5m.intervals. For under water.	
	Net Total Quantity	200.0 metre
	Say 200.0 metre @ Rs.1500.0	**300000.00**
5	56.8 Recovering disturbed samples and preserving the same in air tight sample containers including waxing labelling packing storing including cost of containers as per IS Code.	
	Net Total Quantity	39.0 each
	Say 39.0 each @ Rs.63.0	**2457.00**
6	56.9.1 Erecting platform over 2 nos of 2nd Class Boat USING Mango wood planks of of not less than 30 mm thick, Mango wood joists of 100mm x 70mm at 60cm intervals including labour and hire of all materials and dismantling the platform after completion of work etc complete excluding hire of boats (A Platform of Minimum size 6.00m x 5.00m will be required)	
	Net Total Quantity	30.0 sqm
	Say 30.0 sqm @ Rs.494.8	**14844.00**

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7	56.10 Hire charges for providing 2 nos of 2nd Class boat with boatman for erecting the platform over which the boring plant is to be erected, and 1 no of 2nd Class boat with 1 boatman for conveying the departmental staff and labour engaged from the banks to platform and back etc.	
	Net Total Quantity	40.0 Day
	Say 40.0 Day @ Rs.2087.0	**83480.00**
8	od35465/2019_2020 null Lateral load testing of single pile in accordance with IS Code of practice IS : 2911 (Part IV) for determining safe allowable lateral load on pile: Above 50 tonne and upto 100 tonne capacity pile.	
	Net Total Quantity	2.0 per test
	Say 2.0 per test @ Rs.42528.97	**85057.94**
9	od35466/2019_2020 null Vertical load testing of piles in accordance with IS 2911(Part IV) including installation of loading platform and preparation of pile head or construction of test cap and dismantling of test cap after test etc. complete as per specification & the direction of engineer -in-Charge. Pile capacity = 350 tonne Initial test	
	Net Total Quantity	2.0 per test
	Say 2.0 per test @ Rs.240118.35	**480236.70**
10	od35467/2019_2020 null Vertical load testing of piles in accordance with IS 2911(Part IV) including installation of loading platform and preparation of pile head or construction of test cap and dismantling of test cap after test etc. complete as per specification & the direction of engineer -in-Charge. Pile Capacity = 350 tonne Routine test	
	Net Total Quantity	5.0 per test
	Say 5.0 per test @ Rs.125125.0	**625625.00**
2 PART-B: FOR FOUNDATIONS		
1	12.25.3 Bored cast-in-situ M35 grade R.C.C. Pile Using Batching Plant, Transit Mixer and Concrete Pump excluding Reinforcement complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m. Pile diameter-1200 mm	
	Net Total Quantity	7844.0 metre
	Say 7844.0 metre @ Rs.15650.77	**122764639.88**
2	12.38.D.2 Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical Specification R C C Grade M35 - Using Batching plant, Transit Mixer and Concrete pump	
	Net Total Quantity	1812.29 cum
	Say 1812.294 cum @ Rs.8705.09	**15776182.38**
3	12.1.2.B Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material. Ordinary Rock (not requiring blasting) - Depth up to 3 m - Mechanical Means 	
	Net Total Quantity	1385.89 cum
	Say 1385.887 cum @ Rs.83.21	**115319.66**

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4	od35618/2019_2020 null Bored cast-in-situ M40 grade R.C.C. Pile Using Batching Plant, Transit Mixer and Concrete Pump excluding Reinforcement complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m. Pile diameter-1800 mm	
	Net Total Quantity	4618.4 metre
	Say 4618.4 metre @ Rs.27601.52	**127474859.97**
5	od35322/2019_2020 null Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical Specification R C C Grade M40 - Using Batching plant, Transit Mixer and Concrete pump	
	Net Total Quantity	8335.09 cum
	Say 8335.094 cum @ Rs.8860.48	**73852933.69**
6	od35806/2019_2020 null Providing Steel Liner 6 mm thick for Piles including Fabricating and Setting out as per Detailed Drawing.	
	Net Total Quantity	237.7 MT
	Say 237.697 MT @ Rs.96415.97	**22917786.82**
7	od35818/2019_2020 null Providing Steel Liner 12mm thick for Piles including Fabricating and Setting out as per Detailed Drawing.	
	Net Total Quantity	986.68 MT
	Say 986.683 MT @ Rs.96415.97	**95131998.53**
8	12.39 Providing and laying of PCC M15 leveling course 100 mm thick below the pile cap	
	Net Total Quantity	44.94 cum
	Say 44.944 cum @ Rs.7509.47	**337505.62**
9	od35355/2019_2020 null Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Foundations	
	Net Total Quantity	3678.52 MT
	Say 3678.517 MT @ Rs.91640.15	**337099849.66**
3 PART-C: FOR SUBSTRUCTURE		
1	13.5.H.r.2 Plain/Reinforced cement concrete in sub-structure complete as per drawing and Technical Specifications RCC Grade M35 - With Batching Plant, Transit Mixer and Concrete Pump - Height above 10m 	
	Net Total Quantity	998.95 cum
	Say 998.948 cum @ Rs.9631.56	**9621427.60**
2	od35328/2019_2020 null Plain/Reinforced cement concrete in Substructure complete as per drawing and Technical Specififcations RCC Grade M50- Using concrete mixer for Heights above 10m	
	Net Total Quantity	2728.16 cum
	Say 2728.163 cum @ Rs.10628.38	**28995953.07**

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3	od35346/2019_2020 null Plain/Reinforced cement concrete in substructrue complete as per drawing and Technical Specifications RCC Grade M55-Using concrete mixer for heights above 10m	
	Net Total Quantity	3205.62 cum
	Say 3205.62 cum @ Rs.11115.34	**35631556.21**
4	od35357/2019_2020 null Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Substructure	
	Net Total Quantity	2038.94 MT
	Say 2038.935 MT @ Rs.96509.71	**196777025.56**
5	13.13 Supplying, fitting and fixing in position true to line and level sliding plate bearing with PTFE surface sliding on stainless steel complete including all accessories as per drawing and Technical Specifications and BS: 5400, section 9.1 & 9.2 (for PTFE) and clause 2004 of MoRTH Specifications.	
	Net Total Quantity	6800.0 tonne
	Say 6800.0 tonne @ Rs.13.44	**91392.00**
6	od35406/2019_2020 null Supplying, fitting and fixing in position true to line and level sliding plate bearing with PTFE surface sliding on stainless steel complete including all accessories as per drawing and Technical Specifications -for Spherical Bearings	
	Net Total Quantity	3400.0 tonne
	Say 3400.0 tonne @ Rs.20.16	**68544.00**
4 PART-D: FOR SUPERSTRUCTURE		
1	14.1F.2.C "Furnishing and Placing PSC Grade M45 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification. For T-beam & slab including launching of precast girders by launching truss upto 40 m span - Height above 10m	
	Net Total Quantity	7432.43 cum
	Say 7432.425 cum @ Rs.11651.93	**86602095.83**
2	14.1G.1.C "Furnishing and Placing PSC Grade M50 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification. For cast-in-situ box girder, segmental construction and balanced cantilever- Height above 10m	
	Net Total Quantity	1811.25 cum
	Say 1811.25 cum @ Rs.14201.7	**25722829.13**
3	od35428/2019_2020 null Furnishing and Placing PSC Grade M60 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification. For cast-in-situ box girder, segmental construction and balanced cantilever- Height above 10m	
	Net Total Quantity	9177.0 cum
	Say 9177.0 cum @ Rs.16529.16	**151688101.32**
4	od35438/2019_2020 null Supply, Fitting and Placing HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Superstructure	
	Net Total Quantity	3684.14 MT

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	Say 3684.135 MT @ Rs.98628.74	**363361593.04**
5	14.3 High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as per drawing and Technical Specifications	
	Net Total Quantity	522.0 MT
	Say 522.003 MT @ Rs.156717.7	**81807109.55**
6	od35429/2019_2020 null Providing/fabricating and stressing of stay cables, threading them (i.e. cutting, pulling, pushing and placing) , placing them in proper profiles including anchorages, bearing plates, wedges,recess filling etc.complete as per detailed drawings and approved specifications, grouting the cables approved equivalent as per the specifications, all complete including the cost of all labour, machinery and materials and hardware etc, as per the specifications and directions of the Engineer-in-charge.	
	Net Total Quantity	209.97 MT
	Say 209.97 MT @ Rs.1567177.17	**329060190.38**
7	14.22 Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation	
	Net Total Quantity	130.0 metre
	Say 130.0 metre @ Rs.10901.72	**1417223.60**
8	od35430/2019_2020 null Providing and laying of a modular strip box seal expansion joint catering to a horizontal movement beyond 210 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer /supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.	
	Net Total Quantity	46.0 metre
	Say 46.0 metre @ Rs.326764.57	**15031170.22**
9	od35431/2019_2020 null Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified	
	Net Total Quantity	4970.0 metre
	Say 4970.0 metre @ Rs.5500.57	**27337832.90**
10	14.9 Drainage Spouts complete as per drawing and Technical specification	
	Net Total Quantity	150.0 no
	Say 150.0 no @ Rs.4701.04	**705156.00**
11	od35437/2019_2020 null null Providing and Fixing PVC pipes 110mm OD(6kg/cm2) Down water pipe complete as drawing and Technical Specification	
	Net Total Quantity	2000.0 metre
	Say 2000.0 metre @ Rs.290.13	**580260.00**
12	14.16 Providing and applying 2 coats of water based cement paint to unplastered concrete surface after cleaning the surface of dirt, dust, oil, grease, efflorescence and applying paint @ of 1 litre for 2 sqm.	

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	Net Total Quantity	24370.0 sqm
	Say 24370.0 sqm @ Rs.219.46	**5348240.20**
13	5.6.2.b.1 Providing and laying bituminous concrete with 100-120 TPH hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder (NRMB) @ 5.4 per cent of mix and filler with Anti stripping additive material 1.0 kg per 1 tonne of bitumen, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects For Grading -II (13.2 mm Nominal size).	
	Net Total Quantity	1228.83 cum
	Say 1228.825 cum @ Rs.12743.07	**15659002.99**
14	14.10 PCC M15 Grade leveling course below approach slab complete as per drawing and Technical specification.	
	Net Total Quantity	12.0 cum
	Say 12.0 cum @ Rs.7516.5	**90198.00**
15	14.11 Reinforced cement concrete approach slab including reinforcement and formwork complete as per drawing and Technical specification.	
	Net Total Quantity	42.0 cum
	Say 42.0 cum @ Rs.12291.21	**516230.82**
16	55.26 Providing and applying elastic, elastomeric membrane forming system with anticarbonation and breathing properties. The system should be based on solvent free acrylic polymers with selected mineral fillers and should be ultra-violet resistant, crack bridging type, carbonation resistant, breathable, enviornment friendly, water proofing coating. For anticarbonation, equivalent air layer thickness denoted as R or SD CO2 grater than 50 m and for breathability equivalent air layer thickness denoted as SD H2O shall be less than 4 m for vapour transmitting barrier. The system consists of one coat primer @ 75- 100 g/m2. The consumption of main polymer coating to give film thickness of 200-225 microns (Solid contents- 70%+ -3%) should be approximately. 400-450 g/m2 per two coats depending upon the method of application (either by roller or brush) and surface smoothness of the concrete. The total dry film thickness of the coating system should be minimum 200 microns for the above system. Polymer coating should be in suitable approved shades, including cost of materials, cleaning, chipping and removing the dirt particles of the concrete slab with wire brush and water,labour charges for filling the bug holes, cracks, joints etc with one component polymer modified fine repair and cosmetic mortar, labour for applying the above coating, scaffolding charges,etc. complete as per IRC SP:80 Clause 6.5.1 and Clause 2808 in the Specifications Book for Roads & Bridges published by the Ministry during April 2013.	
	Net Total Quantity	22500.0 sqm
	Say 22500.0 sqm @ Rs.805.89	**18132525.00**
	5 PART-E: RE WALL PORTION	
1	7.5.2 Assembling, joining and laying of reinforcing facing elements of RCC for Reinforced Earth Structures	
	Net Total Quantity	4232.24 sqm
	Say 4232.241 sqm @ Rs.2151.73	**9106639.93**

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2	12.1.2.B Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material. Ordinary Rock (not requiring blasting) - Depth up to 3 m - Mechanical Means 	
	Net Total Quantity	2268.0 cum
	Say 2268.0 cum @ Rs.83.21	**188720.28**
3	13.5.B Plain/Reinforced Cement Concrete in sub-structure complete as per drawing and Technical Specifications PCC Grade M20 - Height upto 5m	
	Net Total Quantity	262.66 cum
	Say 262.66 cum @ Rs.9071.2	**2382641.39**
4	13.5.A Plain/Reinforced cement concrete in sub-structure complete as per drawing and Technical Specifications PCC Grade M15 - Height upto 5m 	
	Net Total Quantity	239.19 cum
	Say 239.19 cum @ Rs.8268.15	**1977658.80**
5	od35459/2019_2020 null Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified	
	Net Total Quantity	1740.0 metre
	Say 1740.0 metre @ Rs.5500.57	**9570991.80**
6	od35461/2019_2020 null Reinforced cement concrete friction slab including reinforcement and formwork complete as per drawing and Technical specification.	
	Net Total Quantity	1015.0 cum
	Say 1015.0 cum @ Rs.15975.92	**16215558.80**
6 PART-F: PROJECT AMENITIES & STRUCTURAL HEALTH MONITORING SYSTEMS		
1	od35468/2019_2020 null Providing Touring Amenities like Cafeteria, Elevator/Lifts, ramps etc at main bridge portion	
	Net Total Quantity	1.0 L.S
	Say 1.0 L.S @ Rs.1.500000013E7	**15000000.13**
2	od36035/2019_2020 null Installing Structural Health Monitoring systems at Cable stayed/ extradosed bridge portions to monitor the structural behaviour of the bridge.	
	Net Total Quantity	1.0 L.S
	Say 1.0 L.S @ Rs.2.000000063E7	**20000000.63**
7 PART-G: SITE CLEARANCE		

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1	2.3.2.A Clearing and grubbing road land including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, up to a lead of 1000 metres including removal and disposal of top organic soil not exceeding 150 mm in thickness In area of light jungle - By Mechanical Means 	
	Net Total Quantity	2.19 Hecter
	Say 2.194 Hecter @ Rs.54806.88	**120246.29**
2	2.10.B Dismantling of kilometre stone including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and back filling of pit Dismantling of Ordinary KM Stone including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and back filling of pit	
	Net Total Quantity	3.0 each
	Say 3.0 each @ Rs.396.44	**1189.32**
3	2.5.2.A Dismantling of flexible pavements and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately Bituminous course - By Mechanical Means 	
	Net Total Quantity	2310.35 cum
	Say 2310.35 cum @ Rs.406.18	**938417.96**
4	2.5.1.B Dismantling of flexible pavements and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately Granular courses - By Manual Means 	
	Net Total Quantity	4620.7 cum
	Say 4620.7 cum @ Rs.858.12	**3965115.08**
8 PART-H: PAVEMENT BILL		
1	4.1.A.2 Construction of granular sub-base by providing graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401 Grading-II - Plant Mix Method 	
	Net Total Quantity	2192.63 cum
	Say 2192.627 cum @ Rs.3389.91	**7432808.19**
2	4.12 Providing, laying, spreading and compacting graded stone aggregate to Wet Mix Macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub- base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.	
	Net Total Quantity	2703.35 cum
	Say 2703.354 cum @ Rs.3245.29	**8773167.70**
3	3.18 Construction of sub-grade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2	
	Net Total Quantity	5481.57 cum
	Say 5481.567 cum @ Rs.469.66	**2574472.76**

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4	5.1.a Providing and applying primer coat with bitumen emulsion (SS) on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.70 - 1.0 kg/sqm using mechanical means.	
	Net Total Quantity	30555.0 sqm
	Say 30555.0 sqm @ Rs.56.21	**1717496.55**
5	5.2.a Providing and applying tack coat with bitumen emulsion(RS) using emulsion pressure distributor at the rate of 0.20 - 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.	
	Net Total Quantity	30555.0 sqm
	Say 30555.0 sqm @ Rs.10.98	**335493.90**
6	5.4.1 Providing and laying dense bituminous macadam with 80-100 TPH HMP producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder (VG 30) @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects. Grading - I (37.5 mm Nominal Size) 	
	Net Total Quantity	1453.81 cum
	Say 1453.807 cum @ Rs.9091.5	**13217286.34**
7	5.6.1.a Providing and laying bituminous concrete with 80-100 TPH hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder(NRMB) @ 5.2 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects For Grading - I (19 mm nominal size) 	
	Net Total Quantity	1222.2 cum
	Say 1222.2 cum @ Rs.11915.34	**14562928.55**
	9 PART-I: ROAD FURNITURE	
1	8.14.1 Reinforced cement concrete M15 grade Kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc. 5th Kilometre stone (precast)	
	Net Total Quantity	1.0 each
	Say 1.0 each @ Rs.5260.8	**5260.80**
2	8.14.2 Reinforces cement concrete M 15 grade Kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc Ordinary kilometer stone (precast)	
	Net Total Quantity	5.0 each
	Say 5.0 each @ Rs.3193.74	**15968.70**
3	8.14.3 Reinforced cement concrete M15 grade Hectometer stone of standard design as per IRC-8-1980, fixing in position including painting and printing etc Hectometer stone (precast)	
	Net Total Quantity	27.0 no
	Say 27.0 no @ Rs.862.94	**23299.38**

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4	8.16 Reinforced cement concrete M-15 grade boundary pillars of standard design as per IRC:25-19767, fixed in position including finishing and lettering but excluding painting .	
	Net Total Quantity	132.0 no
	Say 132.0 no @ Rs.960.22	**126749.04**
5	8.11.1 Painting lines, dashes, arrows etc on roads in two coats on new work with ready mixed road marking paint conforming to IS:164 on bituminous surface, including cleaning the surface of all dirt, dust and other foreign matter, demarcation at site and traffic control Over 10 cm in width	
	Net Total Quantity	1934.0 sqm
	Say 1934.0 sqm @ Rs.191.13	**369645.42**
6	8.4.3 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 60 cm circular	
	Net Total Quantity	18.0 each
	Say 18.0 each @ Rs.4052.14	**72938.52**
7	8.4.9 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 75 cm circular	
	Net Total Quantity	8.0 each
	Say 8.0 each @ Rs.4831.52	**38652.16**
8	8.4.10 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 90 cm circular	
	Net Total Quantity	4.0 each
	Say 4.0 each @ Rs.5782.45	**23129.80**

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9	8.4.2 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 60 cm equilateral triangle	
	Net Total Quantity	76.0 each
	Say 76.0 each @ Rs.3429.62	**260651.12**
10	8.4.1 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 90 cm equilateral triangle	
	Net Total Quantity	14.0 each
	Say 14.0 each @ Rs.4380.56	**61327.84**
11	8.4.12 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 50cmx 60 cm rectangular (Single chevron etc.)	
	Net Total Quantity	76.0 each
	Say 76.0 each @ Rs.4135.48	**314296.48**
12	8.35 Providing and fixing reflective road studs (Raised Pavement Marker) of ' category A' made out of ASA/HIPS/ABS moulded body with shanks and conforming to ASTM D 4280, strong enough to support a load of more than 13.635 T when tested in accordance with ASTM D 4280, reflective panel confirming to ASTM D 788, and reflectivity conforming to clause 804.4. including installation, drilling, fixing with adhesive etc. with 2 years warranty for the road stud as well as for in field performance as per clause 804.7.3 Road Markers/Road Stud with Lense Reflector :-	
	Net Total Quantity	1650.0 no
	Say 1650.0 no @ Rs.222.0	**366300.00**
13	8.23.A Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per clause 811.3 	
	Net Total Quantity	320.0 metre

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	Say 320.0 metre @ Rs.3967.85	**1269712.00**
14	od35479/2019_2020 null Providing and laying factory made chamfered edge Cement Concrete paver blocks in footpath, parks, lawns, drive ways or light traffic parking etc, of required strength, thickness & size/ shape, made by table vibratory method using PU mould, laid in required colour & pattern over 50mm thick compacted bed of sand, compacting and proper embedding/laying of inter locking paver blocks into the sand bedding layer through vibratory compaction by using plate vibrator, filling the joints with sand and cutting of paver blocks as per required size and pattern, finishing and sweeping extra sand. complete all as per direction of Engineer-in- Charge. 60mm thick cement concrete paver block of M35 grade with approved colour, design & pattern	
	Net Total Quantity	5940.0 cum
	Say 5940.0 cum @ Rs.1173.19	**6968748.60**
15	od35561/2019_2020 null Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3	
	Net Total Quantity	1.0 no
	Say 1.0 no @ Rs.1265000.0	**1265000.00**
16	od35562/2019_2020 null Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3	
	Net Total Quantity	4.0 no
	Say 4.0 no @ Rs.632500.0	**2530000.00**
17	od35563/2019_2020 null Providing and fixing reflective Solar road studs (Raised Pavement Marker) of ' category A' made out of ASA/HIPS/ABS moulded body with shanks and conforming to ASTM D 4280, strong enough to support a load of more than 13.635 T when tested in accordance with ASTM D 4280, reflective panel confirming to ASTM D 788, and reflectivity conforming to clause 804.4. including installation, drilling, fixing with adhesive etc. with 2 years warranty for the road stud as well as for in field performance as per clause 804.7.3 Solar Stud	
	Net Total Quantity	165.0 no
	Say 165.0 no @ Rs.2500.0	**412500.00**
18	od35564/2019_2020 null High Mast light of pole height 25m	
	Net Total Quantity	2.0 100 meter
	Say 2.0 100 meter @ Rs.525000.03	**1050000.06**
19	8.15 Supplying and installation of delineator (Road way indicators) posts 80- 100cm high above ground level, pained black and white in 15 cm wide strips, fitted with min. 80 x 100 mm rectangular or 75 mm dia circular retro reflectorised panels at the top with minimum visibility of 300m with provisions to prevent edge lifting and vandalisam, and conforming to clause 806 , IRC-79 and the drawings including fixing to ground (The deleniator shall be of approved type as per specification)	
	Net Total Quantity	35.0 each

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	Say 35.0 each @ Rs.568.21	**19887.35**
20	8.29.2 Providing and laying of a reinforced cement concrete pipe duct, 300 mm dia, across the road (new construction), extending from drain to drain in cuts and toe of slope to toe of slope in fills, constructing head walls at both ends, providing a minimum fill of granular material over top and sides of RCC pipe as per IRC:98-1997, bedded on a 0.3 m thick layer of granular material free of rock pieces, outer to outer distance of pipe at least half dia of pipe subject to minimum 450 mm in case of double and triple row ducts, joints to be made leak proof, invert level of duct to be above higher than ground level to prevent entry of water and dirt, all as per IRC: 98 - 1997 and approved drawings. Cable Duct Across the Road - Double row for two utility services	
	Net Total Quantity	52.0 RM
	Say 52.0 RM @ Rs.8010.45	**416543.40**
21	8.5 Providing and fixing of direction and place identification retro-reflectorised sign with 7 years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with area not exceeding 0.9 sqm, with suitable back supporting frame of MS angle 40x40x6 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.	
	Net Total Quantity	10.0 sqm
	Say 10.0 sqm @ Rs.8960.22	**89602.20**
22	od35591/2019_2020 null Informatory Sign 1)Advance Direction Sign 2)Reassurance Sign	
	Net Total Quantity	10.0 no
	Say 10.0 no @ Rs.5078.0	**50780.00**
23	od35592/2019_2020 null Facility Information Sign 1)Flag Type 2)Informatory Sign 3)Facility Informatory sign	
	Net Total Quantity	78.0 no
	Say 78.0 no @ Rs.3350.0	**261300.00**
24	od35593/2019_2020 null Informatory Sign 1)Flag type Direction Sign	
	Net Total Quantity	4.0 no
	Say 4.0 no @ Rs.3088.0	**12352.00**
25	od35594/2019_2020 null Construction Zone Informatory Sign	
	Net Total Quantity	10.0 no
	Say 10.0 no @ Rs.3699.99	**36999.90**
26	od35595/2019_2020 null Construction Zone Mandatory Sign	
	Net Total Quantity	20.0 no

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	Say 20.0 no @ Rs.4257.99	**85159.80**
27	od35596/2019_2020 null Construction Zone Cautionary sign	
	Net Total Quantity	20.0 no
	Say 20.0 no @ Rs.3321.0	**66420.00**
28	od35597/2019_2020 null Delineators Stickers Provided at the Place of WBCB in the Edge of the Carriageway	
	Net Total Quantity	166.0 no
	Say 166.0 no @ Rs.600.0	**99600.00**
29	od35600/2019_2020 null Providing and erecting Overhead Signs complete as per Drawing and Technical Specification Clause 802 Forgiving Delineator Post	
	Net Total Quantity	113.0 no
	Say 113.0 no @ Rs.1001.99	**113224.87**
30	od35601/2019_2020 null Providing and Fixing retro-reflected road delineators complete as per drawing and technical specification Clause 805 One way Hazard Marker	
	Net Total Quantity	6.0 no
	Say 6.0 no @ Rs.491.0	**2946.00**
31	od35602/2019_2020 null Providing and erecting street light mounted on a steel circular hollow pole of standard specifications for street lighting, 9 m high spaced 40 m apart, 1.8 m overhang on both sides if fixed in the median and on one side if fixed on the footpath, fitted with sodium vapour lamp and fixed firmly in concrete foundation. For Fixing in Median	
	Net Total Quantity	128.0 no
	Say 128.0 no @ Rs.100000.0	**12800000.00**
	10 Drainage Works	
1	od35357/2019_2020 null Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Substructure	
	Net Total Quantity	78.9 MT
	Say 78.897 MT @ Rs.96509.71	**7614326.59**
2	13.5.B Plain/Reinforced Cement Concrete in sub-structure complete as per drawing and Technical Specifications PCC Grade M20 - Height upto 5m	
	Net Total Quantity	1424.0 cum
	Say 1424.0 cum @ Rs.9071.2	**12917388.80**
	Total	**2371223575.49**
	Provision for GST payments (in %) @	**12.0%**
	Amount reserved for GST payments	**284546829.06**
	Total	**2655770404.55**

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Lumpsum for roundoff	**0.00**
TOTAL	**2655770404.55**
Rounded Total	**Rs 2,65,57,70,405**
Rupees Two Hundred Sixty Five Crore Fifty Seven Lakh Seventy Thousand Four Hundred and Five only	

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ANNEXURE-3
(BILL OF QUANTITIES/DETAILED ESTIMATE)

DETAILED ESTIMATE

Detailed Project Report for Construction of Cable Stayed Bridge across Ponnani Estuary

(Dsor year: 2016 ,Cost Index Applied for this estimate is 31.06%)

Sl No	Description	No	L	B	D	Cf	Quantity	Remarks
1 PART-A: INVESTIGATIONS AND TESTS								
1	56.2.a Setting up boring at each bore hole locations including carrying all necessary plant, equipment and materials of boring and field tests and collection of samples at each bore hole location. For machine boring.							
Total No. of bore holes								
	No .of boreholes	39					39.0	
						Total Quantity	39.0 Nos hole	
						Total Deducted Quantity	0.0 Nos hole	
						Net Total Quantity	39.0 Nos hole	
						Say 39.0 Nos hole @ Rs.3000.0	**117000.00**	
2	56.3.d.1 Boring with rotary power drilling equipment in all types of soil having N value less than 50 excluding hard rock soft rock, or medium rock for strata above 30m depth including conducting necessary S.P.T and recovery of undisturbed soil samples at 5m.intervals. For ordinary soil.							
Number of bore holes at land portion								
	Number of bore holes at land portion	35	50.000				1750.0	assuming 50m for ordinary soils
						Total Quantity	1750.0 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	1750.0 metre	
						Say 1750.0 metre @ Rs.1100.0	**1925000.00**	
3	56.1.a Mobilization including transportation of all necessary plan and equipment's and materials of boring field testing and sampling and demobilization after completing the work For machine boring							
No.of rigs deployed for whole project								
	No.of rigs	2					2.0	
						Total Quantity	2.0 set	
						Total Deducted Quantity	0.0 set	
						Net Total Quantity	2.0 set	
						Say 2.0 set @ Rs.15798.0	**31596.00**	

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4	56.3.d.2 Boring with rotary power drilling equipment in all types of soil having N value less than 50 excluding hard rock soft rock, or medium rock for strata above 30m depth including conducting necessary S.P.T and recovery of undisturbed soil samples at 5m.intervals. For under water.							
No.of bor holes at marine portion								
	No.of bore holes at marine portion	4	50.000				200.0	assming 50m of ordinary soils
						Total Quantity	200.0 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	200.0 metre	
						Say 200.0 metre @ Rs.1500.0	**300000.00**	
5	56.8 Recovering disturbed samples and preserving the same in air tight sample containers including waxing labelling packing storing including cost of containers as per IS Code.							
No.of samples								
	No.of bore hole samples	39					39.0	
						Total Quantity	39.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	39.0 each	
						Say 39.0 each @ Rs.63.0	**2457.00**	
6	56.9.1 Erecting platform over 2 nos of 2nd Class Boat USING Mango wood planks of of not less than 30 mm thick, Mango wood joists of 100mm x 70mm at 60cm intervals including labour and hire of all materials and dismantling the platform after completion of work etc complete excluding hire of boats (A Platform of Minimum size 6.00m x 5.00m will be required)							
Erection of platform for marine boreholes								
	Plat form size 6m x 5m	1	6.000	5.000			30.0	
						Total Quantity	30.0 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	30.0 sqm	
						Say 30.0 sqm @ Rs.494.8	**14844.00**	
7	56.10 Hire charges for providing 2 nos of 2nd Class boat with boatman for erecting the platform over which the boring plant is to be erected, and 1 no of 2nd Class boat with 1 boatman for conveying the departmental staff and labour engaged from the banks to platform and back etc.							
Hiring of boats for marine bore holes								
	No.of days	40					40.0	
						Total Quantity	40.0 Day	
						Total Deducted Quantity	0.0 Day	
						Net Total Quantity	40.0 Day	
						Say 40.0 Day @ Rs.2087.0	**83480.00**	

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8	od35465/2019_2020 null Lateral load testing of single pile in accordance with IS Code of practice IS : 2911 (Part IV) for determining safe allowable lateral load on pile: Above 50 tonne and upto 100 tonne capacity pile.							
Initial Lateral Load Test								
	No.of Tests to be done	2					2.0	
						Total Quantity	2.0 per test	
						Total Deducted Quantity	0.0 per test	
						Net Total Quantity	2.0 per test	
						Say 2.0 per test @ Rs.42528.97	**85057.94**	
9	od35466/2019_2020 null Vertical load testing of piles in accordance with IS 2911(Part IV) including installation of loading platform and preparation of pile head or construction of test cap and dismantling of test cap after test etc. complete as per specification & the direction of engineer -in-Charge. Pile capacity = 350 tonne Initial test							
Initial Vertical Load tests								
	No.of tests	2					2.0	
						Total Quantity	2.0 per test	
						Total Deducted Quantity	0.0 per test	
						Net Total Quantity	2.0 per test	
						Say 2.0 per test @ Rs.240118.35	**480236.70**	
10	od35467/2019_2020 null Vertical load testing of piles in accordance with IS 2911(Part IV) including installation of loading platform and preparation of pile head or construction of test cap and dismantling of test cap after test etc. complete as per specification & the direction of engineer -in-Charge. Pile Capacity = 350 tonne Routine test							
Routine Vertical Load Tests								
	No.of tests	5					5.0	
						Total Quantity	5.0 per test	
						Total Deducted Quantity	0.0 per test	
						Net Total Quantity	5.0 per test	
						Say 5.0 per test @ Rs.125125.0	**625625.00**	
2 PART-B: FOR FOUNDATIONS								
1	12.25.3 Bored cast-in-situ M35 grade R.C.C. Pile Using Batching Plant, Transit Mixer and Concrete Pump excluding Reinforcement complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m. Pile diameter-1200 mm							
1200mm dia piles with M35 grade using transit mixer								
	From A1 to P16	17*4	53.000				3604.0	=17*4 piles per pier
	For P17 & P22	2*8	53.000				848.0	=2*8 piles per pier
	From P23 to A2	16*4	53.000				3392.0	=16*4 piles per pier
						Total Quantity	7844.0 metre	

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						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	7844.0 metre	
						Say 7844.0 metre @ Rs.15650.77	**122764639.88**	
2	12.38.D.2 Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical Specification R C C Grade M35 - Using Batching plant, Transit Mixer and Concrete pump							
	RCC M35 grade for Pile caps at viaduct using transit mixer							
	From A1 to P16	17	5.100	5.100	1.800		795.906	
	For P17 & P22	2	13.500	5.500	1.800		267.3	
	From P23 to A2	16	5.100	5.100	1.800		749.088	
						Total Quantity	1812.29 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1812.29 cum	
						Say 1812.294 cum @ Rs.8705.09	**15776182.38**	
3	12.1.2.B Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material. Ordinary Rock (not requiring blasting) - Depth up to 3 m - Mechanical Means 							
	Excavation of Pile caps for approaches							
	From A1 to P1	2	5.1+2*0.5	5.1+2*0.5	0.75+1.8+0.1		197.213	
	From P25 to A2	14	5.1+2*0.5	5.1+2*0.5	0.75+1.8+0.1		1380.491	
	Deduction of volume of piles							
	From A1 to P1	8			2.650	1.13	-23.977	=2 * 4piles * Area of piles* 2.65
	From P25 to A2	56			2.650	1.13	-167.84	=14*4piles*Area of pile*2.65
						Total Quantity	1577.7 cum	
						Total Deducted Quantity	-191.82 cum	
						Net Total Quantity	1385.89 cum	
						Say 1385.887 cum @ Rs.83.21	**115319.66**	
4	od35618/2019_2020 null Bored cast-in-situ M40 grade R.C.C. Pile Using Batching Plant, Transit Mixer and Concrete Pump excluding Reinforcement complete as per Drawing and Technical Specifications and removal of excavated earth with all lifts and lead upto 1000 m. Pile diameter-1800 mm							
	Pile dia 1800mm for main bridge							
	For P18 & P21	2*4	50.200				401.6	=2*4 piles on each pier

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	For P19 & P20	2*42	50.200				4216.8	=2*42 piles on each pier
						Total Quantity	4618.4 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	4618.4 metre	
						Say 4618.4 metre @ Rs.27601.52	**127474859.97**	
5	od35322/2019_2020 null Cement Concrete for Reinforced Concrete in Pile Cap complete as per Drawing and Technical Specification R C C Grade M40 - Using Batching plant, Transit Mixer and Concrete pump							
	RCC M40 grade for Pile caps at main bridge using transit mixer							
	For P18 & P21	2	8.100	8.100	2.700		354.294	
	For P19 & P20	2	34.400	29.000	4.000		7980.8	
						Total Quantity	8335.09 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	8335.09 cum	
						Say 8335.094 cum @ Rs.8860.48	**73852933.69**	
6	od35806/2019_2020 null Providing Steel Liner 6 mm thick for Piles including Fabricating and Setting out as per Detailed Drawing.							
	Pile liner of 6mm thick for viaduct							
	From A1 to P16	17*4	9.000			0.18	109.212	3.14*0.25*((1.2+2*0.006)*(1.2+2*0.006)-(1.2*1.2))*7.85=0.178451
	For P17 & P22	2*8	9.000			0.18	25.697	3.14*0.25*((1.2+2*0.006)*(1.2+2*0.006)-(1.2*1.2))*7.85=0.178451
	From P23 to A2	16*4	9.000			0.18	102.788	3.14*0.25*((1.2+2*0.006)*(1.2+2*0.006)-(1.2*1.2))*7.85=0.178451
						Total Quantity	237.7 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	237.7 MT	

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						Say 237.697 MT @ Rs.96415.97	**22917786.82**	
7	od35818/2019_2020 null Providing Steel Liner 12mm thick for Piles including Fabricating and Setting out as per Detailed Drawing.							
Pile liner of 12mm thick for main bridge								
	For P18 & P21	2*4	20.000			0.54	85.799	3.14*0.25*((1.8+2*0.012)*(1.8+2*0.012)-(1.8*1.8))*7.85=0.53624
	For P19 & P20	2*42	20.000			0.54	900.884	3.14*0.25*((1.8+2*0.012)*(1.8+2*0.012)-(1.8*1.8))*7.85=0.53624
						Total Quantity	986.68 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	986.68 MT	
						Say 986.683 MT @ Rs.96415.97	**95131998.53**	
8	12.39 Providing and laying of PCC M15 leveling course 100 mm thick below the pile cap							
Laying PCC M15 levelling course for viaducts								
	From A1 to P1	2	5.1+2*0.1	5.1+2*0.1	0.100		5.618	
	From P25 to A2	14	5.1+2*0.1	5.1+2*0.1	0.100		39.326	
						Total Quantity	44.94 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	44.94 cum	
						Say 44.944 cum @ Rs.7509.47	**337505.62**	
9	od35355/2019_2020 null Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Foundations							
HYSD Reinforcement Fe500 for foundations								
	Piles for 1.2m dia as per item 1 of foundations @ 100kg/cum	1	7844.000	0.25*3.14*1.2*1.2		0.1	886.686	=100/1000
	Piles for 1.8m dia as per item 4 for foundations at 125kg/cum	1	4618.400	0.25*3.14*1.8*1.8		0.13	1527.038	=125/1000
	M35 pile caps as per item 2 of foundations at 100kg/cum	1	1812.294			0.1	181.23	=100/1000

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	M40 pile caps as per item 5 of foundations at 125kg/cum	1	8335.094			0.13	1083.563	=125/1000
						Total Quantity	3678.52 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	3678.52 MT	
						Say 3678.517 MT @ Rs.91640.15	**337099849.66**	
3 PART-C: FOR SUBSTRUCTURE								
1	13.5.H.r.2 Plain/Reinforced cement concrete in sub-structure complete as per drawing and Technical Specifications RCC Grade M35 - With Batching Plant, Transit Mixer and Concrete Pump - Height above 10m 							
Substructure M35 using transit mixer								
	For A1-pier	2	3.000	0.680	0.890		3.632	2 piers of 3 x 0.68
	For P1-pier	1	3.000	0.800	3.899		9.358	1 piers of 3 x 0.8
	For P2-pier	1	3.000	0.800	2.814		6.754	1 piers of 3 x 0.8
	For P3-pier	1	3.000	0.800	3.564		8.554	1 piers of 3 x 0.8
	For P4-pier	1	3.000	0.800	4.314		10.354	1 piers of 3 x 0.8
	For P5-pier	2	3.000	0.680	5.064		20.662	2 piers of 3 x 0.68
	For P6-pier	1	3.000	0.800	5.814		13.954	1 piers of 3 x 0.8
	For P7-pier	1	3.000	0.800	6.564		15.754	1 piers of 3 x 0.8
	For P8-pier	1	3.000	0.800	7.314		17.554	1 piers of 3 x 0.8
	For P9-pier	2	3.000	0.680	8.064		32.902	2 piers of 3 x 0.68
	For P10-pier	1	3.000	0.800	8.814		21.154	1 piers of 3 x 0.8
	For P11-pier	1	3.000	0.800	9.564		22.954	1 piers of 3 x 0.8
	For P12-pier	1	3.000	0.800	10.314		24.754	1 piers of 3 x 0.8
	For P13-Pier	2	3.000	0.680	11.064		45.142	2 piers of 3 x 0.68
	For P14-Pier	1	3.000	0.800	11.814		28.354	1 piers of 3 x 0.8
	For P15-pier	1	3.000	0.800	12.564		30.154	1 piers of 3 x 0.8
	For P16-pier	1	3.000	0.800	13.282		31.877	1 piers of 3 x 0.8
	For P23-pier	1	3.000	0.800	13.363		32.072	1 piers of 3 x 0.8
	For P24-pier	1	3.000	0.800	11.553		27.728	1 piers of 3 x 0.8

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	For P25-pier	1	3.000	0.800	11.080		26.592	1 piers of 3 x 0.8
	For P26-pier	2	3.000	0.680	10.294		42.0	2 piers of 3 x 0.68
	For P27-pier	1	3.000	0.800	9.546		22.911	1 piers of 3 x 0.8
	For P28-pier	1	3.000	0.800	8.837		21.209	1 piers of 3 x 0.8
	For P29-pier	1	3.000	0.800	7.969		19.126	1 piers of 3 x 0.8
	For P30-pier	2	3.000	0.680	7.170		29.254	2 piers of 3 x 0.68
	For P31-pier	1	3.000	0.800	6.237		14.969	1 piers of 3 x 0.8
	For P32-pier	1	3.000	0.800	5.432		13.037	1 piers of 3 x 0.8
	For P33-pier	1	3.000	0.800	4.779		11.47	1 piers of 3 x 0.8
	For P34-pier	2	3.000	0.680	3.947		16.104	2 piers of 3 x 0.68
	For P35-pier	1	3.000	0.800	3.228		7.748	1 piers of 3 x 0.8
	For P36-pier	1	3.000	0.800	2.567		6.161	1 piers of 3 x 0.8
	For P37-pier	1	3.000	0.800	1.884		4.522	1 piers of 3 x 0.8
	For A2-pier	2	3.000	0.680	1.012		4.129	1 piers of 3 x 0.8
	For P17 towards P16	1	3.000	0.680	13.701		27.951	1 piers of 3 x 0.68
	For P17 towards P18	1	2.500	2.500	13.118		81.988	1 piers of 2.5 x 2.5
	For P22 towards P21	1	2.500	2.500	13.185		82.407	1 piers of 2.5 x 2.5
	For P22 towards P23	1	3.000	0.680	14.560		29.703	1 piers of 3 x 0.68
	Pier caps at P17,P18,P19 & P22-upper rectangular	4	8.500	2.500	0.800		68.0	Pier cap size-8.5x2.5x0.8x1.2
	Pier caps at P17,P18,P19 & P22-lower triangular cantilever portion	4	2*0.5*(8.5-2.5)	1.200	2.500	0.5	36.0	Pier cap size-8.5x2.5x0.8x1.2
	Pier caps at P17,P18,P19 & P22-middle solid rectangular	4	2.500	2.500	1.200		30.0	Pier cap size-8.5x2.5x0.8x1.2
						Total Quantity	998.95 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	998.95 cum	

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						Say 998.948 cum @ Rs.9631.56	**9621427.60**	
2	od35328/2019_2020 null Plain/Reinforced cement concrete in Substructure complete as per drawing and Technical Specififcations RCC Grade M50- Using concrete mixer for Heights above 10m							
Lower pylon at main bridge-M50 grade using transit mixer								
	P18 towards transition zone	1	2.500	2.500	14.398	1.05	94.487	5% extra for curvatures
	P21 towards transition zone	1	2.500	2.500	14.442	1.05	94.776	5% extra for curvatures
	Lower pylon at P19 & P20	2	4.000	18.000	6.000	1.05	907.2	5% extra for curvatures
	Lower pylon-bifurcating portion at P19 & P20	2*2	3.500	18.500	6.000	1.05	1631.7	5% extra for curvatures
						Total Quantity	2728.16 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	2728.16 cum	
						Say 2728.163 cum @ Rs.10628.38	**28995953.07**	
3	od35346/2019_2020 null Plain/Reinforced cement concrete in substructrue complete as per drawing and Technical Specifications RCC Grade M55-Using concrete mixer for heights above 10m							
Upper pylon at main bridge-M55 grade using transit mixer								
	Upper pylon at P19 & P20	2*2	31.000	3.000	0.5*(6+4.5)	1.1	2148.3	10% for curvature
	Upper pylon junction at P19 & P20	2*2	3.500	4.500	3.000	1.1	207.9	10% for curvature
	Upper pylon-Top portion at P19 & P20	2	23.400	3.000	0.5*(7.5+3.5)	1.1	849.42	10% for curvature
						Total Quantity	3205.62 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	3205.62 cum	
						Say 3205.62 cum @ Rs.11115.34	**35631556.21**	
4	od35357/2019_2020 null Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Substructure							
HYSD Reinforcement Fe500 for substructure								
	For Pier caps as per item 1 of substructure @ 150kg/cum	1	133.600			0.15	20.04	=150/1000

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	For EJ piers as per item 1 of substructure at approach viaduct @ 350kg/cum	1	251.479			0.35	88.018	=350/1000
	For Integral Inner Piers as per Item 1 of substructure at 200kg/cum	1	449.064			0.2	89.813	=200/1000
	For end piers at Transition zone as per item 1 of substructure at 200kg/cum	1	164.396			0.2	32.88	=200/1000
	For P18 & P21 towards main bridge	1	180.251			0.35	63.088	=350/1000
	For pier caps at P17 & P22 at 150kg/cum	1	33.4*2			0.15	10.02	=150/1000
	For pier caps at P18 & P21 at 175kg/cum	1	33.4*2			0.18	11.69	=175/1000
	For lower pylons as per item 2 of substructure at 300kg/cum	1	2539.000			0.3	761.7	=300/1000
	For upper pylons as per item 3 of substructure at 300kg/cum	1	3205.620			0.3	961.686	=300/1000
						Total Quantity	2038.94 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	2038.94 MT	
						Say 2038.935 MT @ Rs.96509.71	**196777025.56**	
5	13.13 Supplying, fitting and fixing in position true to line and level sliding plate bearing with PTFE surface sliding on stainless steel complete including all accessories as per drawing and Technical Specifications and BS: 5400, section 9.1 & 9.2 (for PTFE) and clause 2004 of MoRTH Specifications.							
POT/PTFE Bearings for 50m spans								
	POT/PTFE Bearings V=850Tonnes	8				850.0	6800.0	for 8 Nos of bearings
						Total Quantity	6800.0 tonne	
						Total Deducted Quantity	0.0 tonne	
						Net Total Quantity	6800.0 tonne	
						Say 6800.0 tonne @ Rs.13.44	**91392.00**	
6	od35406/2019_2020 null Supplying, fitting and fixing in position true to line and level sliding plate bearing with PTFE surface sliding on stainless steel complete including all accessories as per drawing and Technical Specifications -for Spherical Bearings							
Spherical Bearings for main spans								

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	Spherical Bearings V=850	4				850.0	3400.0	for main spans
						Total Quantity	3400.0 tonne	
						Total Deducted Quantity	0.0 tonne	
						Net Total Quantity	3400.0 tonne	
						Say 3400.0 tonne @ Rs.20.16	**68544.00**	
4 PART-D: FOR SUPERSTRUCTURE								
1	14.1F.2.C "Furnishing and Placing PSC Grade M45 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification. For T-beam & slab including launching of precast girders by launching truss upto 40 m span - Height above 10m							
RCC I-girders for viaduct portion with M45 grade								
	RCC I Girders with M45 grade	33	30.000	13.000	0.550	1.05	7432.425	5% extra for curvature effects
						Total Quantity	7432.43 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	7432.43 cum	
						Say 7432.425 cum @ Rs.11651.93	**86602095.83**	
2	14.1G.1.C "Furnishing and Placing PSC Grade M50 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification. For cast-in-situ box girder, segmental construction and balanced cantilever- Height above 10m							
PSC M50 grade for varying deck width								
	PSC Box girder of M50	2	50.000	23.000	0.750	1.05	1811.25	5% extra for catering tolerances
						Total Quantity	1811.25 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1811.25 cum	
						Say 1811.25 cum @ Rs.14201.7	**25722829.13**	
3	od35428/2019_2020 null Furnishing and Placing PSC Grade M60 Using Batching Plant, Transit Mixer and Concrete Pump as per drawing and Technical Specification. For cast-in-situ box girder, segmental construction and balanced cantilever- Height above 10m							
Main bridge portion with M60 grade								
	For main bridge	1	100+200 +100	23.000	0.950	1.05	9177.0	5% extra to cater for tolerances
						Total Quantity	9177.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	9177.0 cum	

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					Say 9177.0 cum @ Rs.16529.16		**151688101.32**	
4	od35438/2019_2020 null Supply, Fitting and Placing HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Superstructure							
HYSD Reinforcement Fe500 for superstructure								
	For RCC 45 as per Item 1 of superstructure @ 200kg/cum	1	7432.425			0.2	1486.485	=200/1000
	For RCC 50 as per Item 2 of superstructure @ 200kg/cum	1	1811.250			0.2	362.25	=200/1000
	For RCC 60 as per Item 3 of superstructure @ 200kg/cum	1	9177.000			0.2	1835.4	=200/1000
						Total Quantity	3684.14 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	3684.14 MT	
						Say 3684.135 MT @ Rs.98628.74	**363361593.04**	
5	14.3 High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as per drawing and Technical Specifications							
HTS strands for viaduct portion								
	For PSC M50 as per Item 2 of superstructure @ 45kg/cum	1	1811.250			0.05	81.507	=45/1000
	For PSC M60 as per Item 3 of superstructure @ 48kg/cum	1	9177.000			0.05	440.496	=45/1000
						Total Quantity	522.0 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	522.0 MT	
						Say 522.003 MT @ Rs.156717.7	**81807109.55**	
6	od35429/2019_2020 null Providing/fabricating and stressing of stay cables, threading them (i.e. cutting, pulling, pushing and placing) , placing them in proper profiles including anchorages, bearing plates, wedges,recess filling etc.complete as per detailed drawings and approved specifications, grouting the cables approved equivalent as per the specifications, all complete including the cost of all labour, machinery and materials and hardware etc, as per the specifications and directions of the Engineer-in-charge.							
Stay cables with anchorage on main bridge								
	For PSC M60 as per Item 3 of superstructure @ 22.88kg/cum	1	9177.000			0.02	209.97	on main bridge
						Total Quantity	209.97 MT	
						Total Deducted Quantity	0.0 MT	

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						Net Total Quantity	209.97 MT	
						Say 209.97 MT @ Rs.1567177.17	**329060190.38**	
7	14.22 Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation							
Strip seal expansion joints at viaduct location								
	For Viaducts at A1,P5,P9,P13,P17,P22,P26,P30,P34 & A2	10	13.000				130.0	At viaduct location
						Total Quantity	130.0 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	130.0 metre	
						Say 130.0 metre @ Rs.10901.72	**1417223.60**	
8	od35430/2019_2020 null Providing and laying of a modular strip box seal expansion joint catering to a horizontal movement beyond 210 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer /supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.							
Modular type Expansion joints at Main bridge								
	For Main bridge at P18 & P21	2	23.000				46.0	at main bridge
						Total Quantity	46.0 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	46.0 metre	
						Say 46.0 metre @ Rs.326764.57	**15031170.22**	
9	od35431/2019_2020 null Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified							
RCC Crash barriers including viaduct								
	From A1 to P17	17*3	30.000				1530.0	3 on one span
	From P17 to P18	1*4	50.000				200.0	4 on one span
	From P18 to P21	1*4	400.000				1600.0	4 on one span
	From P21 to P22	1*4	50.000				200.0	4 on one span
	From P22 to A2	16*3	30.000				1440.0	4 on one span
						Total Quantity	4970.0 metre	
						Total Deducted Quantity	0.0 metre	

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					Net Total Quantity		4970.0 metre	
					Say 4970.0 metre @ Rs.5500.57		**27337832.90**	
10	14.9 Drainage Spouts complete as per drawing and Technical specification							
	Drainage spouts along bridge							
	No.of drainage spouts	1				150.0	150.0	over full length of bridge
					Total Quantity		150.0 no	
					Total Deducted Quantity		0.0 no	
					Net Total Quantity		150.0 no	
					Say 150.0 no @ Rs.4701.04		**705156.00**	
11	od35437/2019_2020 null null Providing and Fixing PVC pipes 110mm OD(6kg/cm2) Down water pipe complete as drawing and Technical Specification							
	Downtake & Runner Pipes							
	PVC dia 110mm in Rm	1				2000.0	2000.0	for overall length of bridge
					Total Quantity		2000.0 metre	
					Total Deducted Quantity		0.0 metre	
					Net Total Quantity		2000.0 metre	
					Say 2000.0 metre @ Rs.290.13		**580260.00**	
12	14.16 Providing and applying 2 coats of water based cement paint to unplastered concrete surface after cleaning the surface of dirt, dust, oil, grease, efflorescence and applying paint @ of 1 litre for 2 sqm.							
	Water proofing membrane over deck slab							
	For main bridge	1	100+200 +100	23.000			9200.0	for overall length of bridge
	For transition zone	2	50.000	23.000			2300.0	for overall length of bridge
	For Viaduct	17+16	30.000	13.000			12870.0	for overall length of bridge
					Total Quantity		24370.0 sqm	
					Total Deducted Quantity		0.0 sqm	
					Net Total Quantity		24370.0 sqm	
					Say 24370.0 sqm @ Rs.219.46		**5348240.20**	

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13	5.6.2.b.1 Providing and laying bituminous concrete with 100-120 TPH hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder (NRMB) @ 5.4 per cent of mix and filler with Anti stripping additive material 1.0 kg per 1 tonne of bitumen, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects For Grading -II (13.2 mm Nominal size).							
Wearing coat over bridge portion								
	For Viaduct	17+16	30.000	9.500	0.065		611.325	65mm thick
	For Transition Zone	2	50.000	9.5+9.5	0.065		123.5	65mm thick
	For Main bridge	1	100+200 +100	9.5+9.5	0.065		494.0	65mm thick
						Total Quantity	1228.83 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1228.83 cum	
						Say 1228.825 cum @ Rs.12743.07	**15659002.99**	
14	14.10 PCC M15 Grade leveling course below approach slab complete as per drawing and Technical specification.							
Approach slab PCC M15								
	PCC M15 for approach slab	2	12.000	5.000	0.100		12.0	
						Total Quantity	12.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	12.0 cum	
						Say 12.0 cum @ Rs.7516.5	**90198.00**	
15	14.11 Reinforced cement concrete approach slab including reinforcement and formwork complete as per drawing and Technical specification.							
For Approach slab M30 grade								
	M30 grade concrete	2	12.000	5.000	0.350		42.0	
						Total Quantity	42.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	42.0 cum	
						Say 42.0 cum @ Rs.12291.21	**516230.82**	

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16	55.26 Providing and applying elastic, elastomeric membrane forming system with anticarbonation and breathing properties. The system should be based on solvent free acrylic polymers with selected mineral fillers and should be ultra-violet resistant, crack bridging type, carbonation resistant, breathable, enviornment friendly, water proofing coating. For anticarbonation, equivalent air layer thickness denoted as R or SD CO2 grater than 50 m and for breathability equivalent air layer thickness denoted as SD H2O shall be less than 4 m for vapour transmitting barrier. The system consists of one coat primer @ 75- 100 g/m2. The consumption of main polymer coating to give film thickness of 200-225 microns (Solid contents- 70%+ -3%) should be approximately. 400-450 g/m2 per two coats depending upon the method of application (either by roller or brush) and surface smoothness of the concrete. The total dry film thickness of the coating system should be minimum 200 microns for the above system. Polymer coating should be in suitable approved shades, including cost of materials, cleaning, chipping and removing the dirt particles of the concrete slab with wire brush and water,labour charges for filling the bug holes, cracks, joints etc with one component polymer modified fine repair and cosmetic mortar, labour for applying the above coating, scaffolding charges,etc. complete as per IRC SP:80 Clause 6.5.1 and Clause 2808 in the Specifications Book for Roads & Bridges published by the Ministry during April 2013.							
Anti carbonate painting for main bridge								
	Anti Carbonate painting in sqm	1				22500.0	22500.0	For main bridge superstructure and pylons
						Total Quantity	22500.0 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	22500.0 sqm	
						Say 22500.0 sqm @ Rs.805.89	**18132525.00**	
5 PART-E: RE WALL PORTION								
1	7.5.2 Assembling, joining and laying of reinforcing facing elements of RCC for Reinforced Earth Structures							
RE wall at approaches								
	From Ch:2+750 to 2+920	1	2920-2750	3.8275-2.296+1.3		1.11	534.305	at 2+750
	From Ch:2+750 to 2+920	1	2920-2750	7.004-1.974+1.3		1.11	1194.471	at 2+920
	Behind A1	1	13.000	7.004-1.974+1.3		1.11	91.342	
	From 4+410 to 4+660	1	4660-4410	7.842-2.6825+1.3		1.11	1792.512	at 4+410
	From 4+410 to 4+660	1	4660-4410	2.973-2.396+1.3		1.12	525.56	at 4+660
	Behind A2	1	13.000	7.842-2.6825+1.3		1.12	94.051	
						Total Quantity	4232.24 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	4232.24 sqm	

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						Say 4232.241 sqm @ Rs.2151.73	**9106639.93**	
2	12.1.2.B Earth work in excavation of foundation of structures as per drawing and technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material. Ordinary Rock (not requiring blasting) - Depth up to 3 m - Mechanical Means 							
Excavation for RE wall								
	From CH:2+750 to Ch:2+920	2	2920-2750	1.800	1.500	1.0	918.0	
	From CH:4+410 to Ch:4+660	2	4660-4410	1.800	1.500	1.0	1350.0	
						Total Quantity	2268.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	2268.0 cum	
						Say 2268.0 cum @ Rs.83.21	**188720.28**	
3	13.5.B Plain/Reinforced Cement Concrete in sub-structure complete as per drawing and Technical Specifications PCC Grade M20 - Height upto 5m							
Coping Beam & Head wall M20 grade								
	From Ch:2+750 to Ch:2+920	2	2920-2750	0.100	0.100		3.4	
	From Ch:4+410 to 4+660	2	4660-4410	0.100	0.100		5.0	
	Behind A1 & A2	2	13.000	0.100	0.100		0.26	
	PCC Head wall from Ch:2+650 to Ch:2+750	2	2750-2650	1.700	0.500		170.0	
	PCC Head wall from Ch:4+660 to Ch:4+720	2	4720-4660	1.400	0.500		84.0	
						Total Quantity	262.66 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	262.66 cum	
						Say 262.66 cum @ Rs.9071.2	**2382641.39**	
4	13.5.A Plain/Reinforced cement concrete in sub-structure complete as per drawing and Technical Specifications PCC Grade M15 - Height upto 5m 							
PCC M15 for levelling pad & below friction slab								
	Levelling pad from Ch:2+750 to Ch:2+920	2	2920-2750	0.150	0.100		5.1	
	Levelling pad from Ch:4+410 to Ch:4+660	2	4660-4410	0.150	0.100		7.5	
	Behind A1 & A2	2	13.000	0.150	0.100		0.39	

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	Friction slab from Ch:2+650 to Ch:2+920	2	2920-2650	2.600	0.075		105.3	
	Friction slab from Ch:4+410 to Ch:4+720	2	4720-4410	2.600	0.075		120.9	
						Total Quantity	239.19 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	239.19 cum	
						Say 239.19 cum @ Rs.8268.15	**1977658.80**	
5	od35459/2019_2020 null Provision of an Reinforced cement concrete crash barrier at the edges of the road, approaches to bridge structures and medians, constructed with M-40 grade concrete with HYSD reinforcement conforming to IRC:21 and dowel bars 25 mm dia, 450 mm long at expansion joints filled with pre-moulded asphalt filler board, keyed to the structure on which it is built and installed as per design given in the enclosure to MOST circular No. RW/NH - 33022/1/94-DO III dated 24 June 1994 as per dimensions in the approved drawing and at locations directed by the Engineer, all as specified							
Crash barrier at RE wall portion								
	From Ch:2+650 to 2+920	3	2920-2650				810.0	
	From Ch:4+410 to Ch:4+720	3	4720-4410				930.0	
						Total Quantity	1740.0 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	1740.0 metre	
						Say 1740.0 metre @ Rs.5500.57	**9570991.80**	
6	od35461/2019_2020 null Reinforced cement concrete friction slab including reinforcement and formwork complete as per drawing and Technical specification.							
Friction slab M40 at RE wall portion								
	From Ch:2+650 to Ch:2+920	2	2920-2650	2.5*0.25 +0.2*1+0 .5*0.1			472.5	
	From Ch: 4+410 to Ch:4+720	2	4720-4410	2.5*0.25 +0.2*1+0 .5*0.1			542.5	
						Total Quantity	1015.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1015.0 cum	
						Say 1015.0 cum @ Rs.15975.92	**16215558.80**	
6 PART-F: PROJECT AMENITIES & STRUCTURAL HEALTH MONITORING SYSTEMS								
1	od35468/2019_2020 null Providing Touring Amenities like Cafeteria, Elevator/Lifts, ramps etc at main bridge portion							
Providing Touring Amenities like Cafeteria, Elevator/Lifts, ramps etc at main bridge portion								
	Lumpsum	1					1.0	
						Total Quantity	1.0 L.S	

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						Total Deducted Quantity	0.0 L.S	
						Net Total Quantity	1.0 L.S	
						Say 1.0 L.S @ Rs.1.500000013E7	**15000000.13**	
2	od36035/2019_2020 null Installing Structural Health Monitoring systems at Cable stayed/ extradosed bridge portions to monitor the structural behaviour of the bridge.							
Providing SHM system at main bridge								
	No.of systems at main bridge portion	1					1.0	
						Total Quantity	1.0 L.S	
						Total Deducted Quantity	0.0 L.S	
						Net Total Quantity	1.0 L.S	
						Say 1.0 L.S @ Rs.2.000000063E7	**20000000.63**	
7 PART-G: SITE CLEARANCE								
1	2.3.2.A Clearing and grubbing road land including uprooting rank vegetation, grass, bushes, shrubs, saplings and trees girth up to 300 mm, removal of stumps of trees cut earlier and disposal of unserviceable materials and stacking of serviceable material to be used or auctioned, up to a lead of 1000 metres including removal and disposal of top organic soil not exceeding 150 mm in thickness In area of light jungle - By Mechanical Means 							
Clearing and grubbing								
	Clearing and grubbing by maechanical means	1	2890.000	6.600			2.194	
						Total Quantity	2.19 Hecter	
						Total Deducted Quantity	0.0 Hecter	
						Net Total Quantity	2.19 Hecter	
						Say 2.194 Hecter @ Rs.54806.88	**120246.29**	
2	2.10.B Dismantling of kilometre stone including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and back filling of pit Dismantling of Ordinary KM Stone including cutting of earth, foundation and disposal of dismantled material with all lifts and lead upto 1000 m and back filling of pit							
Dismantling of kilometre stone								
	Dismantling of kilometre stone	3					3.0	
						Total Quantity	3.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	3.0 each	
						Say 3.0 each @ Rs.396.44	**1189.32**	
3	2.5.2.A Dismantling of flexible pavements and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately Bituminous course - By Mechanical Means 							
Bituminous course								
	Bituminous course	1	2870.000	7.000	0.100	1.15	2310.35	
						Total Quantity	2310.35 cum	

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						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	2310.35 cum	
						Say 2310.35 cum @ Rs.406.18	**938417.96**	
4	2.5.1.B Dismantling of flexible pavements and disposal of dismantled materials up to a lead of 1000 metres, stacking serviceable and unserviceable materials separately Granular courses - By Manual Means 							
Granular courses								
	Granular courses	1	2870.000	7.000	0.200	1.15	4620.7	Granular courses
						Total Quantity	4620.7 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	4620.7 cum	
						Say 4620.7 cum @ Rs.858.12	**3965115.08**	
8 PART-H: PAVEMENT BILL								
1	4.1.A.2 Construction of granular sub-base by providing graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401 Grading-II - Plant Mix Method 							
GSB-Grading-II - Plant Mix Method								
	GSB-Grading-II - Plant Mix Method	1	2910.000	3.588	0.200	1.05	2192.627	GSB-Grading-II - Plant Mix Method
						Total Quantity	2192.63 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	2192.63 cum	
						Say 2192.627 cum @ Rs.3389.91	**7432808.19**	
2	4.12 Providing, laying, spreading and compacting graded stone aggregate to Wet Mix Macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub- base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.							
Wet Mix Macadam								
	Wet Mix Macadam	1	2910.000	3.539	0.250	1.05	2703.354	Wet Mix Macadam
						Total Quantity	2703.35 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	2703.35 cum	
						Say 2703.354 cum @ Rs.3245.29	**8773167.70**	
3	3.18 Construction of sub-grade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2							
sub-grade and earthen shoulders								

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	sub-grade and earthen shoulders	1	2910.000	3.588	0.500	1.05	5481.567	sub-grade and earthen shoulders
						Total Quantity	5481.57 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	5481.57 cum	
						Say 5481.567 cum @ Rs.469.66	**2574472.76**	
4	5.1.a Providing and applying primer coat with bitumen emulsion (SS) on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.70 - 1.0 kg/sqm using mechanical means.							
	primer coat							
	primer coat	1	2910.000	10.000		1.05	30555.0	primer coat
						Total Quantity	30555.0 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	30555.0 sqm	
						Say 30555.0 sqm @ Rs.56.21	**1717496.55**	
5	5.2.a Providing and applying tack coat with bitumen emulsion(RS) using emulsion pressure distributor at the rate of 0.20 - 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.							
	Tack Coat							
	Tack Coat	1	2910.000	10.000		1.05	30555.0	Tack Coat
						Total Quantity	30555.0 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	30555.0 sqm	
						Say 30555.0 sqm @ Rs.10.98	**335493.90**	
6	5.4.1 Providing and laying dense bituminous macadam with 80-100 TPH HMP producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder (VG 30) @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects. Grading - I (37.5 mm Nominal Size) 							
	DBM							
	DBM	1	2910.000	6.344	0.075	1.05	1453.807	DBM
						Total Quantity	1453.81 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1453.81 cum	
						Say 1453.807 cum @ Rs.9091.5	**13217286.34**	

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7	5.6.1.a Providing and laying bituminous concrete with 80-100 TPH hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with bituminous binder(NRMB) @ 5.2 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects For Grading - I (19 mm nominal size) 							
BC								
	BC	1	2910.000	10.000	0.040	1.05	1222.2	BC
						Total Quantity	1222.2 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1222.2 cum	
						Say 1222.2 cum @ Rs.11915.34	**14562928.55**	
9 PART-I: ROAD FURNITURE								
1	8.14.1 Reinforced cement concrete M15 grade Kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc. 5th Kilometre stone (precast)							
5th Kilometre stone								
	5th Kilometre stone	1					1.0	5th Kilometre stone
						Total Quantity	1.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	1.0 each	
						Say 1.0 each @ Rs.5260.8	**5260.80**	
2	8.14.2 Reinforces cement concrete M 15 grade Kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc Ordinary kilometer stone (precast)							
Ordinary kilometer stone								
	Ordinary kilometer stone	5					5.0	
						Total Quantity	5.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	5.0 each	
						Say 5.0 each @ Rs.3193.74	**15968.70**	
3	8.14.3 Reinforced cement concrete M15 grade Hectometer stone of standard design as per IRC-8-1980, fixing in position including painting and printing etc Hectometer stone (precast)							
Hectometer stone (precast)								
	Hectometer stone (precast)	27					27.0	
						Total Quantity	27.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	27.0 no	

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						Say 27.0 no @ Rs.862.94	**23299.38**	
4	8.16 Reinforced cement concrete M-15 grade boundary pillars of standard design as per IRC:25-19767, fixed in position including finishing and lettering but excluding painting .							
Boundary pillars								
	Boundary pillars	132					132.0	Boundary pillars
						Total Quantity	132.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	132.0 no	
						Say 132.0 no @ Rs.960.22	**126749.04**	
5	8.11.1 Painting lines, dashes, arrows etc on roads in two coats on new work with ready mixed road marking paint conforming to IS:164 on bituminous surface, including cleaning the surface of all dirt, dust and other foreign matter, demarcation at site and traffic control Over 10 cm in width							
Road marking paint								
	Road marking paint	1	1934.000	1.000			1934.0	
						Total Quantity	1934.0 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	1934.0 sqm	
						Say 1934.0 sqm @ Rs.191.13	**369645.42**	
6	8.4.3 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 60 cm circular							
60 cm circular								
	60 cm circular	18					18.0	60 cm circular
						Total Quantity	18.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	18.0 each	
						Say 18.0 each @ Rs.4052.14	**72938.52**	
7	8.4.9 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 75 cm circular							
75 cm circular								

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	75 cm circular	8					8.0	
						Total Quantity	8.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	8.0 each	
						Say 8.0 each @ Rs.4831.52	**38652.16**	
8	8.4.10 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 90 cm circular							
90 cm circular								
	90 cm circular	4					4.0	90 cm circular
						Total Quantity	4.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	4.0 each	
						Say 4.0 each @ Rs.5782.45	**23129.80**	
9	8.4.2 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 60 cm equilateral triangle							
60 cm equilateral triangle								
	60 cm equilateral triangle	76					76.0	60 cm equilateral triangle
						Total Quantity	76.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	76.0 each	
						Say 76.0 each @ Rs.3429.62	**260651.12**	
10	8.4.1 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting vide clause 801.3.3 fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 90 cm equilateral triangle							

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90 cm equilateral triangle								
	90 cm equilateral triangle	14					14.0	90 cm equilateral triangle
Total Quantity							14.0 each	
Total Deducted Quantity							0.0 each	
Net Total Quantity							14.0 each	
Say 14.0 each @ Rs.4380.56							**61327.84**	
11	8.4.12 Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign with 7years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with suitable back supporting frame of MS angle 25x25x3 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc. 50cmx 60 cm rectangular (Single chevron etc.)							
50cmx 60 cm rectangular (Single chevron)								
	50cmx 60 cm rectangular (Single chevron)	76					76.0	50cmx 60 cm rectangular (Single chevron)
Total Quantity							76.0 each	
Total Deducted Quantity							0.0 each	
Net Total Quantity							76.0 each	
Say 76.0 each @ Rs.4135.48							**314296.48**	
12	8.35 Providing and fixing reflective road studs (Raised Pavement Marker) of ' category A' made out of ASA/HIPS/ABS moulded body with shanks and conforming to ASTM D 4280, strong enough to support a load of more than 13.635 T when tested in accordance with ASTM D 4280, reflective panel confirming to ASTM D 788, and reflectivity conforming to clause 804.4. including installation, drilling, fixing with adhesive etc. with 2 years warranty for the road stud as well as for in field performance as per clause 804.7.3 Road Markers/Road Stud with Lense Reflector :-							
Normal Road Studs								
	Normal Road Studs	1650					1650.0	Normal Road Studs
Total Quantity							1650.0 no	
Total Deducted Quantity							0.0 no	
Net Total Quantity							1650.0 no	
Say 1650.0 no @ Rs.222.0							**366300.00**	
13	8.23.A Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per clause 811.3 							
"W" metal beam crash barrier								

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	"W" metal beam crash barrier	1	320.000				320.0	
						Total Quantity	320.0 metre	
						Total Deducted Quantity	0.0 metre	
						Net Total Quantity	320.0 metre	
						Say 320.0 metre @ Rs.3967.85	**1269712.00**	
14	od35479/2019_2020 null Providing and laying factory made chamfered edge Cement Concrete paver blocks in footpath, parks, lawns, drive ways or light traffic parking etc, of required strength, thickness & size/ shape, made by table vibratory method using PU mould, laid in required colour & pattern over 50mm thick compacted bed of sand, compacting and proper embedding/laying of inter locking paver blocks into the sand bedding layer through vibratory compaction by using plate vibrator, filling the joints with sand and cutting of paver blocks as per required size and pattern, finishing and sweeping extra sand. complete all as per direction of Engineer-in-Charge. 60mm thick cement concrete paver block of M35 grade with approved colour, design & pattern							
Paver Block								
	Paver Block	1	3300.000	1.800			5940.0	Paver Block
						Total Quantity	5940.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	5940.0 cum	
						Say 5940.0 cum @ Rs.1173.19	**6968748.60**	
15	od35561/2019_2020 null Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3							
Full Width Overhead Gantry								
	Full Width Overhead Gantry	1					1.0	Full Width Overhead Gantry
						Total Quantity	1.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	1.0 no	
						Say 1.0 no @ Rs.1265000.0	**1265000.00**	
16	od35562/2019_2020 null Providing and erecting gantry mounted variable message sign board electronically operated capable of flashing the desired message over a designed support system of aluminium alloy or galvanised steel, erected as per approved design and drawings and with lateral clearance as per clause 802.3							
Over head cantilever girder								
	Over head cantilever girder	4					4.0	

Public Works Department
PRICE

						Total Quantity	4.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	4.0 no	
						Say 4.0 no @ Rs.632500.0	**2530000.00**	
17	od35563/2019_2020 null Providing and fixing reflective Solar road studs (Raised Pavement Marker) of ' category A' made out of ASA/HIPS/ABS moulded body with shanks and conforming to ASTM D 4280, strong enough to support a load of more than 13.635 T when tested in accordance with ASTM D 4280, reflective panel confirming to ASTM D 788, and reflectivity conforming to clause 804.4. including installation, drilling, fixing with adhesive etc. with 2 years warranty for the road stud as well as for in field performance as per clause 804.7.3 Solar Stud								
Solar Road Studs								
	Solar Road Studs	165					165.0	Solar Road Studs
						Total Quantity	165.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	165.0 no	
						Say 165.0 no @ Rs.2500.0	**412500.00**	
18	od35564/2019_2020 null High Mast light of pole height 25m							
High Mast light of pole height 25m								
	High Mast light of pole height 25m	2					2.0	High Mast light of pole height 25m
						Total Quantity	2.0 100 meter	
						Total Deducted Quantity	0.0 100 meter	
						Net Total Quantity	2.0 100 meter	
						Say 2.0 100 meter @ Rs.525000.03	**1050000.06**	
19	8.15 Supplying and installation of delineator (Road way indicators) posts 80- 100cm high above ground level, pained black and white in 15 cm wide strips, fitted with min. 80 x 100 mm rectangular or 75 mm dia circular retro reflectorised panels at the top with minimum visibility of 300m with provisions to prevent edge lifting and vandalisam, and conforming to clause 806 , IRC-79 and the drawings including fixing to ground (The deleniator shall be of approved type as per specification)							
Road Way Delinators								
	Road Way Delinators	35					35.0	Road Way Delinators
						Total Quantity	35.0 each	
						Total Deducted Quantity	0.0 each	
						Net Total Quantity	35.0 each	

Public Works Department
PRICE

						Say 35.0 each @ Rs.568.21	**19887.35**	
20	8.29.2 Providing and laying of a reinforced cement concrete pipe duct, 300 mm dia, across the road (new construction), extending from drain to drain in cuts and toe of slope to toe of slope in fills, constructing head walls at both ends, providing a minimum fill of granular material over top and sides of RCC pipe as per IRC:98-1997, bedded on a 0.3 m thick layer of granular material free of rock pieces, outer to outer distance of pipe at least half dia of pipe subject to minimum 450 mm in case of double and triple row ducts, joints to be made leak proof, invert level of duct to be above higher than ground level to prevent entry of water and dirt, all as per IRC: 98 - 1997 and approved drawings. Cable Duct Across the Road - Double row for two utility services							
Pipe Culvert								
	Pipe Culvert	1	52.000				52.0	Pipe Culvert
						Total Quantity	52.0 RM	
						Total Deducted Quantity	0.0 RM	
						Net Total Quantity	52.0 RM	
						Say 52.0 RM @ Rs.8010.45	**416543.40**	
21	8.5 Providing and fixing of direction and place identification retro-reflectorised sign with 7 years warranty manufactured as per IRC :67 made of Type IV micro prismatic grade sheeting fixed over aluminium sheeting, 2 mm thick/ aluminium composit material sheeting 4 mm thick with area not exceeding 0.9 sqm, with suitable back supporting frame of MS angle 40x40x6 and supported on GI pipe pole 50mm NB confirming to IS 1239 firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete min size 45 cm x 45 cm x 60 cm, 60 cm below ground level including painting all exposed surface with 2 coats of epoxy painting over epoxy primer and as per approved drawing and clause 801 including lettering symbols etc.							
Place Identification Sign								
	Place Identification Sign	10					10.0	Place Identification Sign
						Total Quantity	10.0 sqm	
						Total Deducted Quantity	0.0 sqm	
						Net Total Quantity	10.0 sqm	
						Say 10.0 sqm @ Rs.8960.22	**89602.20**	
22	od35591/2019_2020 null Informatory Sign 1)Advance Direction Sign 2)Reassurance Sign							
Informatory Sign 1)Advance Direction Sign 2)Reassurance Sign								
	Informatory Sign 1)Advance Direction Sign 2)Reassurance Sign1	10					10.0	Informatory Sign 1)Advance Direction Sign 2)Reassurance Sign
						Total Quantity	10.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	10.0 no	

Public Works Department
PRICE

						Say 10.0 no @ Rs.5078.0	**50780.00**	
23	od35592/2019_2020 null Facility Information Sign 1)Flag Type 2)Informatory Sign 3)Facility Informatory sign							
Facility Information Sign 1)Flag Type 2)Informatory Sign 3)Facility Informatory sign								
	Facility Information Sign 1)Flag Type 2)Informatory Sign 3)Facility Informatory sign	78					78.0	Facility Information Sign 1)Flag Type 2)Informatory Sign 3)Facility Informatory sign
						Total Quantity	78.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	78.0 no	
						Say 78.0 no @ Rs.3350.0	**261300.00**	
24	od35593/2019_2020 null Informatory Sign 1)Flag type Direction Sign							
Flag type Direction Sign								
	Flag type Direction Sign	4					4.0	Flag type Direction Sign
						Total Quantity	4.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	4.0 no	
						Say 4.0 no @ Rs.3088.0	**12352.00**	
25	od35594/2019_2020 null Construction Zone Informatory Sign							
Informatory Sign								
	Informatory Sign	10					10.0	Informatory Sign
						Total Quantity	10.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	10.0 no	
						Say 10.0 no @ Rs.3699.99	**36999.90**	
26	od35595/2019_2020 null Construction Zone Mandatory Sign							
Mandatory Sign								
	Mandatory Sign	20					20.0	Mandatory Sign
						Total Quantity	20.0 no	

Public Works Department
PRICE

						Total Deducted Quantity	0.0 no	
						Net Total Quantity	20.0 no	
						Say 20.0 no @ Rs.4257.99	**85159.80**	
27	od35596/2019_2020 null Construction Zone Cautionary sign							
Cautionary sign								
	Cautionary sign	20					20.0	Cautionary sign
						Total Quantity	20.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	20.0 no	
						Say 20.0 no @ Rs.3321.0	**66420.00**	
28	od35597/2019_2020 null Delineators Stickers Provided at the Place of WBCB in the Edge of the Carriageway							
	Delineators Stickers Provided at the Place of WBCB in the Edge of the Carriageway	166					166.0	Delineators Stickers Provided at the Place of WBCB in the Edge of the Carriage way
						Total Quantity	166.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	166.0 no	
						Say 166.0 no @ Rs.600.0	**99600.00**	
29	od35600/2019_2020 null Providing and erecting Overhead Signs complete as per Drawing and Technical Specification Clause 802 Forgiving Delineator Post							
Forgiving Delineator Post								
	Forgiving Delineator Post	113					113.0	Forgiving Delineator Post
						Total Quantity	113.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	113.0 no	
						Say 113.0 no @ Rs.1001.99	**113224.87**	
30	od35601/2019_2020 null Providing and Fixing retro-reflected road delineators complete as per drawing and technical specification Clause 805 One way Hazard Marker							
One way Hazard Marker								

Public Works Department
PRICE

	One way Hazard Marker	6					6.0	One way Hazard Marker
						Total Quantity	6.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	6.0 no	
						Say 6.0 no @ Rs.491.0	**2946.00**	
31	od35602/2019_2020 null Providing and erecting street light mounted on a steel circular hollow pole of standard specifications for street lighting, 9 m high spaced 40 m apart, 1.8 m overhang on both sides if fixed in the median and on one side if fixed on the footpath, fitted with sodium vapour lamp and fixed firmly in concrete foundation. For Fixing in Median							
	light Pole of 9m Height							
	light Pole of 9m Height	128					128.0	light Pole of 9m Height
						Total Quantity	128.0 no	
						Total Deducted Quantity	0.0 no	
						Net Total Quantity	128.0 no	
						Say 128.0 no @ Rs.100000.0	**12800000.00**	
	10 Drainage Works							
1	od35357/2019_2020 null Supply, Fitting and Placing un- coated HYSD bar Reinforcement in Foundation complete as per Drawing and Technical Specifications-including epoxy coating for Substructure							
	HYSD Bar for Drain							
	HYSD Bar for Drain	1	5780.000	0.150	0.650	0.14	78.897	HYSD Bar for Drain
						Total Quantity	78.9 MT	
						Total Deducted Quantity	0.0 MT	
						Net Total Quantity	78.9 MT	
						Say 78.897 MT @ Rs.96509.71	**7614326.59**	
2	13.5.B Plain/Reinforced Cement Concrete in sub-structure complete as per drawing and Technical Specifications PCC Grade M20 - Height upto 5m							
	For Drain and Pre Cast Slab							
	For Drain and Pre Cast Slab	1	7302.564	0.650	0.150	2.0	1424.0	For Drain and Pre Cast Slab
						Total Quantity	1424.0 cum	
						Total Deducted Quantity	0.0 cum	
						Net Total Quantity	1424.0 cum	
						Say 1424.0 cum @ Rs.9071.2	**12917388.80**	
						Total	**2371223575.49**	

Public Works Department
PRICE

Provision for GST payments (in %) @	**12.0%**
Amount reserved for GST payments	**284546829.06**
Total	**2655770404.55**
Lumpsum for roundoff	**0.00**
TOTAL	**2655770404.55**
Rounded Total	**Rs 2,65,57,70,405**
Rupees Two Hundred Sixty Five Crore Fifty Seven Lakh Seventy Thousand Four Hundred and Five only	

Public Works Department
PRICE

L&T Infrastructure Engineering Limited

TC 2 Building, 3rd Floor, Mount Poonamallee Road,
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Chennai-600 089, Tamil Nadu, India
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ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

VOLUME-9 DRAWINGS

DRA□ ING INDE□

PRO□ECT	DPR □OR PONNANI CABLE STAYED BRIDGE	
SL□NO	**DRG□NO□**	**TITLE**
	TYPICAL CROSS SECTION	
1	DDX001	TYPICAL CROSS SECTION TYPE 1&2
	RUNNING CROSS SECTION	
2	DDX101 to DDX110	RUNNING CROSS SECTION FROM CH:0.000 TO CH:4800.000
	ALIGNMENT PLAN	
3	DDO001a to DDO005a	ALIGNMENT PLAN - OPTION 1A FROM CH:0.000 TO CH:4800.000
4	DDO001b to DDO005b	ALIGNMENT PLAN - OPTION 1B FROM CH:0.000 TO CH:4800.000
5	DDO001c to DDO005c	ALIGNMENT PLAN - OPTION 1C FROM CH:0.000 TO CH:4800.000
	E□ISTING □EATURE	
6	DDS001 to DDS010	EXISTING FEATURE PLAN - FROM CH:0.000 TO CH:4800.000
	STRIP PLAN	
7	DDS101 to DDS110	STRIP PLAN - FROM CH:0.000 TO CH:4800.000
	PLAN □ PRO□ILE	
8	DDP001a to DDP010a	PLAN & PROFILE - OPTION 1A FROM CH:0.000 TO CH:4800.000
9	DDP001b to DDP010b	PLAN & PROFILE - OPTION 1B FROM CH:0.000 TO CH:4800.000
10	DDP001c to DDP010c	PLAN & PROFILE - OPTION 1C FROM CH:0.000 TO CH:4800.000
	TYPICAL DRA□ INGS □OR ROAD SIGNS	
11	DDF001	TYPICAL ROAD SIGNS
12	DDF002	DIRECTIONAL ARROWS FOR ROADS
13	DDF003	TYPICAL DETAILS OF ROAD MARKINGS
14	DDF004	TYPICAL DETAILS OF ROAD STUDS
	□UNCTION DEVELOPEMENT	
15	DDJ001	JUNCTION DEVELOPMENT AT CH: 2+680
16	DDJ002	JUNCTION DEVELOPMENT AT CH: 0+800
17	DDJ003	JUNCTION DEVELOPMENT AT CH: 2+550
	ROAD SIGNS PLAN	
18	DDF101 to DDF110	ROAD SIGNS PLAN FROM CH:0.000 TO CH:4800.000

SL□NO	DRG□NO□	STRUCTURE
1	DDG 501	KEY PLAN (SHEET 1 OF 5)
2	DDG 502	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 2 OF 5)
3	DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 3 OF 5)
4	DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 4 OF 5)
5	DDG 505	CROSS SECTIONS (SHEET 5 OF 5)
6	DDG 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m
7	DDI 507	NUMERATION DETAILS OF PILE & PILECAP FOR EJ & INTERMEDIATE PIER LOCATION FOR 4x30 (TYP.)
8	DDI 508	RC DETAILS OF PILE & PILECAP FOR EJ & INTERMEDIATE PIER LOCATION FOR 4x30 (TYP.)
9	DDI 509	NUMERATION DETAILS OF PIER AT EJ & INTERMEDIATE PIER LOCATIONS FOR 4x30m (TYP.)
10	DDI 510	RC DETAILS OF PIER AT EJ & INTERMEDIATE PIER LOCATIONS FOR 4x30m (TYP.)
11	DDI 511	NUMERATION DETAILS OF RCC PRECAST GIRDERS 4x30m (TYP.)
12	DDI 512	RC DETAILS OF RCC PRECAST GIRDERS 4x30m (TYP.)
13	DDI 513	NUMERATION AND RC DETAILS OF DIAPHRAGM AT EJ LOCATION 4x30m (TYP.)
14	DDI 514	NUMERATION AND RC DETAILS OF INTERMEDIATE DIAPHRAGM 4x30m (TYP.)
15	DDI 515	NUMERATION AND RC DETAILS OF DECK SLAB 4x30m (TYP.)
16	DDI 516	CONSTRUCTION METHODOLOGY FOR TYPICAL 4x30m
17	DDI 517	SEGMENT LAYOUT FOR MAIN BRIDGE
18	DDI 518	STAY CABLE FOR MAIN BRIDGE
19	DDI 519	NUMERATION DETAILS OF PILE & PILE CAP FOR PYLON (TYP.)
20	DDI 520	RC DETAILS OF PILE & PILE CAP FOR PYLON (TYP.)
21	DDI 521	NUMERATION DETAILS OF PYLON
22	DDI 522	NUMERATION DETAILS RUNNING AND RC SEGMENT
23	DDI 523	RC DETAILS RUNNING AND RC SEGMENT
24	DDI 524	CONSTRUCTION STAGES DRAWING (SHEET 1 OF 6)
25	DDI 525	CONSTRUCTION STAGES DRAWING (SHEET 2 OF 6)
26	DDI 526	CONSTRUCTION STAGES DRAWING (SHEET 3 OF 6)
27	DDI 527	CONSTRUCTION STAGES DRAWING (SHEET 4 OF 6)
28	DDI 528	CONSTRUCTION STAGES DRAWING (SHEET 5 OF 6)
29	DDI 529	CONSTRUCTION STAGES DRAWING (SHEET 6 OF 6)
30	DDI 530	ARCHITECTURAL VIEW-1
31	DDI 531	ARCHITECTURAL VIEW-2
32	DDI 532	ARCHITECTURAL VIEW-3
33	DDI 533	ARCHITECTURAL VIEW-4
34	DDI 534	ARCHITECTURAL VIEW-5
35	DDI 535	ARCHITECTURAL VIEW-6
36	DDI 536	ARCHITECTURAL VIEW-7
37	DDI 537	ARCHITECTURAL VIEW-8
38	DDI 538	RC DETAILS OF PYLON

FOR APPROVAL

NOTES:

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	YYMMDD	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200213	2	FOR APPROVAL	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING | ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE | PROJECT NO: C1193601

TITLE: DRAWING INDEX | COP: IRC | SCALE: AS SHOWN

L&T Infra Engineering | L&T Infrastructure Engineering Ltd. | DRAWING NO: DDV001 | REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\01INDEX SHEET.DWG

TBNA

ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

HIGHWAY DRAWINGS

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TBNA

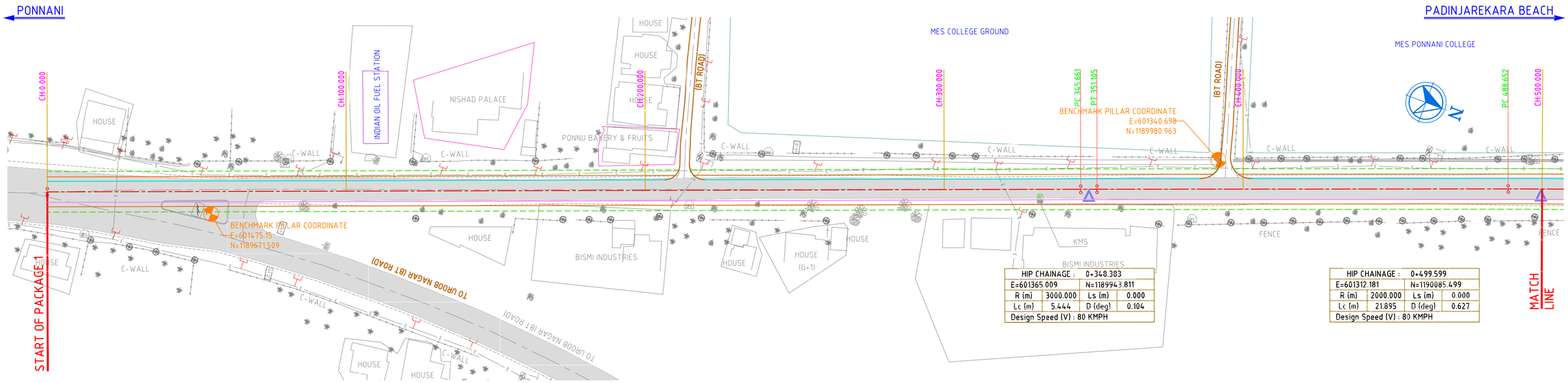
ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

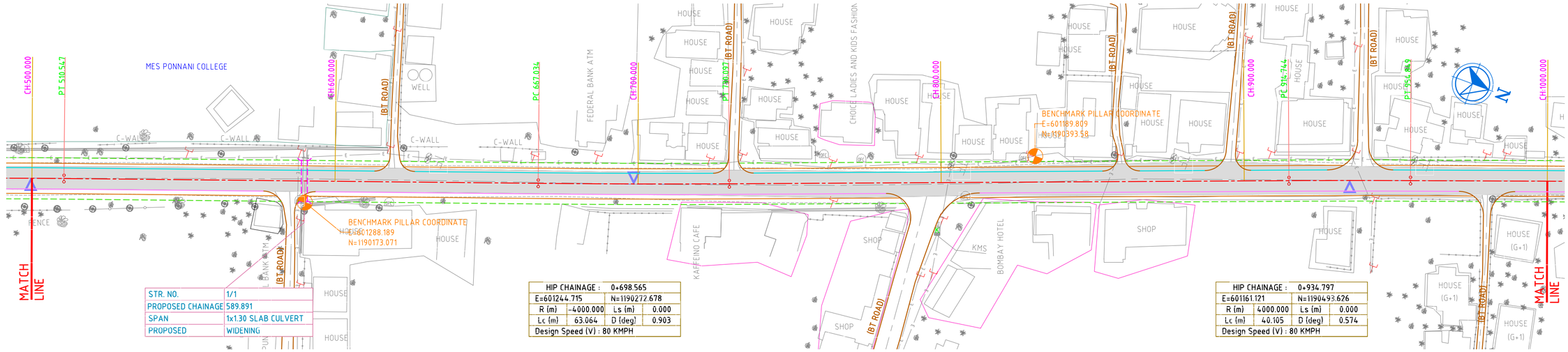
DPR FOR PONNANI CABLE STAYED BRIDGE

ALIGNMENT PLAN

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ALIGNMENT PLAN\DD01011 TO DD01105-RR-ALIGNMENT PLAN KM 0.000 TO KM 4.800 -FINAL.DWG

TBNA





STR. NO.	1/1
PROPOSED CHAINAGE	589.891
SPAN	1x1.30 SLAB CULVERT
PROPOSED	WIDENING

LEGEND:

- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

DESIGN - HIMANSHU (HMS)
DRAWN - DHIVYA (DVB)
CHECKED - NIRMALYA CHAKRABORTI (NCB)
APPROVED - K. GANESH IYER (KGN)

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	INIT. CHECKED	SIGN.	INIT. APPROVED	SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

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ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE
PROJECT NO: C1193601

TITLE: ALIGNMENT PLAN FROM CH:0.000 TO CH:1000.000
COP: IRC
SCALE: 1:1000

L&T Infra Engineering
L&T Infrastructure Engineering Ltd.

DRAWING NO: DD0101
REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ALIGNMENT PLAN\DD0101 TO DD0105-RO-ALIGNMENT PLAN KM 0.000 TO KM 4.800 -FINAL.DWG

TBNA

PONNANI

PADINJAREKARA BEACH

KARUNYA COMMUNITY PHARMACY

KARUNYA COMMUNITY PHARMACY

BENCHMARK PILLAR COORDINATE
E=601090.238
N=1190667.861

BENCHMARK PILLAR COORDINATE
E=601008.228
N=1190810.704

RISWANA TEA STALL

POPULAR HYUNDAI FESTIVE COUTER

MATCH LINE

MATCH LINE

HIP CHAINAGE :		1+088.086	
E=601108.317		N=1190637.533	
R (m)	5000.000	Ls (m)	0.000
Lc (m)	7.485	D (deg)	0.086
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :		1+511.721	
E=600962.975		N=1191035.481	
R (m)	-3000.000	Ls (m)	0.000
Lc (m)	171.556	D (deg)	3.276
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :		1+791.933	
E=600851.948		N=1191292.785	
R (m)	-1500.000	Ls (m)	0.000
Lc (m)	45.133	D (deg)	1.724
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :		1+961.423	
E=600780.112		N=1191446.389	
R (m)	-1200.000	Ls (m)	0.000
Lc (m)	140.340	D (deg)	6.701
Design Speed (V) : 80 KMPH			

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

DESIGN	- HIMANSHU (HMS)
DRAWN	- DHIVYA (DVB)
CHECKED	- NIRMALYA CHAKRABORTI (NCB)
APPROVED	- K. GANESH IYER (KGN)

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REV.	YYMMDD	STATUS	DESCRIPTION	DES.	DRN.	CHECKED		APPROVED	
						INIT.	SIGN.	INIT.	SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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ORIG. SIZE A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ALIGNMENT PLAN FROM CH:1000.000 TO CH:2000.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DD0102

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ALIGNMENT PLAN\DD0101 TO DD0105-R0-ALIGNMENT PLAN KM 0.000 TO KM 4.800 -FINAL.DWG

TBNA

PONNANI

PADINJAREKARA BEACH

HIP CHAINAGE :		2+157.332	
E=600676.903		N=1191613.076	
R (m)	600.000	Ls (m)	35.000
Lc (m)	44.277	D (deg)	7.570
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :		2+296.127	
E=600619.958		N=1191739.818	
R (m)	-180.000	Ls (m)	25.000
Lc (m)	13.821	D (deg)	12.357
Design Speed (V) : 40 KMPH			

STR. NO.	3/1
PROPOSED CHAINAGE	2380.474
SPAN	1x1.0 SLAB CULVERT
PROPOSED	WIDENING

HIP CHAINAGE :		2+418.443	
E=600546.671		N=1191838.671	
R (m)	150.000	Ls (m)	30.000
Lc (m)	38.145	D (deg)	26.029
Design Speed (V) : 40 KMPH			

HIP CHAINAGE :		2+585.879	
E=600515.966		N=1192003.980	
R (m)	-600.000	Ls (m)	35.000
Lc (m)	37.672	D (deg)	6.940
Design Speed (V) : 65 KMPH			

HIP CHAINAGE :		2+823.432	
E=600437.992		N=1192251.854	
R (m)	-170.000	Ls (m)	70.000
Lc (m)	159.543	D (deg)	77.364
Design Speed (V) : 65 KMPH			

BENCHMARK PILLAR COORDINATE
E=600638.276
N=1191682.650

BENCHMARK PILLAR COORDINATE
E=600518.594
N=1191976.661

BENCHMARK PILLAR COORDINATE
E=600614.029
N=1192020.653

BENCHMARK PILLAR COORDINATE
E=600466.11
N=1192475.925

VIADUCT STRUCTURE START
RE WALL END
CH:2920.000

RE WALL START
CH:2750.000

END OF PACKAGE 1
START OF PACKAGE 2

PONNANI FERRY TERMINAL

LEGEND:

- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

DESIGN	- HIMANSHU (HMS)
DRAWN	- UMIVYA (UVB)
CHECKED	- NIRMALYA CHAKRABORTI (NCB)
APPROVED	- K. GANESH IYER (KGN)

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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DRG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ALIGNMENT PLAN FROM CH:2000.000 TO CH:3000.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DD0103

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ALIGNMENT PLAN\DD0101 TO DD0105-RO-ALIGNMENT PLAN KM 0.000 TO KM 4.800 -FINAL.DWG

TBNA

PONNANI

PADINJAREKARA BEACH

CH:3100.000

CS 3162.456

CH:3200.000

ST 3212.456

PC 3218.051

CS 3057.456

CH:3000.000

TYPE : VIADUCT
SIZE : 17×30+1x50

TO PONNANI – PURATHUR

TO PONNANI – PURATHUR JFI

CH:3300.000

HOUSE

HOUSE

HOUSE

HOUSE

HOUSE

HOUSE

HOUSE

HOUSE

HOUSE

HOUSE

SUMP

BENCHMARK PILLAR COORDINATE
E=599887.031
N=1192444.705

TO BEACH (MUD ROAD)

CH:3400.000

PONNANI – PURATHUR JENKAR TERMINAL

PT 3482.450

CH:3500.000

CABLE STAYED
BRIDGE START
VIADUCT STRUCTURE
END CH:3480.000

MATCH LINE

HIP CHAINAGE :		3+100.050	
E=600133.839		N=1192226.176	
R (m)	170.000	Ls (m)	70.000
Lc (m)	84.811	D (deg)	52.177
Design Speed (V) : 65 KMPH			

HIP CHAINAGE :		3+350.100	
E=599959.748		N=1192415.172	
R (m)	1200.000	Ls (m)	0.000
Lc (m)	264.100	D (deg)	12.610
Design Speed (V) : 65 KMPH			

BACKWATER

GPS PILLAR COORDINATE
E=599828.091
N=1192532.128

GPS PILLAR COORDINATE
E=599625.696
N=1192805.090

TRUE GROOVE

CH:3500.000

CH:3600.000

CH:3700.000

CH:3800.000

PC 3881.352

CH:3900.000

CH:4000.000

CABLE STAYED BRIDGE END
VIADUCT STRUCTURE START CH:3880.000

STR. NO.	4/1
PROPOSED CHAINAGE	3680.000
PROPOSED	CABLE STAYED BRIDGE
SPAN	1x100+1x200.00+1x100

MATCH LINE

MATCH LINE

LEGEND:

- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

DESIGN	– HIMANSHU (HMS)
DRAWN	– DHIVYA (DVB)
CHECKED	– NIRMALYA CHAKRABORTI (NCB)
APPROVED	– K. GANESH IYER (KGN)

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ALIGNMENT PLAN FROM CH:3000.000 TO CH:4000.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DD0104

REV: 0

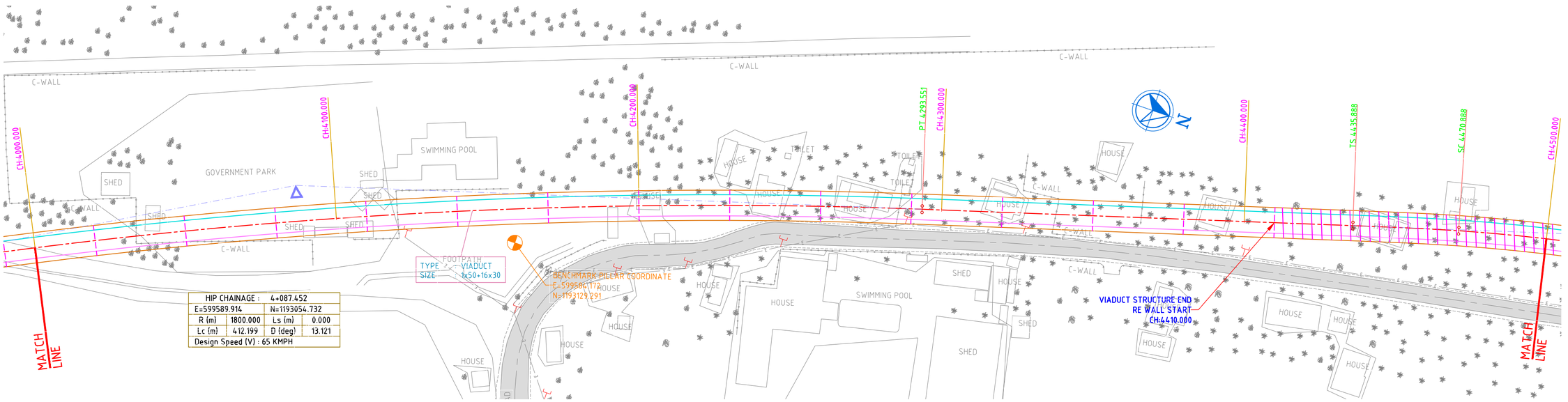
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ALIGNMENT PLAN\DD0101 TO DD0105-RR-ALIGNMENT PLAN KM 0.000 TO KM 4.800 -FINAL.DWG

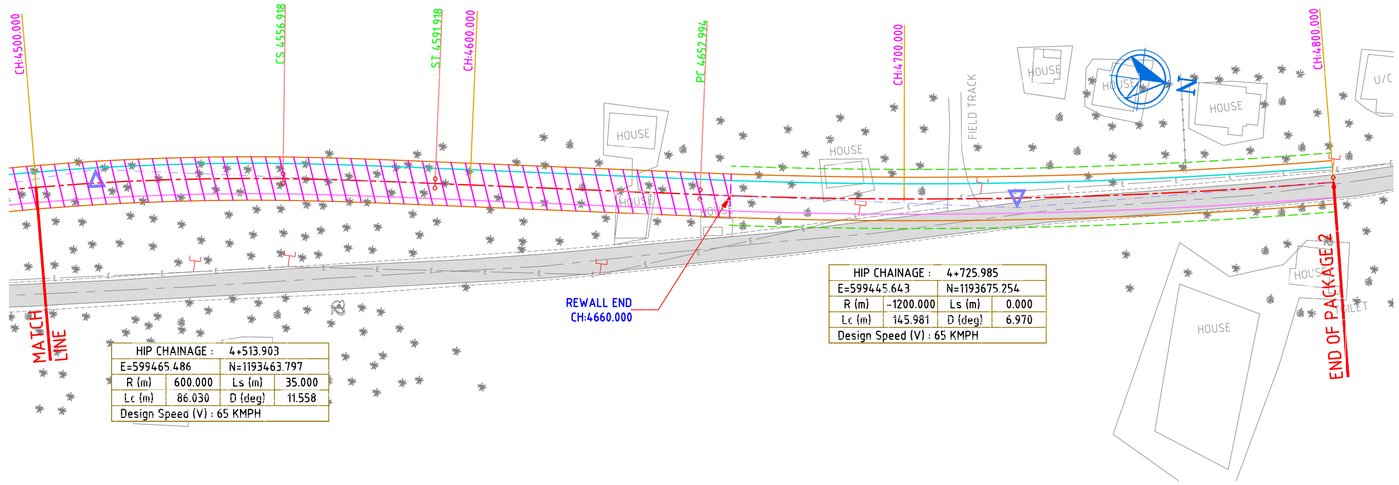
TBNA

PONNANI

PADINJAREKARA BEACH



HIP CHAINAGE :		4+087.452	
E=599589.914		N=1193054.732	
R (m)	1800.000	Ls (m)	0.000
Lc (m)	412.199	D (deg)	13.121
Design Speed (V) : 65 KMPH			



HIP CHAINAGE :		4+513.903	
E=599465.486		N=1193463.797	
R (m)	600.000	Ls (m)	35.000
Lc (m)	86.030	D (deg)	11.558
Design Speed (V) : 65 KMPH			

HIP CHAINAGE :		4+725.985	
E=599445.643		N=1193675.254	
R (m)	-1200.000	Ls (m)	0.000
Lc (m)	145.981	D (deg)	6.970
Design Speed (V) : 65 KMPH			

LEGEND:

- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

DESIGN	- HIMANSHU (HMS)
DRAWN	- DHIVYA (DVB)
CHECKED	- NIRMALYA CHAKRABORTI (NCB)
APPROVED	- K. GANESH IYER (KGN)

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
	REFERENCE DRAWINGS

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ALIGNMENT PLAN FROM CH:4000.000 TO CH:4800.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DD0105

REV: 0

plot scale 50mm

AUTO PATH I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ALIGNMENT PLAN\DD0101 TO DD0105-R0-ALIGNMENT PLAN KM 0.000 TO KM 4.800 -FINAL.DWG

TBNA

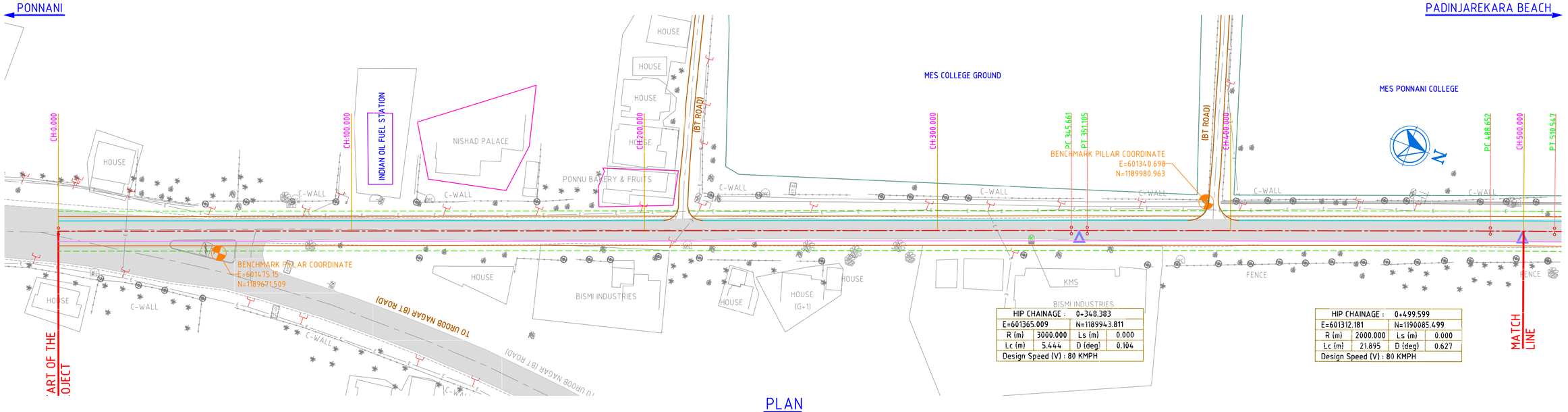
ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

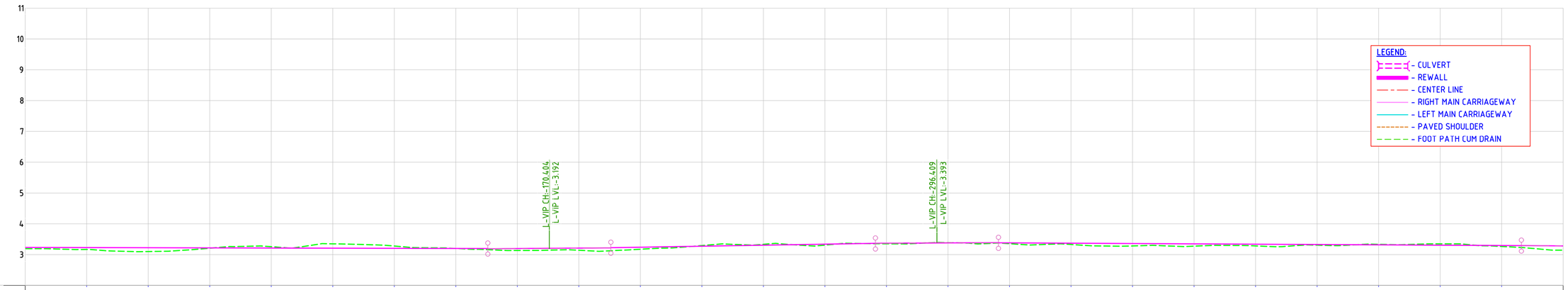
PLAN & PROFILE

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA



PLAN



DATUM=2.000

CHAINAGE(m)	FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	GROUND LEVEL BELOW PROPOSED CENTRE LINE
0.000	3.233	3.193
20.000	3.228	3.167
40.000	3.223	3.100
60.000	3.218	3.208
80.000	3.214	3.258
100.000	3.209	3.350
120.000	3.204	3.279
140.000	3.199	3.199
160.000	3.197	3.133
180.000	3.210	3.141
200.000	3.239	3.174
220.000	3.271	3.293
240.000	3.303	3.334
260.000	3.335	3.308
280.000	3.366	3.351
300.000	3.384	3.389
320.000	3.380	3.355
340.000	3.369	3.329
360.000	3.359	3.281
380.000	3.348	3.274
400.000	3.337	3.282
420.000	3.327	3.308
440.000	3.316	3.333
460.000	3.306	3.350
480.000	3.295	3.264
500.000	3.283	3.145

HORIZONTAL SCHEMATIC: L=345.661; R=3000.000 L=5.444; L=137.547; R=2000.000 L=21.895

VERTICAL SCHEMATIC: G=-0.024% L=150.404; R=21854.541 L=40.000; G=0.159% L=86.005; R=-18835.454 L=40.000; G=-0.053% L=170.004; R=-63081.309 L=40.000

SUPERELEVATION: e=2.500%

LONGITUDINAL PROFILE

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:0.000 TO CH: 500.000

COP: IRC

SCALE: HOR - 1:1000 VER - 1:100

L&T Infra Engineering

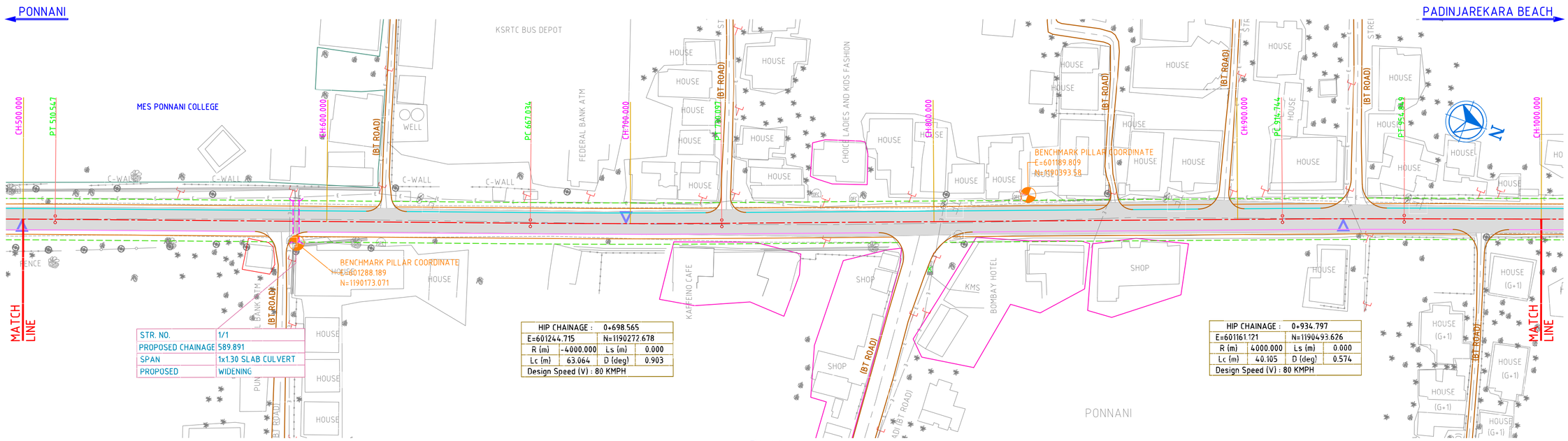
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP001c REV: 0

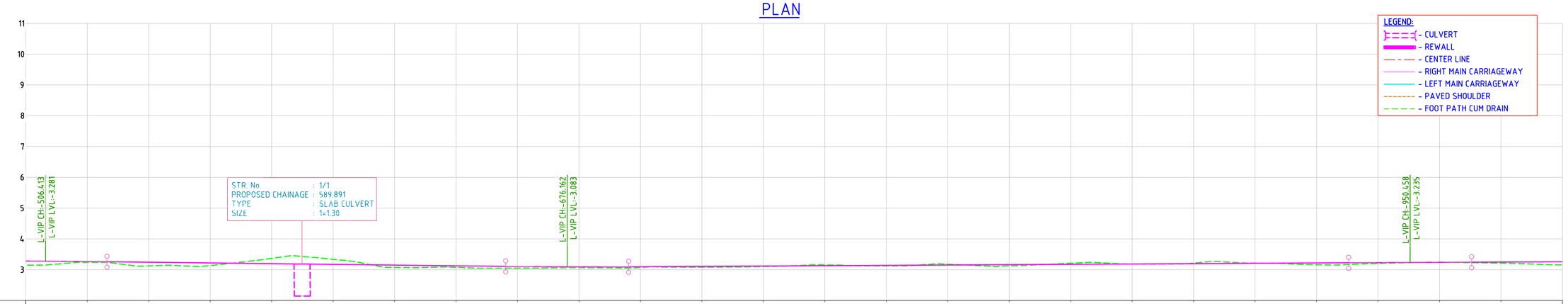
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA



PLAN



LONGITUDINAL PROFILE

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:
1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

DRAWING NO.	TITLE
	REFERENCE DRAWINGS

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING
DRG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE
PROJECT NO: C1193601

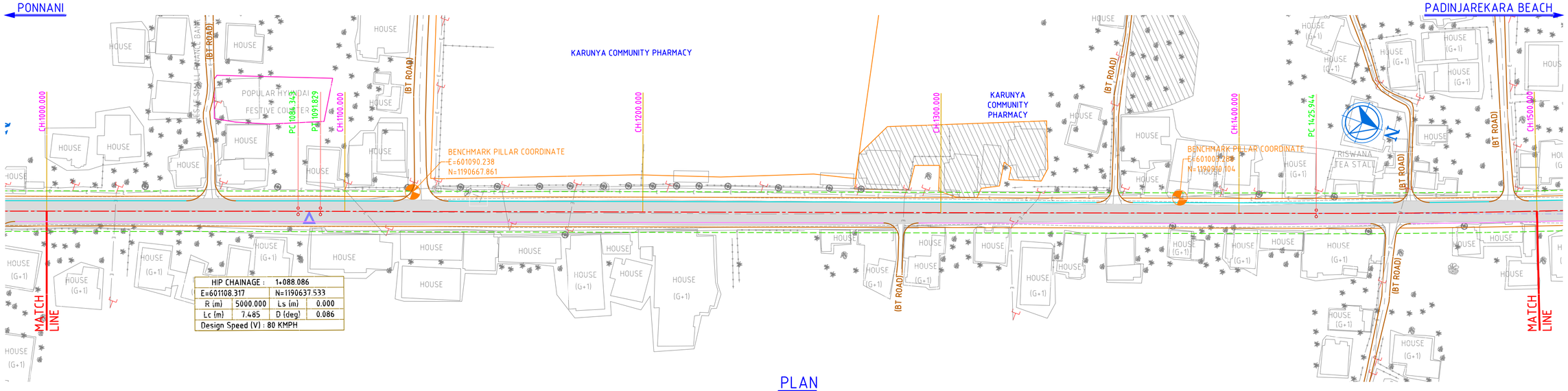
TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:500.000 TO CH: 1000.000
COP: IRC
SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering
L&T Infrastructure Engineering Ltd.
DRAWING NO: DDP002c
REV: 0

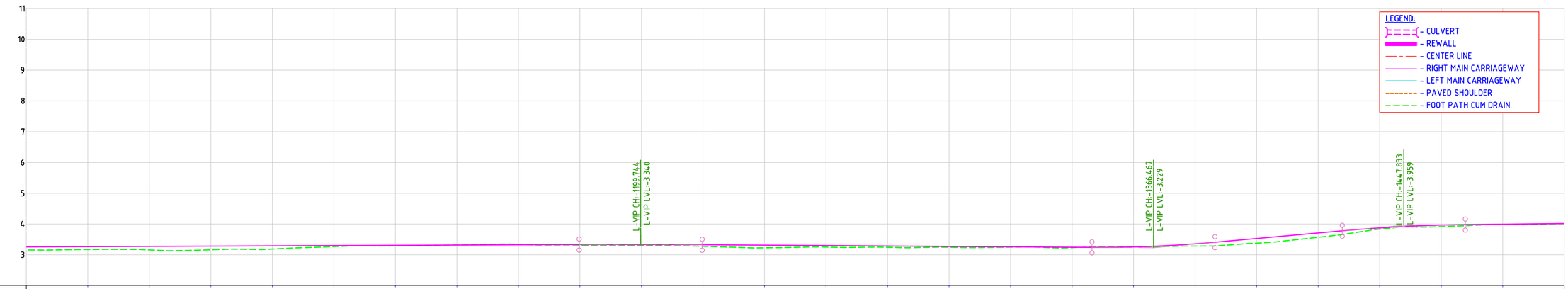
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP003C-RD-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA



PLAN



LONGITUDINAL PROFILE

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM ORIG SIZE: A2
LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:1000.000 TO CH: 1500.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

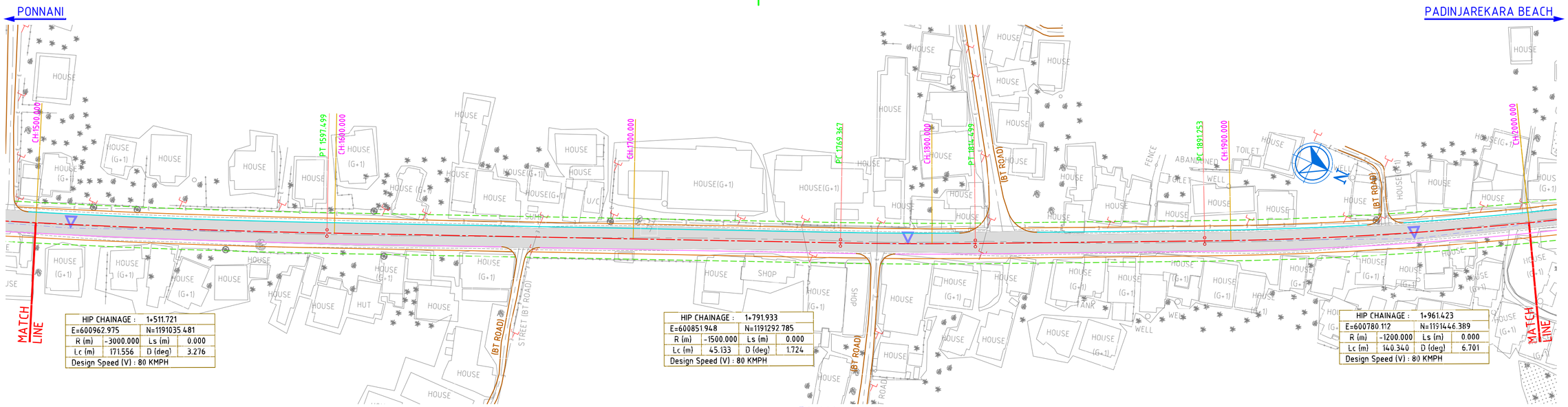
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP003c REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP010C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

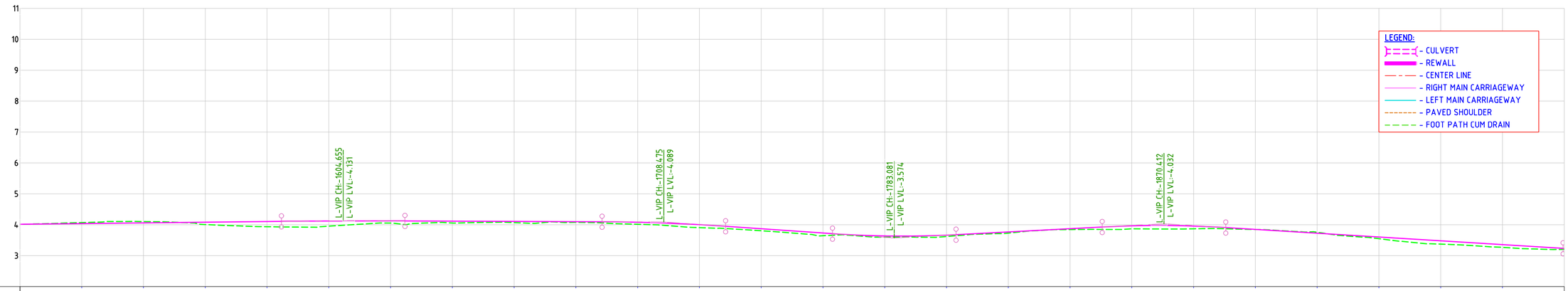


HIP CHAINAGE :	1+511.721		
E=600962.975		N=1191035.481	
R (m)	-3000.000	Ls (m)	0.000
Lc (m)	171.556	D (deg)	3.276
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :	1+791.933		
E=600851.948		N=1191292.785	
R (m)	-1500.000	Ls (m)	0.000
Lc (m)	45.133	D (deg)	1.724
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :	1+961.423		
E=600780.112		N=1191446.389	
R (m)	-1200.000	Ls (m)	0.000
Lc (m)	140.340	D (deg)	6.701
Design Speed (V) : 80 KMPH			

PLAN



LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

DATUM=2.000

FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	4.016	4.038	4.060	4.082	4.104	4.122	4.124	4.117	4.109	4.100	4.082	4.003	3.871	3.733	3.638	3.664	3.767	3.872	3.964	3.958	3.850	3.727	3.604	3.481	3.358	3.235
GROUND LEVEL BELOW PROPOSED CENTRE LINE	4.013	4.070	4.103	4.007	3.937	3.954	4.054	4.056	4.069	4.080	4.015	3.907	3.806	3.644	3.601	3.620	3.730	3.845	3.869	3.869	3.847	3.758	3.549	3.374	3.269	3.204
HORIZONTAL SCHEMATIC	R=-3000.000 L=171.556					L=171.867									R=-1500.000 L=45.133		L=76.753			R=-1200.000 L=140.340						
VERTICAL SCHEMATIC	G=0.110% L=116.822			R=-26606.293 L=40.000		G=-0.041% L=63.820				R=-6154.878 L=40.000		G=-0.691% L=34.606		R=3291.017 L=40.000		G=0.525% L=47.331		R=-3509.669 L=40.000		G=-0.615% L=109.218					
SUPERELEVATION	e=2.500%																								
CHAINAGE(m)	1500.000	1520.000	1540.000	1560.000	1580.000	1600.000	1620.000	1640.000	1660.000	1680.000	1700.000	1720.000	1740.000	1760.000	1780.000	1800.000	1820.000	1840.000	1860.000	1880.000	1900.000	1920.000	1940.000	1960.000	1980.000	2000.000

LONGITUDINAL PROFILE

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING | ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:1500.000 TO CH: 2000.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP004c | REV: 0

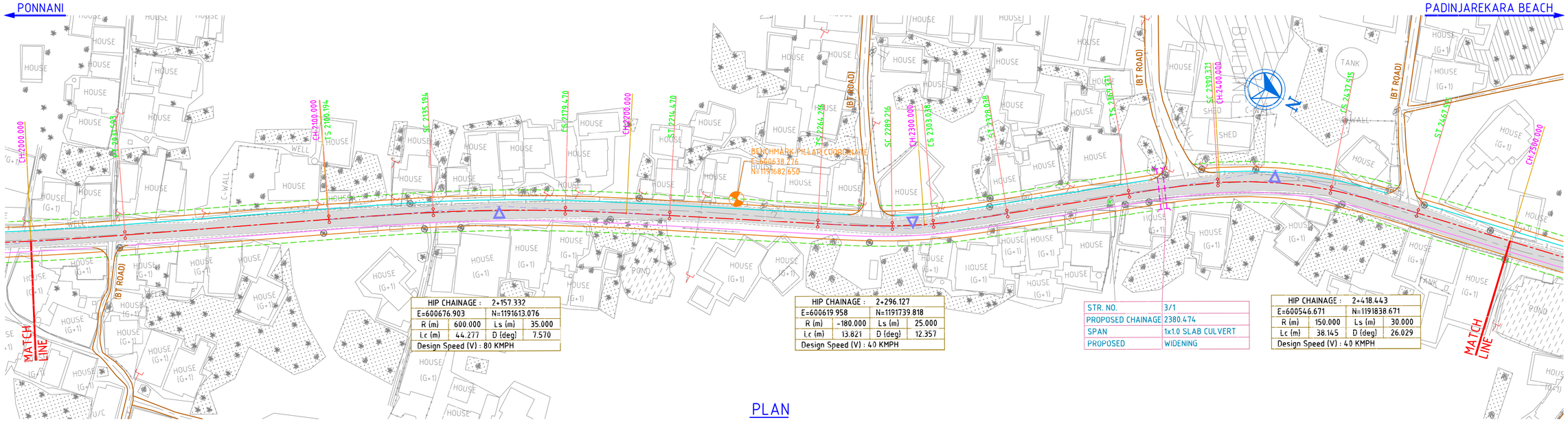
plot scale 50mm

AUTO PATH:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

PONNANI

PADINJAREKARA BEACH



HIP CHAINAGE :		2+157.332	
E=600676.903		N=1191613.076	
R (m)	600.000	Ls (m)	35.000
Lc (m)	44.277	D (deg)	7.570
Design Speed (V) : 80 KMPH			

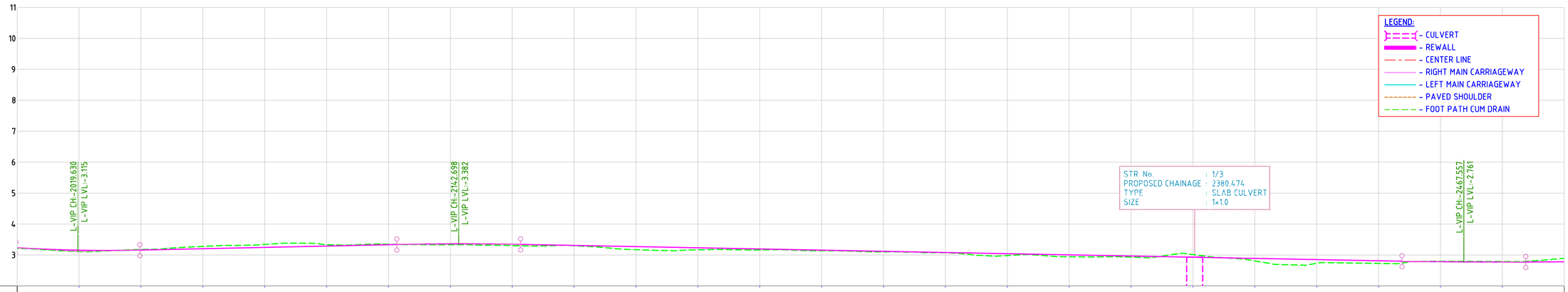
HIP CHAINAGE :		2+296.127	
E=600619.958		N=1191739.818	
R (m)	-180.000	Ls (m)	25.000
Lc (m)	13.821	D (deg)	12.357
Design Speed (V) : 40 KMPH			

STR. NO.	3/1
PROPOSED CHAINAGE	2380.474
SPAN	1x1.0 SLAB CULVERT
PROPOSED	WIDENING

HIP CHAINAGE :		2+418.443	
E=600546.671		N=1191838.671	
R (m)	150.000	Ls (m)	30.000
Lc (m)	38.145	D (deg)	26.029
Design Speed (V) : 40 KMPH			

PLAN

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN



DATUM=2.000

FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	3.235	3.155	3.159	3.202	3.245	3.289	3.332	3.360	3.348	3.310	3.272	3.234	3.196	3.158	3.119	3.081	3.043	3.005	2.967	2.928	2.890	2.852	2.814	2.781	2.771	2.781
GROUND LEVEL BELOW PROPOSED CENTRE LINE	3.204	3.113	3.176	3.279	3.341	3.331	3.349	3.332	3.306	3.300	3.171	3.167	3.164	3.137	3.101	3.073	2.982	2.944	2.932	3.015	2.809	2.731	2.727	2.796	2.788	2.893
HORIZONTAL SCHEMATIC	R=-1200.000 L=140.340		L=68.601		L=35.000		R=600.000 L=44.277		L=35.000		L=49.746				R=-180.000 L=13.821		L=25.000		L=41.333		L=30.000		R=150.000 L=38.145		L=30.000		L=64.529
VERTICAL SCHEMATIC	R=4808.584 L=40.000			G=0.217% L=83.068				R=-9806.253 L=40.000				G=-0.191% L=284.858												R=15898.955 L=40.000		G=0.061% L=128.521
SUPERELEVATION	e=2.500%					e=4.741%			e=4.741%		e=2.500%				e=3.951%		e=3.951%		e=2.500%				e=4.741%		e=4.741%	
CHAINAGE(m)	2000.000	2020.000	2040.000	2060.000	2080.000	2100.000	2120.000	2140.000	2160.000	2180.000	2200.000	2220.000	2240.000	2260.000	2280.000	2300.000	2320.000	2340.000	2360.000	2380.000	2400.000	2420.000	2440.000	2460.000	2480.000	2500.000

LONGITUDINAL PROFILE

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:2000.000 TO CH: 2500.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

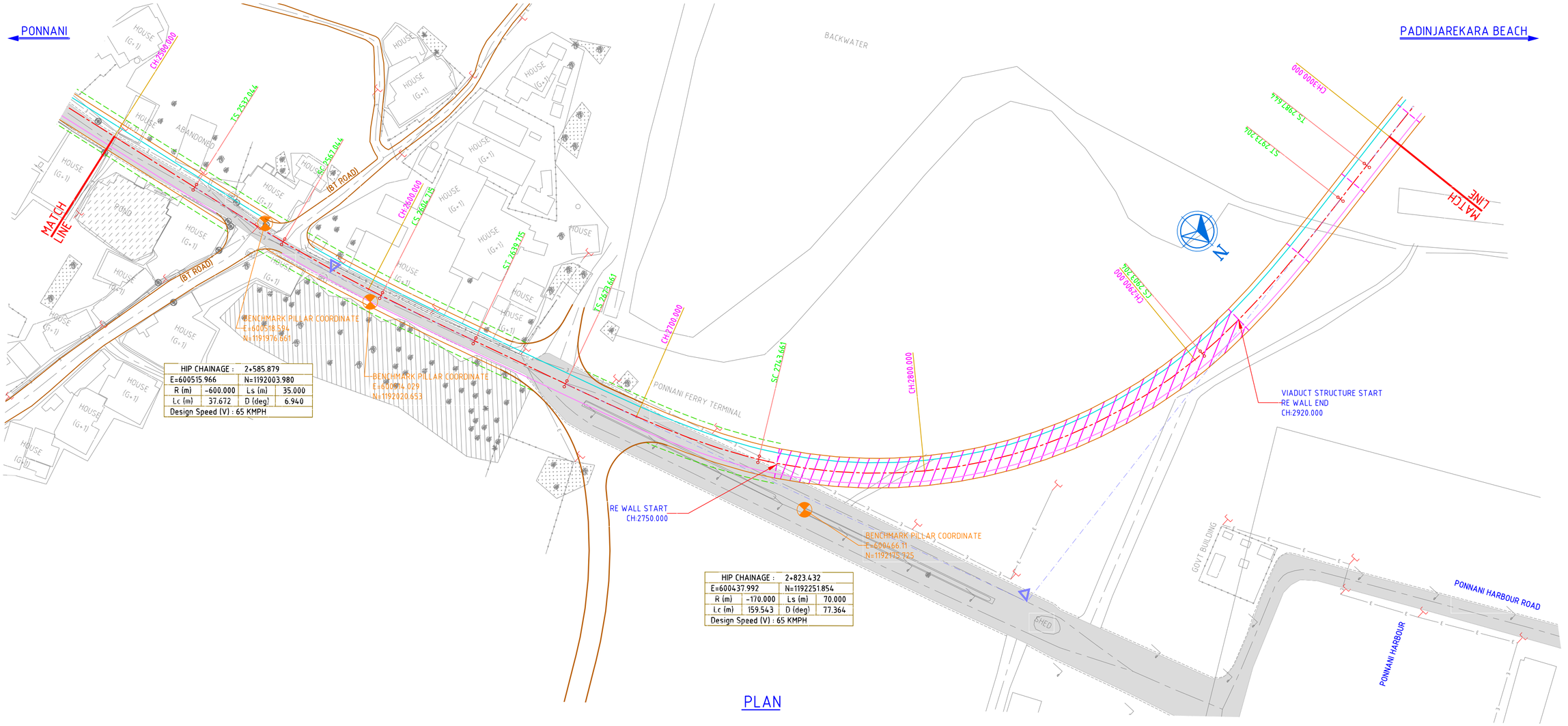
DRAWING NO: DDP005c

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP001C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA



PLAN

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:2500.000 TO CH: 3000.000

COP: IRC

SCALE: HOR - 1:1000 VER - 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP006c REV: 0

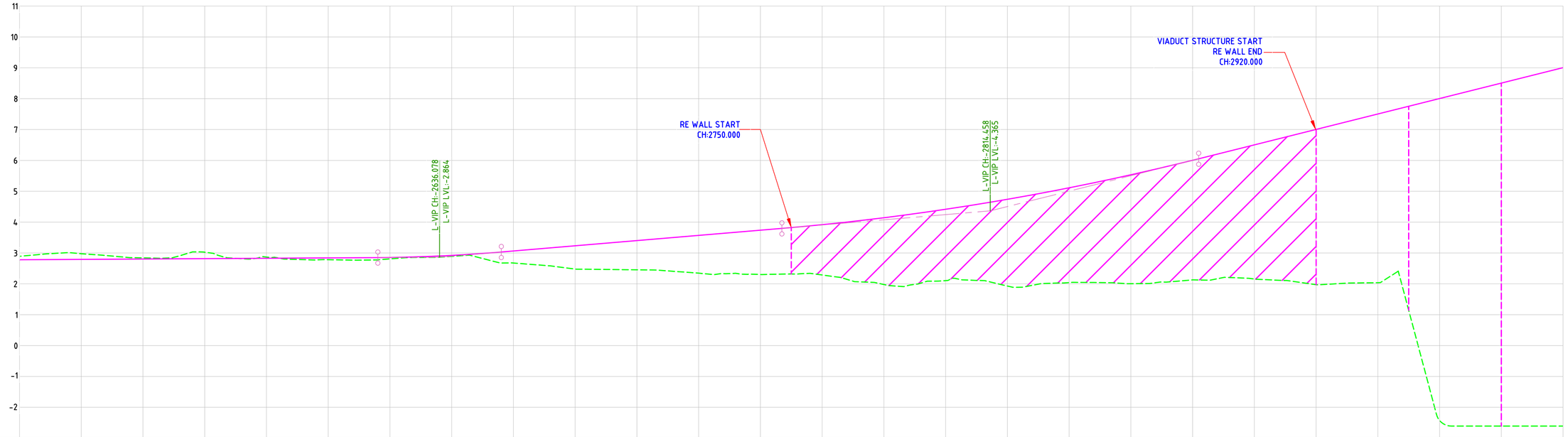
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

PONNANI

PADINJAREKARA BEACH



DATUM=-3.000

FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	2.781	2.793	2.805	2.817	2.829	2.842	2.855	2.922	3.065	3.233	3.402	3.570	3.738	3.917	4.142	4.416	4.739	5.112	5.533	6.004	6.504	7.004	7.504	8.004	8.504	9.004
GROUND LEVEL BELOW PROPOSED CENTRE LINE	2.893	2.976	2.840	3.026	2.868	2.782	2.809	2.891	2.675	2.480	2.455	2.347	2.304	2.288	1.978	2.104	1.929	2.041	2.005	2.129	2.156	1.974	2.037	-2.608	-2.608	-2.608
HORIZONTAL SCHEMATIC	L=64.529		L=35.000		R=-600.000 L=37.672		L=35.000		L=33.946		L=70.000		R=-170.000 L=159.543										L=70.000		L=14.441	L=70.000
VERTICAL SCHEMATIC	G=0.061% L=128.521						R=5120.406 L=40.000		G=0.842% L=90.880				R=8141.591 L=135.000						G=2.500% L=495.392							
SUPERELEVATION	e=3.130%																									
	e=3.130%																									
																						e=5.000%				
																						e=5.000%				
CHAINAGE(m)	2500.000	2520.000	2540.000	2560.000	2580.000	2600.000	2620.000	2640.000	2660.000	2680.000	2700.000	2720.000	2740.000	2760.000	2780.000	2800.000	2820.000	2840.000	2860.000	2880.000	2900.000	2920.000	2940.000	2960.000	2980.000	3000.000

LONGITUDINAL PROFILE

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:2500.000 TO CH: 3000.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

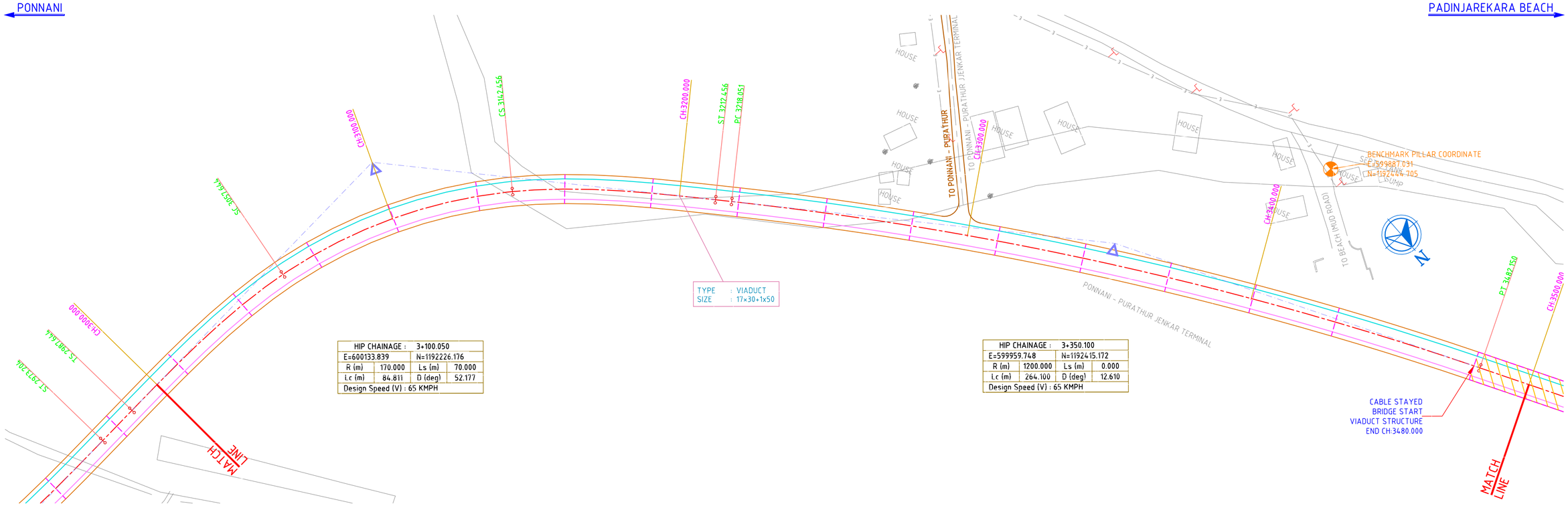
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP006c REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP003C-RG-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA



PLAN

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

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ORIG. SIZE: A2
PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:3000.000 TO CH: 3500.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP007c

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

PONNANI

PADINJAREKARA BEACH

TYPE : VIADUCT
SIZE : 17x30+1x50

CABLE STAYED BRIDGE
START VIADUCT STRUCTURE
END CH:3480.000

L-VIP CH:-3479.851
L-VIP LVL:-21.000

DATUM=-10.000

FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	9.004	9.504	10.004	10.504	11.004	11.504	12.004	12.504	13.004	13.504	14.004	14.504	15.004	15.504	16.004	16.504	17.004	17.504	18.004	18.503	18.972	19.393	19.764	20.087	20.361	20.586
GROUND LEVEL BELOW PROPOSED CENTRE LINE	-2.608	-2.608	-2.608	-2.608	-2.608	-2.608	1.482	1.616	1.717	2.092	2.316	2.282	1.991	1.428	-1.608	-1.608	-1.808	-1.908	-1.808	-2.008	-1.808	-1.808	-1.908	-9.408	-9.408	-9.308
HORIZONTAL SCHEMATIC	L=70.000			R=170.000 L=84.811						L=70.000		L=5.595				R=1200.000 L=264.100									L=399.202	
VERTICAL SCHEMATIC	G=2.500% L=495.392																							R=-8200.004 L=205.000		
SUPERELEVATION				e=5.000%																						
				e=5.000%																						
CHAINAGE(m)	3000.000	3020.000	3040.000	3060.000	3080.000	3100.000	3120.000	3140.000	3160.000	3180.000	3200.000	3220.000	3240.000	3260.000	3280.000	3300.000	3320.000	3340.000	3360.000	3380.000	3400.000	3420.000	3440.000	3460.000	3480.000	3500.000

LONGITUDINAL PROFILE

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:3000.000 TO CH: 3500.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

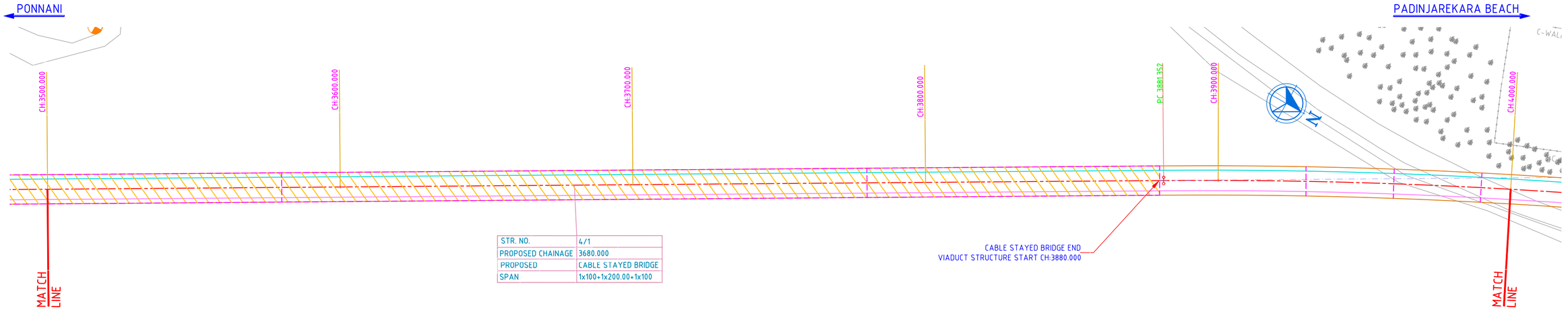
DRAWING NO: DDP007c

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA



PLAN

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2
PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:3500.000 TO CH: 4000.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP008c REV: 0

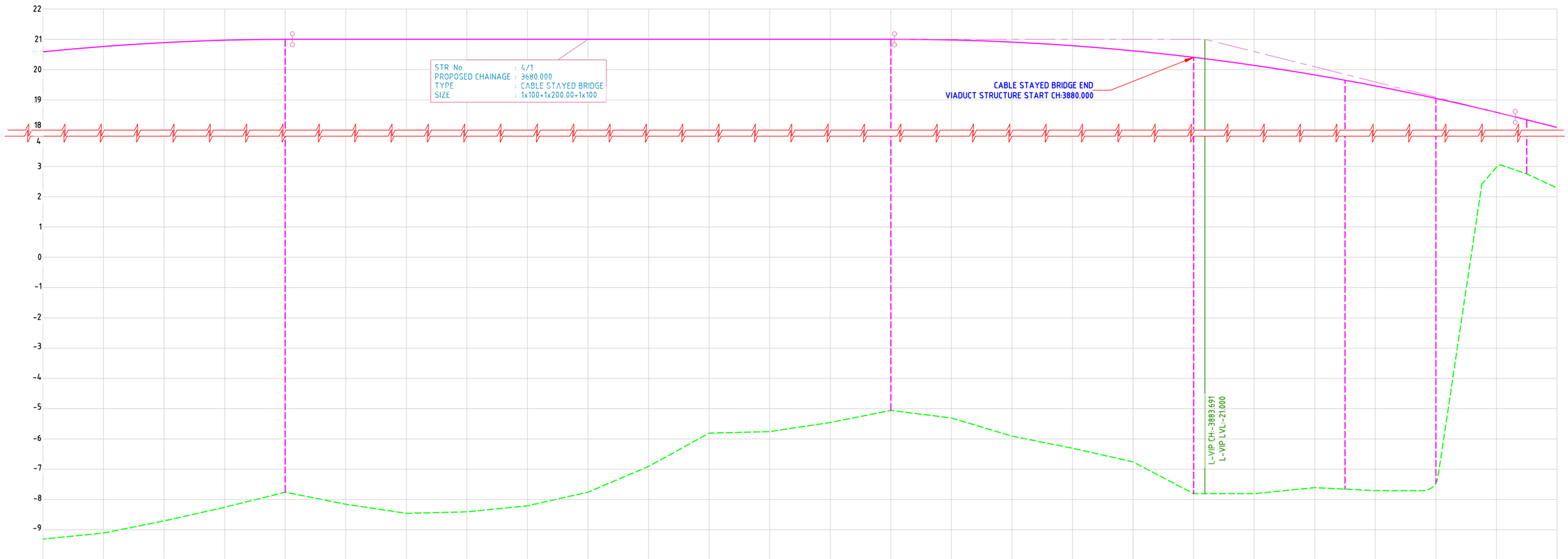
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

PONNANI

PADINJAREKARA BEACH



DATUM=-10.000

FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	20.586	20.763	20.891	20.970	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	20.978	20.908	20.789	20.621	20.405	20.139	19.825	19.462	19.050	18.590	18.092
GROUND LEVEL BELOW PROPOSED CENTRE LINE	-9.308	-9.108	-8.708	-8.258	-7.758	-8.158	-8.458	-8.408	-8.208	-7.758	-6.908	-5.808	-5.758	-5.458	-5.058	-5.308	-5.908	-6.308	-6.758	-7.808	-7.808	-7.608	-7.708	-7.708	2.976	2.330
HORIZONTAL SCHEMATIC	L=399.202																			R=1800.000 L=412.199						
VERTICAL SCHEMATIC	R=-8200.004 L=205.000					G=0.000% L=198.840										R=-8199.919 L=205.000									G=-2.500% L=542.113	
SUPERELEVATION	e=2.500%																									
CHAINAGE(m)	3500.000	3520.000	3540.000	3560.000	3580.000	3600.000	3620.000	3640.000	3660.000	3680.000	3700.000	3720.000	3740.000	3760.000	3780.000	3800.000	3820.000	3840.000	3860.000	3880.000	3900.000	3920.000	3940.000	3960.000	3980.000	4000.000

LONGITUDINAL PROFILE

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:3500.000 TO CH: 4000.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP008c

REV: 0

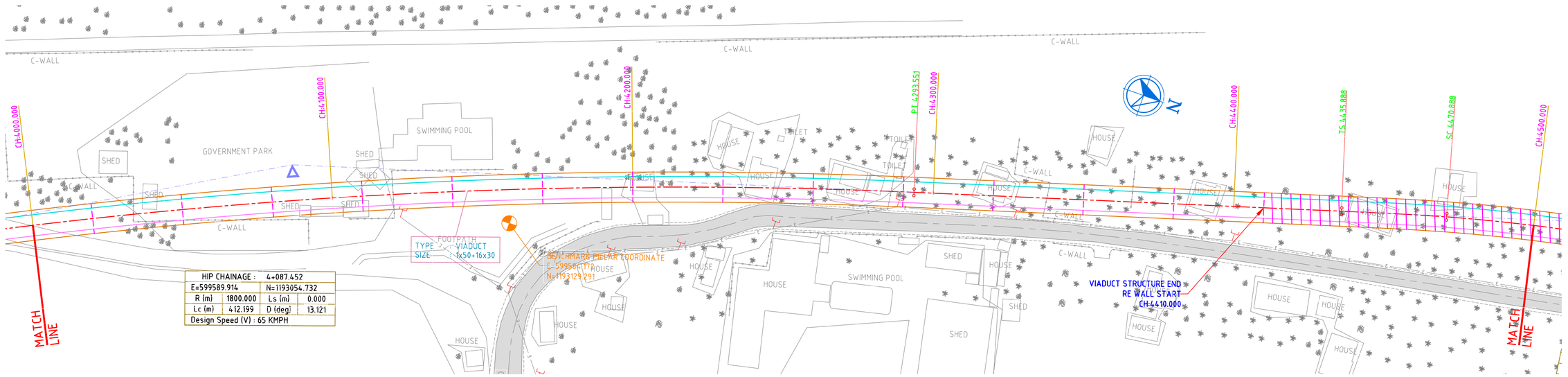
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

PONNANI

PADINJAREKARA BEACH



HIP CHAINAGE :		4+087.452	
E=599589.914		N=1193054.732	
R (m)	1800.000	Ls (m)	0.000
Lc (m)	412.199	D (deg)	13.121
Design Speed (V) : 65 KMPH			

PLAN

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:
1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	YYMMDD	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING | ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:4000.000 TO CH: 4500.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP009c | REV: 0

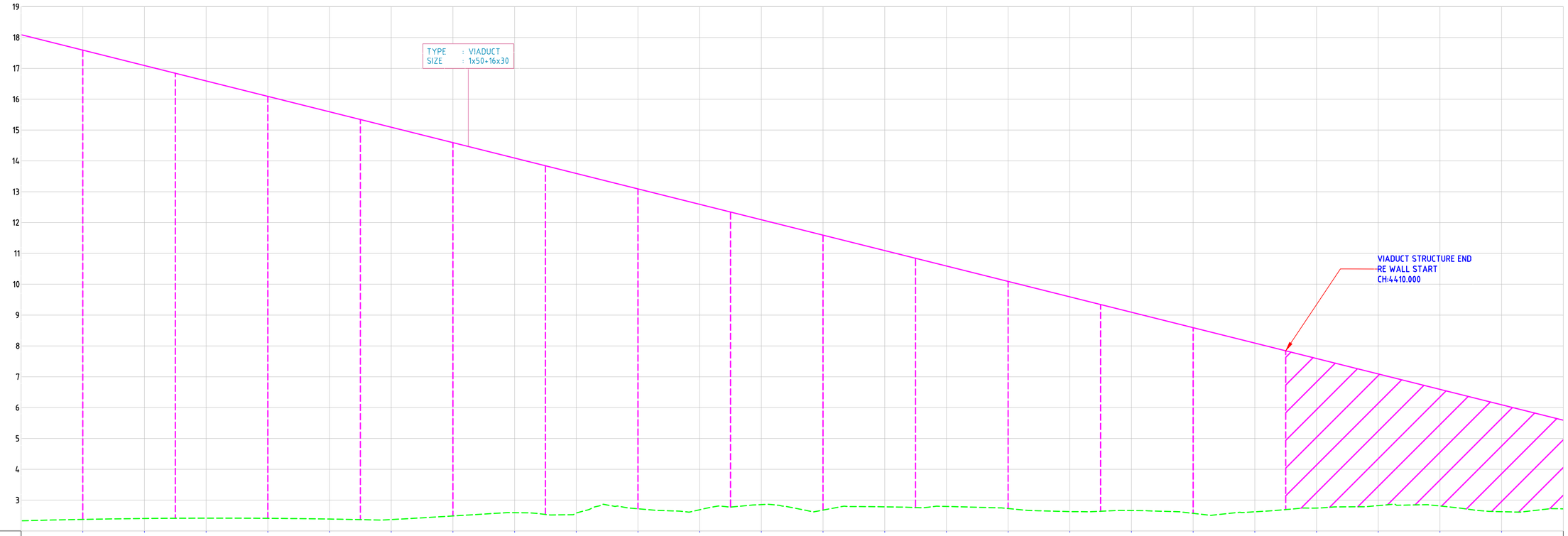
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP001C TO DDP003C-Rd-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

PONNANI

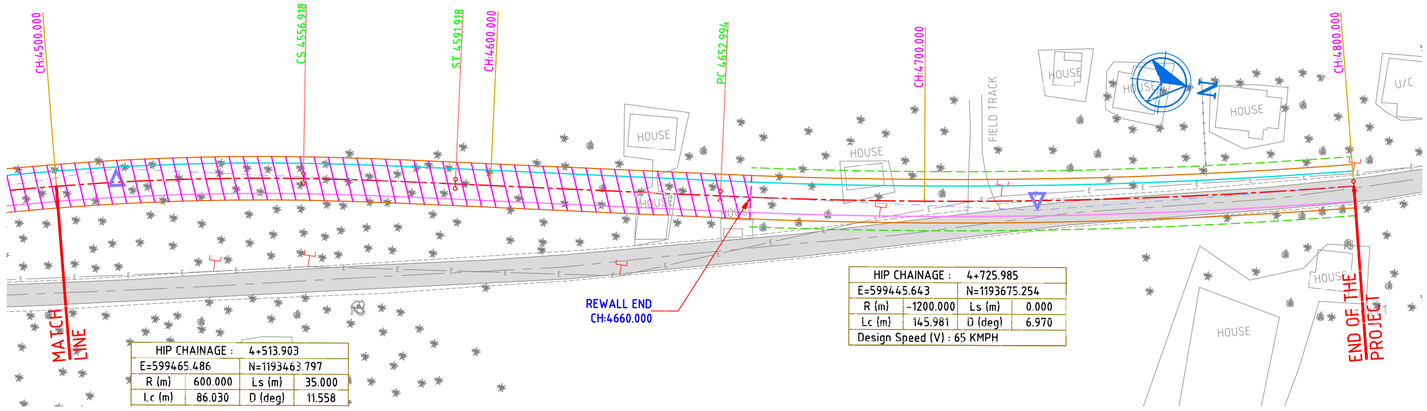
PADINJAREKARA BEACH



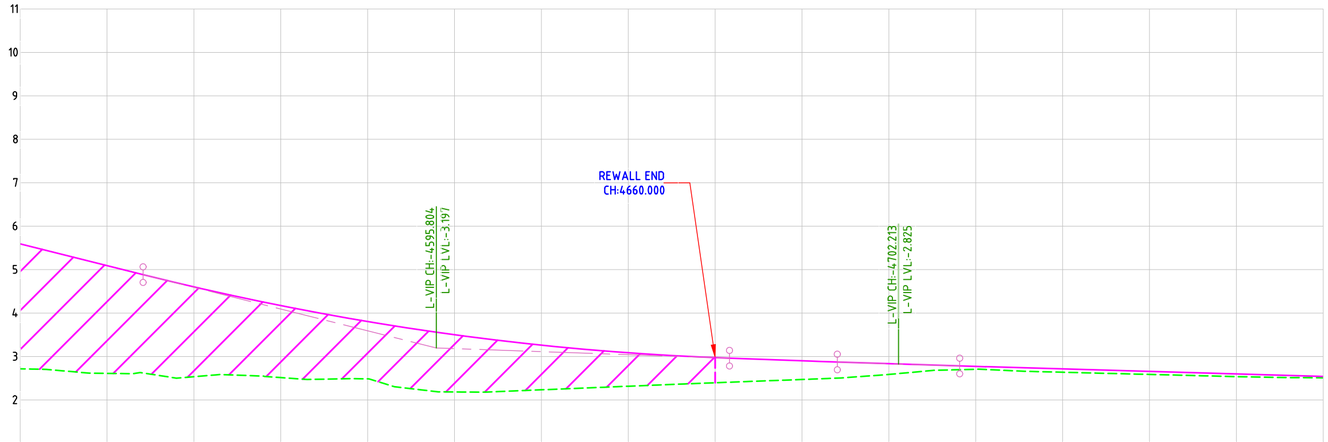
| | | |

PONNANI

PADINJAREKARA BEACH



PLAN



DATUM=1.000

FINISHED ROAD LEVEL AT PROPOSED CENTRE LINE	5.592	5.092	4.603	4.172	3.805	3.502	3.262	3.086	2.973	2.903	2.835	2.773	2.715	2.657	2.599	2.541
GROUND LEVEL BELOW PROPOSED CENTRE LINE	2.717	2.612	2.535	2.515	2.486	2.184	2.234	2.316	2.396	2.471	2.588	2.706	2.638	2.588	2.536	2.510
HORIZONTAL SCHEMATIC	R=600.000 L=86.030			L=35.000		L=61.076					R=-1200.000 L=145.981					
VERTICAL SCHEMATIC	G=-2.500% L=542.113			R=6277.754 L=135.000					G=-0.350% L=18.909	L=18.909	R=67503.897 L=40.000		G=-0.290% L=77.787			
SUPERELEVATION	e=3.130%										e=2.500%					
	e=3.130%															
CHAINAGE(m)	4500.000	4520.000	4540.000	4560.000	4580.000	4600.000	4620.000	4640.000	4660.000	4680.000	4700.000	4720.000	4740.000	4760.000	4780.000	4800.000

LONGITUDINAL PROFILE

LEGEND:
- CULVERT
- REWALL
- CENTER LINE
- RIGHT MAIN CARRIAGEWAY
- LEFT MAIN CARRIAGEWAY
- PAVED SHOULDER
- FOOT PATH CUM DRAIN

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFER TYPICAL CROSS SECTIONS FOR LOCATIONS OF DRAIN.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: PLAN AND PROFILE - OPTION 1C FROM CH:4500.000 TO CH: 4800.000

COP: IRC

SCALE: HOR-1:1000 VER-1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDP010c REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\PLAN & PROFILE\DDP010C TO DDP010C-R0-DVB-PLAN AND PROFILE - OPTION 1C.DWG

TBNA

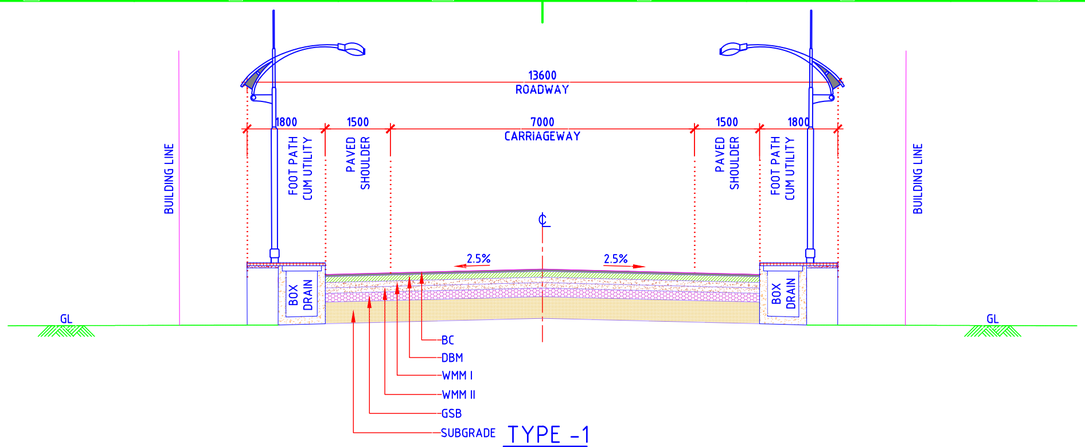
ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

TYPICAL CROSS SECTION

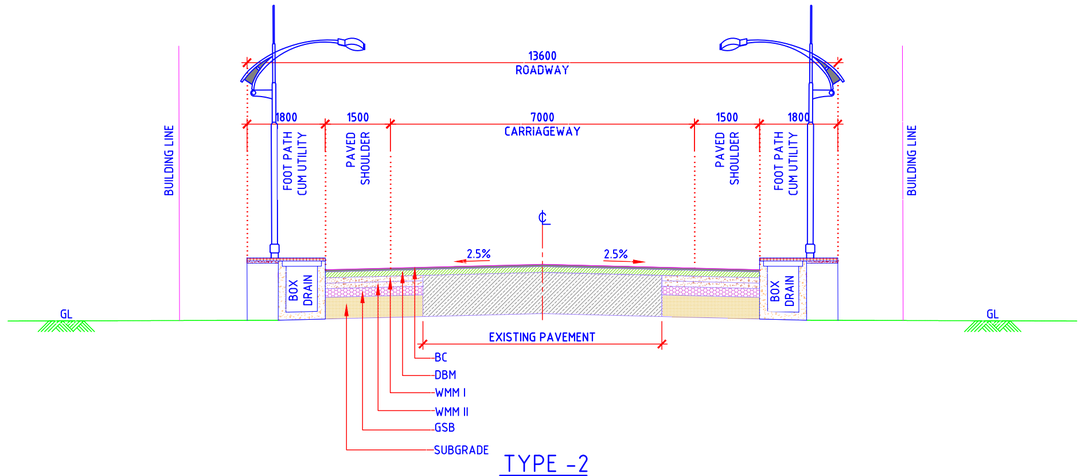
AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\TCS\DDX001-RP-SNY-TYPICAL CROSS SECTION - A2.DWG

TBNA



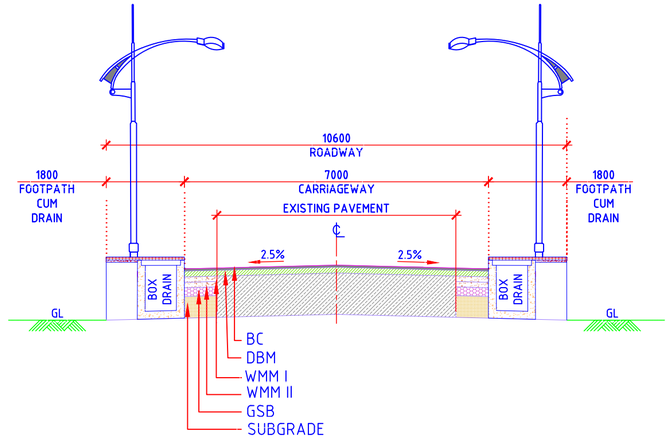
TYPE -1

TYPICAL CROSS SECTION FOR NEW CONSTRUCTION



TYPE -2

TYPICAL CROSS SECTION FOR WIDENING OF EXISTING ROAD



TYPE -3

TYPICAL CROSS SECTION FOR WIDENING OF EXISTING ROAD

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	SNY	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: TYPICAL CROSS SECTIONS

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDX001

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\TCS\DDX001-R0-SNY-TYPICAL CROSS SECTION - A2.DWG

TBNA

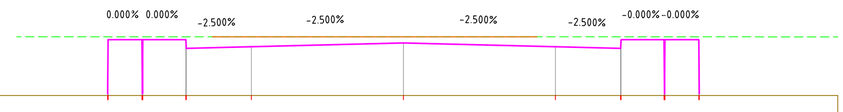
ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

RUNNING CROSS SECTION

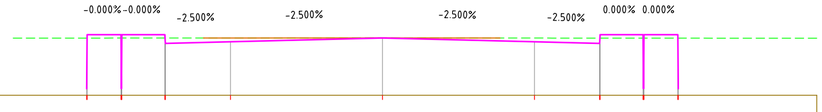
AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX118-R0-DVB-RUNNING CROSS SECTION.DWG

TBNA



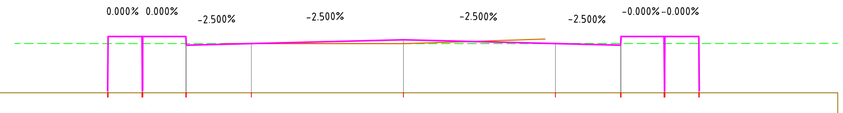
DATUM =2.000									
DESIGN LEVELS	3.284	3.284	3.084	3.121	3.209	3.121	3.084	3.284	3.284
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.401	-3.518	-0.567	0.000	3.075		
EXISTING GROUND LEVELS	3.349			3.350	3.350	3.350			

CHAINAGE=100.000



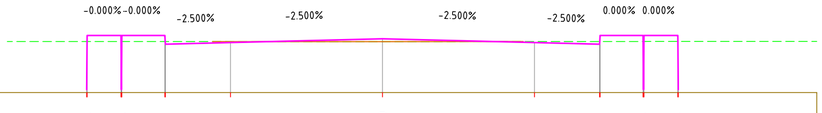
DATUM =2.000									
DESIGN LEVELS	3.394	3.394	3.194	3.231	3.319	3.231	3.194	3.394	3.394
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.121	-3.116	-0.163 0.000	2.708			
EXISTING GROUND LEVELS	3.316			3.318	3.319	3.317			

CHAINAGE=250.000



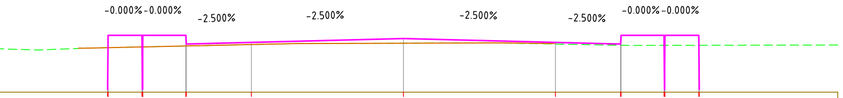
DATUM =2.000									
DESIGN LEVELS	3.296	3.296	3.096	3.133	3.221	3.133	3.096	3.296	3.296
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.137		-0.603	0.000	3.259		
EXISTING GROUND LEVELS	3.135		3.133		3.132			3.135	

CHAINAGE=50.000



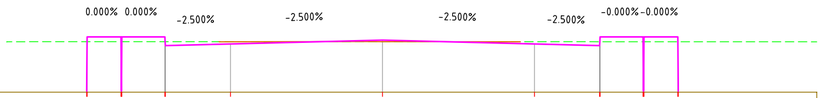
DATUM =2.000									
DESIGN LEVELS	3.314	3.314	3.114	3.152	3.239	3.152	3.114	3.314	3.314
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.911	-3.250	-0.297 0.000	3.241		
EXISTING GROUND LEVELS	3.176			3.174		3.173		3.176	

CHAINAGE=200.000



DATUM =2.000									
DESIGN LEVELS	3.308	3.308	3.108	3.145	3.233	3.145	3.108	3.308	3.308
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET	-7.480	-7.337		-2.506	0.000	1.878	2.082	3.475	
EXISTING GROUND LEVELS	2.970	3.012		3.118		3.133	3.133	3.075	

CHAINAGE=0.000



DATUM =2.000									
DESIGN LEVELS	3.272	3.272	3.072	3.109	3.197	3.109	3.072	3.272	3.272
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.765	-2.924	-0.310 0.000	3.176		
EXISTING GROUND LEVELS	3.154 3.161			3.162		3.163		3.161	

CHAINAGE=150.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:0.000 TO CH:250.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

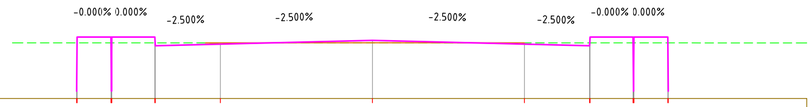
DRAWING NO: DDX101

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-RS-DVB-RUNNING CROSS SECTION.DWG

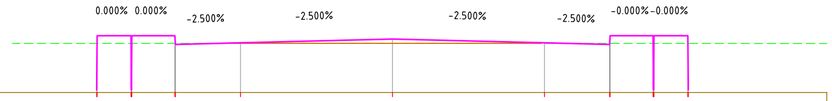
TBNA



DATUM =2.000

DESIGN LEVELS	3.412	3.412	3.212	3.250	3.337	3.250	3.212	3.412	3.412
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.846	-2.908	0.000 0.049	3.501		
EXISTING GROUND LEVELS	3.279			3.281		3.282	3.280		

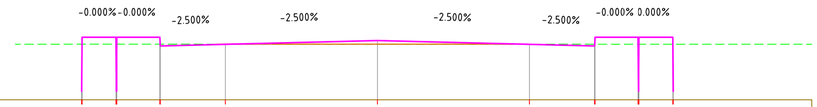
CHAINAGE=400.000



DATUM =2.000

DESIGN LEVELS	3.305	3.305	3.105	3.143	3.230	3.143	3.105	3.305	3.305
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-4.178	-3.402	-0.415 0.000	3.421		
EXISTING GROUND LEVELS	3.127			3.129		3.130	3.129		

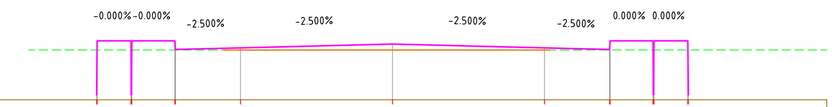
CHAINAGE=550.000



DATUM =2.000

DESIGN LEVELS	3.439	3.439	3.239	3.277	3.364	3.277	3.239	3.439	3.439
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.714	-2.955	0.000 0.002	3.117		
EXISTING GROUND LEVELS	3.280			3.280		3.281	3.280		

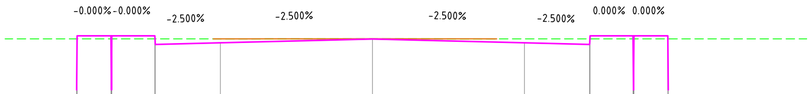
CHAINAGE=350.000



DATUM =2.000

DESIGN LEVELS	3.358	3.358	3.158	3.195	3.283	3.195	3.158	3.358	3.358
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.876	-3.004	-0.032 0.000	3.624		
EXISTING GROUND LEVELS	3.146			3.145		3.145	3.146		

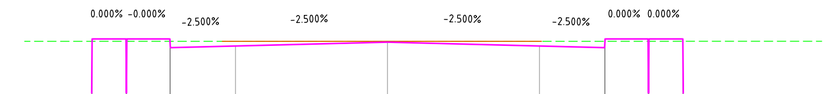
CHAINAGE=500.000



DATUM =2.000

DESIGN LEVELS	3.459	3.459	3.259	3.296	3.384	3.296	3.259	3.459	3.459
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.665	-3.072	-0.119 0.000	2.862		
EXISTING GROUND LEVELS	3.388			3.389		3.389	3.388		

CHAINAGE=300.000



DATUM =2.000

DESIGN LEVELS	3.386	3.386	3.186	3.223	3.311	3.223	3.186	3.386	3.386
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.802	-2.972	-0.014 0.000	3.546		
EXISTING GROUND LEVELS	3.332			3.331		3.330	3.331		

CHAINAGE=450.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	INIT. CHECKED	SIGN.	INIT. APPROVED	SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

DRAWING NO. | TITLE

REFERENCE DRAWINGS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:300.000 TO CH:550.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

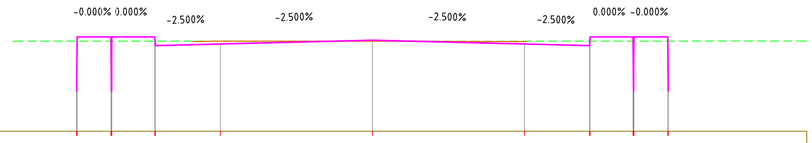
DRAWING NO: DDX102

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-RS-DVB-RUNNING CROSS SECTION.DWG

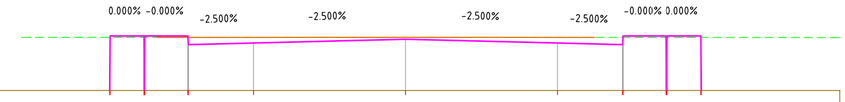
TBNA



DATUM =1.000

DESIGN LEVELS	3.171	3.171	2.971	3.009	3.096	3.009	2.971	3.171	3.171
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-4.118	-3.557	0.000 0.080	3.543		
EXISTING GROUND LEVELS	3.058 3.075			3.074		3.072		3.075	

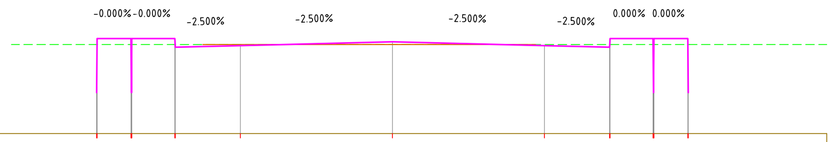
CHAINAGE=700.000



DATUM =2.000

DESIGN LEVELS	3.254	3.254	3.054	3.092	3.179	3.092	3.054	3.254	3.254
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-5.724	-3.461	-0.490 0.000		3.611	4.354	
EXISTING GROUND LEVELS	3.220			3.222	3.222		3.220		

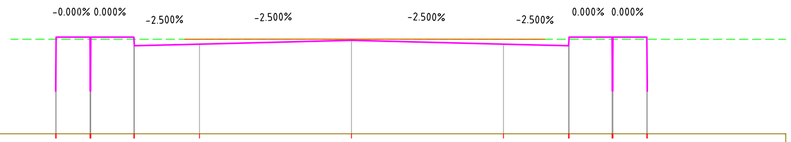
CHAINAGE=850.000



DATUM =1.000

DESIGN LEVELS	3.189	3.189	2.989	3.026	3.114	3.026	2.989	3.189	3.189
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.365	-3.430	-0.445 0.000	3.296			
EXISTING GROUND LEVELS	3.050		3.050		3.050		3.050		

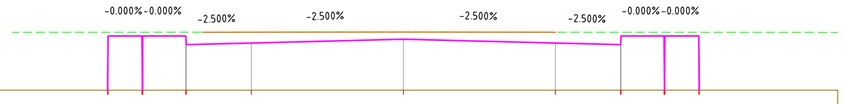
CHAINAGE=650.000



DATUM =1.000

DESIGN LEVELS	3.226	3.226	3.026	3.064	3.151	3.064	3.026	3.226	3.226
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.840	-2.455	0.000 0.502		4.448	
EXISTING GROUND LEVELS	3.177			3.178		3.179		3.177	

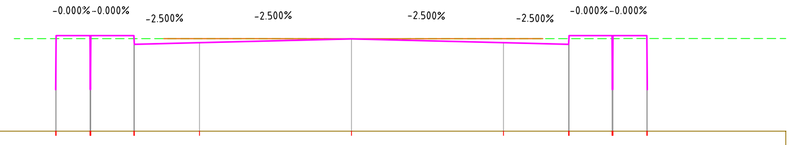
CHAINAGE=800.000



DATUM =2.000

DESIGN LEVELS	3.247	3.247	3.047	3.084	3.172	3.084	3.047	3.247	3.247
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.621	-3.660	-0.675 0.000	3.341 3.505			
EXISTING GROUND LEVELS	3.332			3.336	3.338		3.335		

CHAINAGE=600.000



DATUM =1.000

DESIGN LEVELS	3.199	3.199	2.999	3.036	3.124	3.036	2.999	3.199	3.199
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.323	-2.381	0.000 0.571		4.406		
EXISTING GROUND LEVELS	3.130			3.129	3.128		3.130		

CHAINAGE=750.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:600.000 TO CH:850.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

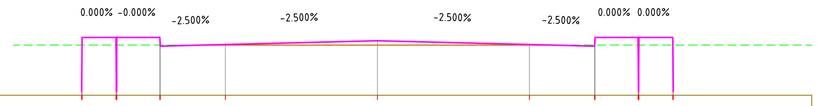
DRAWING NO: DDX103

REV: 0

plot scale 50mm

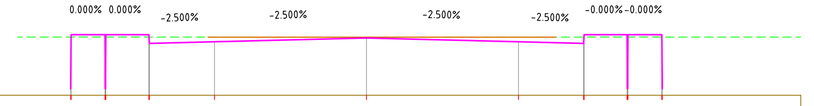
AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-RS-DVB-RUNNING CROSS SECTION.DWG

TBNA



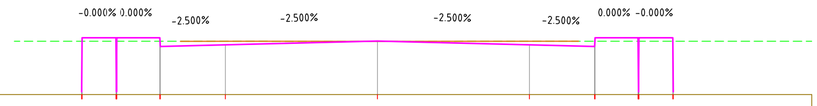
DATUM =2.000									
DESIGN LEVELS	3.331	3.331	3.131	3.168	3.256	3.168	3.131	3.331	3.331
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.250	-3.042	-0.043 0.000		4.035 4.307		
EXISTING GROUND LEVELS	3.156			3.156	3.156	3.156			

CHAINAGE=1000.000



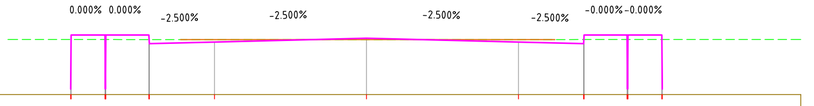
DATUM =2.000									
DESIGN LEVELS	3.394	3.394	3.194	3.231	3.319	3.231	3.194	3.394	3.394
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.649	-2.706	0.000 0.299		4.355	
EXISTING GROUND LEVELS	3.339				3.338	3.338		3.338	

CHAINAGE=1150.000



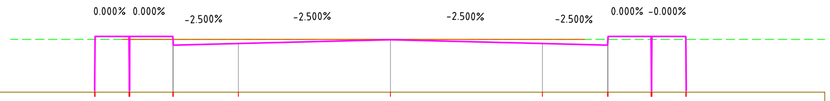
DATUM =2.000									
DESIGN LEVELS	3.309	3.309	3.109	3.146	3.234	3.146	3.109	3.309	3.309
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.537	-3.020	-0.023 0.000	4.059	4.633		
EXISTING GROUND LEVELS	3.228			3.227	3.227	3.228			

CHAINAGE=950.000



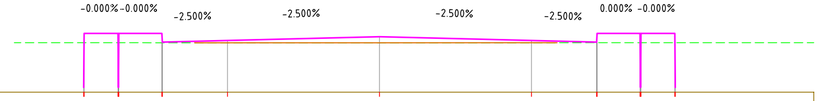
DATUM =2.000									
DESIGN LEVELS	3.373	3.373	3.173	3.210	3.298	3.210	3.173	3.373	3.373
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.281	-2.925	0.000 0.077	4.151 4.339			
EXISTING GROUND LEVELS	3.268			3.267	3.266	3.267			

CHAINAGE=1100.000



DATUM =2.000									
DESIGN LEVELS	3.282	3.282	3.082	3.119	3.207	3.119	3.082	3.282	3.282
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET		-6.171		-3.381	-0.411 0.000	3.714	4.471		
EXISTING GROUND LEVELS	3.214			3.215	3.215	3.214			

CHAINAGE=900.000



DATUM =2.000									
DESIGN LEVELS	3.352	3.352	3.152	3.189	3.277	3.189	3.152	3.352	3.352
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.255	-3.070	-0.070 0.000	4.007 4.090			
EXISTING GROUND LEVELS	3.138			3.137	3.137	3.137			

CHAINAGE=1050.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:900.000 TO CH:1150.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

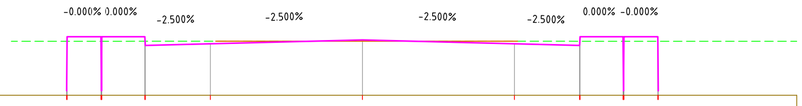
DRAWING NO: DDX104

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-RS-DVB-RUNNING CROSS SECTION.DWG

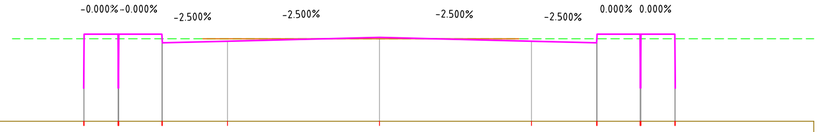
TBNA



DATUM =2.000

DESIGN LEVELS	3.348	3.348	3.148	3.185	3.273	3.185	3.148	3.348	3.348
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.378	-2.752	0.000 0.225	3.570		
EXISTING GROUND LEVELS	3.243				3.244	3.244	3.243		

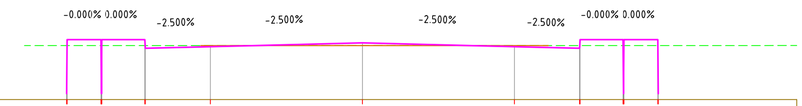
CHAINAGE=1300.000



DATUM =2.000

DESIGN LEVELS	4.005	4.005	3.805	3.843	3.930	3.843	3.805	4.005	4.005
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET			-4.067	-3.098	-0.111 0.000	3.210			
EXISTING GROUND LEVELS	3.899			3.899	3.899	3.899			

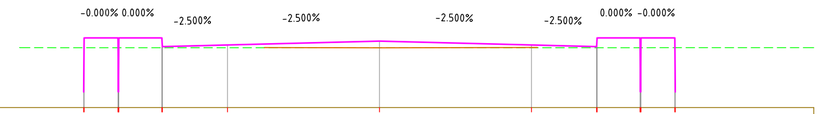
CHAINAGE=1450.000



DATUM =2.000

DESIGN LEVELS	3.381	3.381	3.181	3.219	3.306	3.219	3.181	3.381	3.381
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.722	-2.450	0.000 0.557	4.280		
EXISTING GROUND LEVELS	3.244			3.243	3.242	3.243			

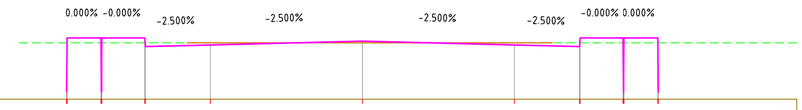
CHAINAGE=1250.000



DATUM =2.000

DESIGN LEVELS	3.605	3.605	3.405	3.442	3.530	3.442	3.405	3.605	3.605
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.651	0.000 0.057	3.638			
EXISTING GROUND LEVELS	3.386 3.380	3.379			3.377				

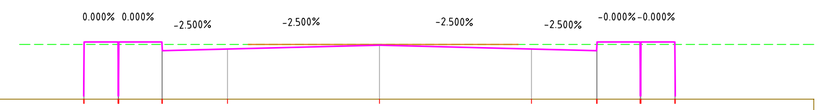
CHAINAGE=1400.000



DATUM =2.000

DESIGN LEVELS	3.409	3.409	3.209	3.247	3.334	3.247	3.209	3.409	3.409
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-4.037	-2.576	0.000 0.429	4.368		
EXISTING GROUND LEVELS	3.297			3.297	3.297	3.297			

CHAINAGE=1200.000



DATUM =2.000

DESIGN LEVELS	3.316	3.316	3.116	3.154	3.241	3.154	3.116	3.316	3.316
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.024	-2.958	0.000 0.048	3.195		
EXISTING GROUND LEVELS	3.260			3.260	3.260	3.260			

CHAINAGE=1350.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REVISIONS

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	INIT.	SIGN.	INIT.	SIGN.
						CHECKED		APPROVED	
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:1200.000 TO CH:1450.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

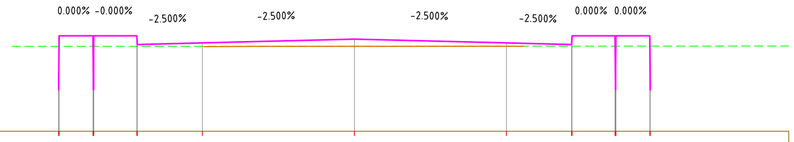
DRAWING NO: DDX105

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-RS-DVB-RUNNING CROSS SECTION.DWG

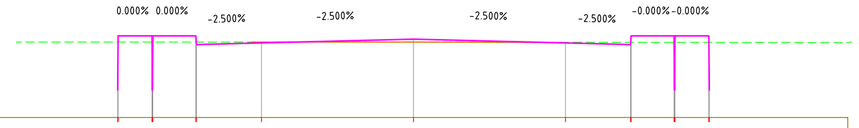
TBNA



DATUM =2.000

DESIGN LEVELS	4.197	4.197	3.997	4.034	4.122	4.034	3.997	4.197	4.197
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.466	-2.139	0.000	0.485	3.899	
EXISTING GROUND LEVELS	3.947 3.955				3.954	3.954		3.958	

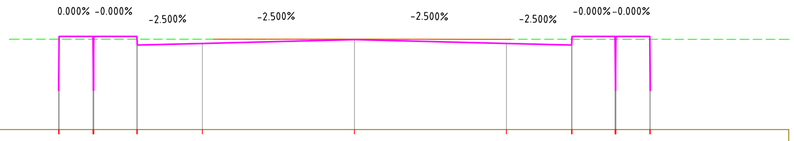
CHAINAGE=1600.000



DATUM =2.000

DESIGN LEVELS	3.877	3.877	3.677	3.715	3.802	3.715	3.677	3.877	3.877
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.738 -3.677	-0.788	0.000	2.844		
EXISTING GROUND LEVELS	3.735			3.735	3.735		3.730		

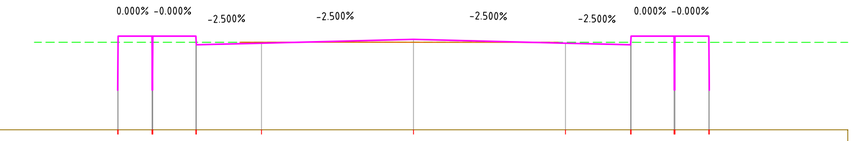
CHAINAGE=1750.000



DATUM =2.000

DESIGN LEVELS	4.146	4.146	3.946	3.984	4.071	3.984	3.946	4.146	4.146
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.240	-2.484	0.000	0.427	3.605	
EXISTING GROUND LEVELS	4.074 4.081				4.082	4.082		4.080	

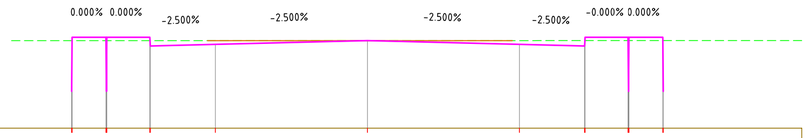
CHAINAGE=1550.000



DATUM =2.000

DESIGN LEVELS	4.157	4.157	3.957	3.994	4.082	3.994	3.957	4.157	4.157
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.997	-0.372 0.000	3.336			
EXISTING GROUND LEVELS	4.015	4.015			4.015	4.014			

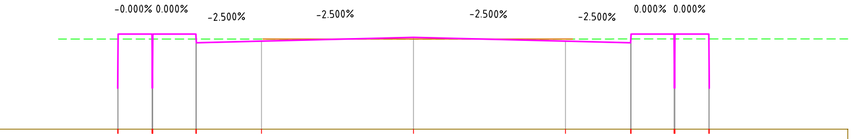
CHAINAGE=1700.000



DATUM =2.000

DESIGN LEVELS	4.091	4.091	3.891	3.929	4.016	3.929	3.891	4.091	4.091
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.684	-0.467 0.000 0.210	1.212	3.338		
EXISTING GROUND LEVELS	4.013 4.014				4.013	4.013	4.014		

CHAINAGE=1500.000



DATUM =2.000

DESIGN LEVELS	4.188	4.188	3.988	4.025	4.113	4.025	3.988	4.188	4.188
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.466	-2.700	0.000 0.183	3.665		
EXISTING GROUND LEVELS	4.075			4.075	4.075		4.076		

CHAINAGE=1650.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:1500.000 TO CH:1750.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

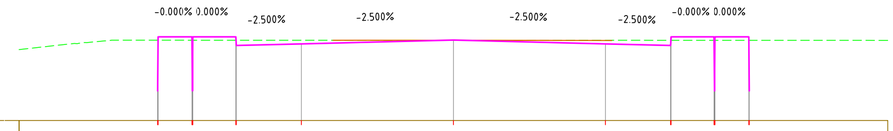
DRAWING NO: DDX106

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX118-RS-DVB-RUNNING CROSS SECTION.DWG

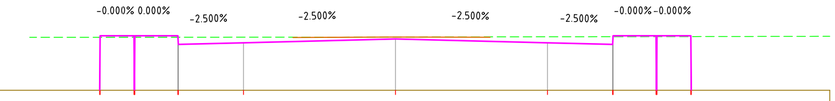
TBNA



DATUM =2.000

DESIGN LEVELS	3.925	3.925	3.725	3.763	3.850	3.763	3.725	3.925	3.925
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.772	0.000 0.477	3.646			
EXISTING GROUND LEVELS	3.773 3.794 3.792 3.843 3.847			3.847	3.847			3.844	

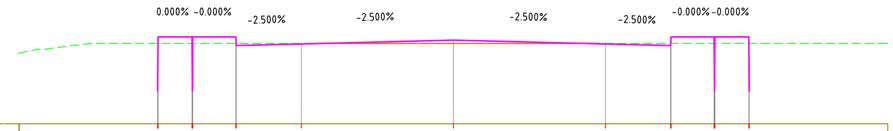
CHAINAGE=1900.000



DATUM =2.000

DESIGN LEVELS	3.255	3.255	3.055	3.093	3.180	3.093	3.055	3.255	3.255
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.360	-0.133 0.000	2.179			
EXISTING GROUND LEVELS	3.218 3.219				3.225	3.230			

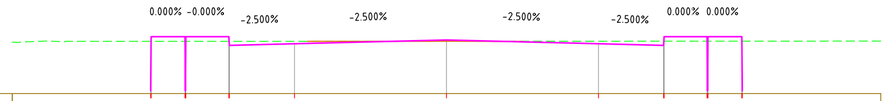
CHAINAGE=2050.000



DATUM =2.000

DESIGN LEVELS	4.000	4.000	3.800	3.837	3.925	3.837	3.800	4.000	4.000
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.596 -2.577	0.000 0.243	3.361			
EXISTING GROUND LEVELS	3.714 3.714	3.789	3.851 3.850	3.850	3.850	3.849			

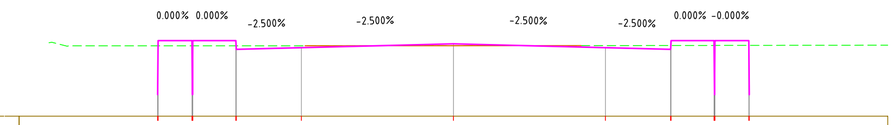
CHAINAGE=1850.000



DATUM =2.000

DESIGN LEVELS	3.310	3.310	3.110	3.148	3.235	3.148	3.110	3.310	3.310
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.195	-0.466 0.000	1.785			
EXISTING GROUND LEVELS	3.186 3.210 3.195 3.202			3.203	3.204				3.208

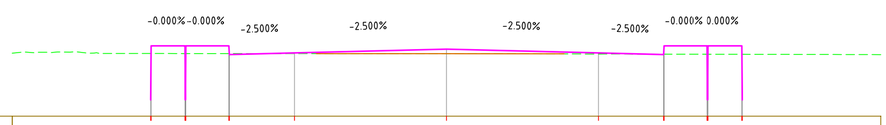
CHAINAGE=2000.000



DATUM =2.000

DESIGN LEVELS	3.739	3.739	3.539	3.576	3.664	3.576	3.539	3.739	3.739
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.416	-0.493 0.000	2.937			
EXISTING GROUND LEVELS	3.690 3.701 3.619		3.619		3.619	3.625			

CHAINAGE=1800.000



DATUM =2.000

DESIGN LEVELS	3.618	3.618	3.418	3.455	3.543	3.455	3.418	3.618	3.618
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.995	0.000 0.339	2.709			
EXISTING GROUND LEVELS	3.478 3.470 3.477 3.484 3.451 3.443			3.441	3.437		3.425		

CHAINAGE=1950.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB	KGN
	YYMMDD					INIT. SIGN.	INIT. SIGN.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:1800.000 TO CH:2050.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

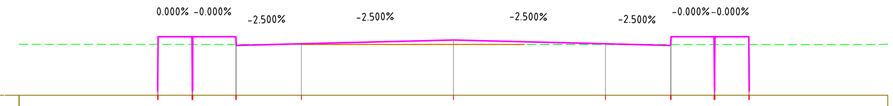
DRAWING NO: DDX107

REV: 0

plot scale 50mm

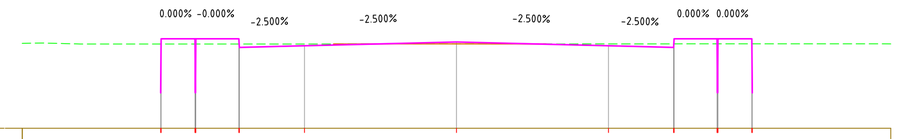
AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-R0-DVB-RUNNING CROSS SECTION.DWG

TBNA



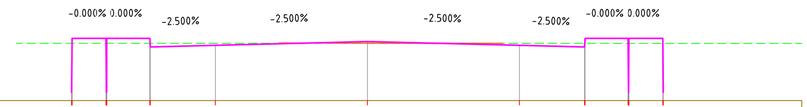
DATUM =2.000									
DESIGN LEVELS	3.347	3.347	3.147	3.185	3.272	3.185	3.147	3.347	3.347
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.491	-1.124	0.000	1.633		
EXISTING GROUND LEVELS	3.171	3.171			3.171		3.169		3.166

CHAINAGE=2200.000



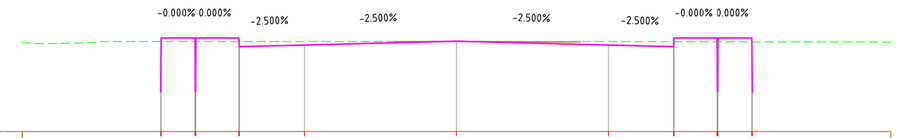
DATUM =1.000									
DESIGN LEVELS	3.061	3.061	2.861	2.898	2.986	2.898	2.861	3.061	3.061
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.831	-0.510	0.000	2.062		
EXISTING GROUND LEVELS	2.959	2.963	2.939	2.940		2.941		2.943	2.944

CHAINAGE=2350.000



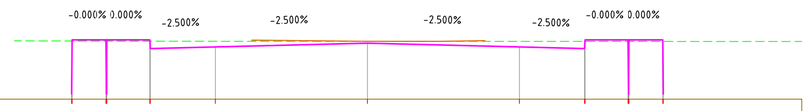
DATUM =2.000									
DESIGN LEVELS	3.434	3.434	3.234	3.272	3.359	3.272	3.234	3.434	3.434
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.027	0.000 0.245	3.119			
EXISTING GROUND LEVELS	3.320	3.320			3.319	3.319			

CHAINAGE=2150.000



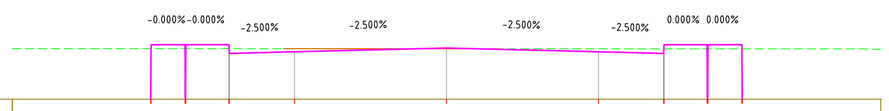
DATUM =1.000									
DESIGN LEVELS	3.156	3.156	2.956	2.994	3.081	2.994	2.956	3.156	3.156
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-1.437	0.000 0.216	2.860			
EXISTING GROUND LEVELS	3.023	3.030	3.047	3.074	3.073	3.073			

CHAINAGE=2300.000



DATUM =2.000									
DESIGN LEVELS	3.364	3.364	3.164	3.201	3.289	3.201	3.164	3.364	3.364
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.665	0.000 0.153	1.627	2.706		
EXISTING GROUND LEVELS	3.341		3.332		3.331	3.330			

CHAINAGE=2100.000



DATUM =2.000									
DESIGN LEVELS	3.252	3.252	3.052	3.089	3.177	3.089	3.052	3.252	3.252
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-3.753	-1.259	0.000	1.150		
EXISTING GROUND LEVELS	3.161		3.161		3.161		3.159		3.155

CHAINAGE=2250.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB	KGN
	YYMMDD					INIT. SIGN.	INIT. SIGN.

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:2100.000 TO CH:2350.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

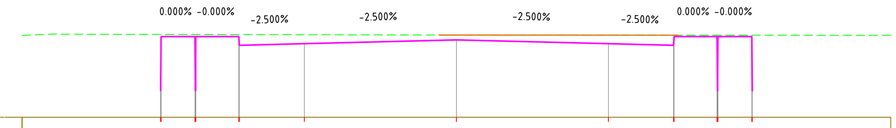
DRAWING NO: DDX108

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-R0-DVB-RUNNING CROSS SECTION.DWG

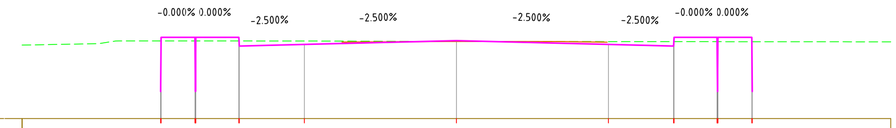
TBNA



DATUM =1.000

DESIGN LEVELS	2.856	2.856	2.656	2.693	2.781	2.693	2.656	2.856	2.856
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET					-0.402 0.000		5.107		
EXISTING GROUND LEVELS	2.915 2.913 2.911			2.902	2.895 2.894 2.894			2.888	

CHAINAGE=2500.000



DATUM =1.000

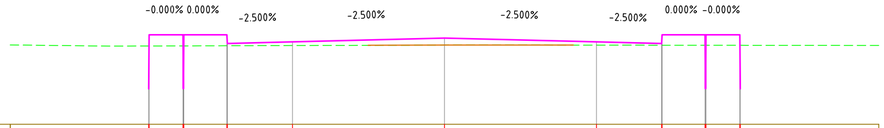
DESIGN LEVELS	2.870	2.870	2.670	2.707	2.795	2.707	2.670	2.870	2.870
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.636	0.000 0.290	2.438	3.471		
EXISTING GROUND LEVELS	2.726 2.787 2.788			2.787	2.775	2.773			

CHAINAGE=2450.000

DATUM =1.000

DESIGN LEVELS	2.965	2.965	2.765	2.803	2.890	2.803	2.765	2.965	2.965
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-2.163	0.000 0.354	3.408			
EXISTING GROUND LEVELS	2.864	2.825	2.820		2.808		2.784		

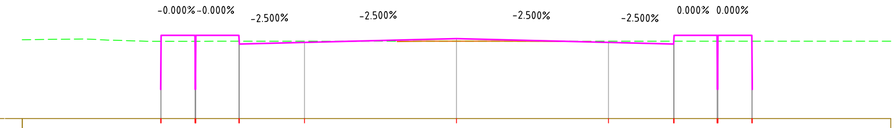
CHAINAGE=2400.000



DATUM =1.000

DESIGN LEVELS	3.059	3.059	2.859	2.897	2.984	2.897	2.859	3.059	3.059
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-1.761	0.000 0.570	2.966			
EXISTING GROUND LEVELS	2.799		2.813		2.824		2.819		

CHAINAGE=2650.000



DATUM =1.000

DESIGN LEVELS	2.917	2.917	2.717	2.754	2.842	2.754	2.717	2.917	2.917
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-1.366	-0.735 0.000	1.175	3.091		
EXISTING GROUND LEVELS	2.834 2.808 2.799 2.781				2.782	2.783	2.783		

CHAINAGE=2600.000

DATUM =1.000

DESIGN LEVELS	2.886	2.886	2.686	2.724	2.811	2.724	2.686	2.886	2.886
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-1.647	-0.293 0.000 0.462	3.178			
EXISTING GROUND LEVELS	3.026 2.991 2.944 2.908	2.916			2.862	2.855 2.857	2.843		

CHAINAGE=2550.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:2400.000 TO CH:2650.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

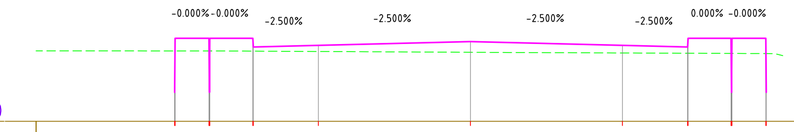
DRAWING NO: DDX109

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-R0-DVB-RUNNING CROSS SECTION.DWG

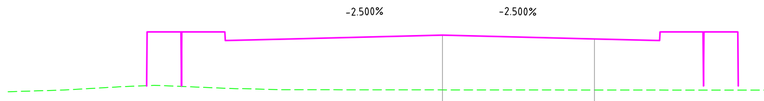
TBNA



DATUM =1.000

DESIGN LEVELS	2.909	2.909	2.709	2.747	2.835	2.747	2.709	2.909	2.909
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING GROUND LEVELS		2.618			2.583			2.557	2.510

CHAINAGE=4700.000



DATUM =1.000

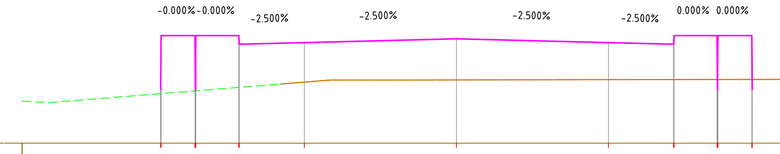
DESIGN LEVELS	3.823	3.736		
DESIGN OFFSET	0.000	3.500		
EXISTING GROUND LEVELS	2.237	2.316	2.379 2.386 2.389	

CHAINAGE=2750.000

DATUM =1.000

DESIGN LEVELS	2.599	2.599	2.399	2.436	2.541	2.436	2.399	2.599	2.599
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING GROUND LEVELS		2.509			2.510				

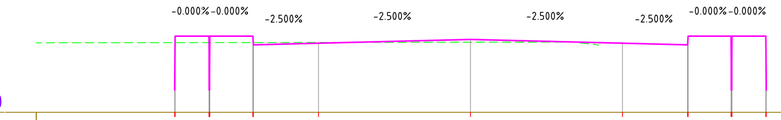
CHAINAGE=4800.000



DATUM =1.000

DESIGN LEVELS	3.477	3.477	3.277	3.314	3.402	3.314	3.277	3.477	3.477
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	0.000	3.500	5.000	6.000	6.800
EXISTING ROAD OFFSET				-4.053	-2.890	-1.058	0.000	7.662	9.605
EXISTING GROUND LEVELS	1.934				2.453	2.453		2.468	2.468

CHAINAGE=2700.000



DATUM =1.000

DESIGN LEVELS	2.753	2.753	2.553	2.590	2.678	2.590	2.553	2.753	2.753
DESIGN OFFSET	-6.800	-6.000	-5.000	-3.500	-0.000	3.500	5.000	6.000	6.800
EXISTING GROUND LEVELS				2.608		2.616 2.596 2.566 2.542			

CHAINAGE=4750.000

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RUNNING CROSS SECTION FROM CH:2700.000 TO CH:4800.000

COP: IRC

SCALE: 1:100

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDX110

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\RUNNING CROSS SECTION\DDX101 TO DDX110-RD-DYB-RUNNING CROSS SECTION.DWG

TBNA

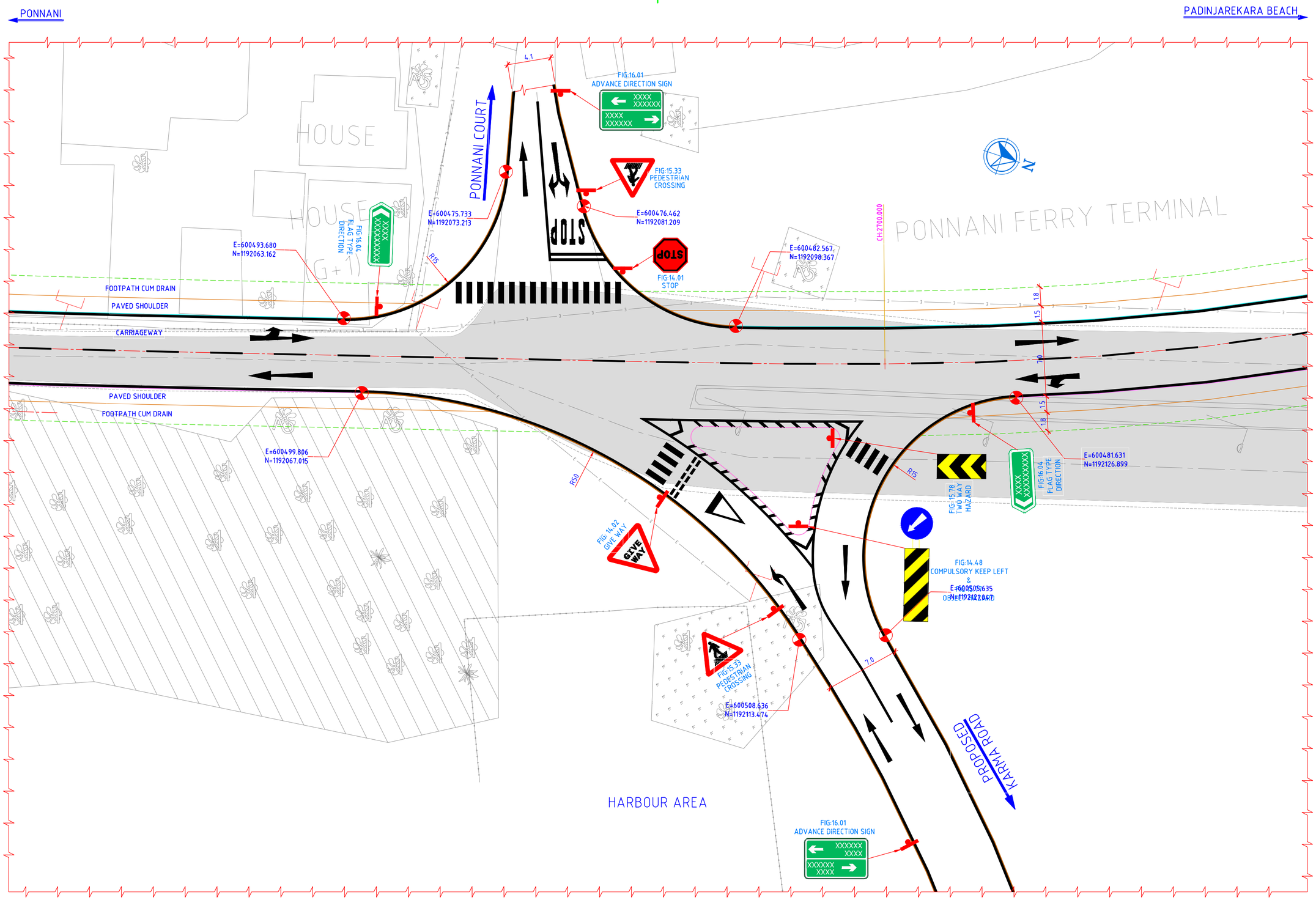
ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

JUNCTION DEVELOPEMT

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\JUNCTION\DOJJ001-R0-DVB-JUNCTION DEVELOPMENT 2+680.DWG

TBNA



NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO. | TITLE

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ORIG. SIZE A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: JUNCTION DEVELOPMENT AT CH:2680

COP: IRC

SCALE: 1:250

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDJ001

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\JUNCTION\DDJ001-RD-DVB-JUNCTION DEVELOPMENT 2+680.DWG

TBNA

PONNANI

PADINJAREKARA BEACH

HOUSE

HOUSE

HOUSE

OFC

OFC

OFC

OFC

CH:800.000

BENCHMARK COORDINATE
E=601189.809
N=1190393.58

FOOTPATH CUM DRAIN

PAVED SHOULDER

CARRIAGEWAY

PAVED SHOULDER

FOOTPATH CUM DRAIN

E=601218.505
N=1190351.846

R8

STOP

STOP

FIG:14.01
STOP

E=601225.466
N=1190362.66

R15

FIG:16.04
FLAG TYPE
DIRECTION

E=601207.646
N=1190380.547

E=601221.456
N=1190370.856

FIG:15.33
PEDESTRIAN
CROSSING

FIG:15.33
PEDESTRIAN
CROSSING

SHOP

KMS

BOMBAY HOTEL

FIG:16.01
ADVANCE DIRECTION SIGN

XXXX
XXXXXX
XXXX
XXXXXX

SHOP

TO KOLLANPADI
(BT ROAD)

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS		
DRAWING NO.	TITLE	

REVISIONS											
REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.		
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN			

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: JUNCTION DEVELOPMENT AT CH:800.000

COP: IRC

SCALE: 1:250

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDJ002

REV: 0

plot scale 50mm

TBNA

AUTO PATH I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\JUNCTION\DDJ002-R0-DVB-JUNCTION DEVELOPMENT-0-800.DWG

PONNANI

PADINJAREKARA BEACH

N

HOUSE

ABANDONED

HOUSE

(G+1)

CH:2500.000

FIG:15.33
PEDESTRIAN
CROSSING

FIG:16.04
FLAG TYPE
DIRECTION

E=600518.161
N=1191972.43

FOOTPATH CUM DRAIN

PAVED SHOULDER

CARRIAGEWAY

R15

E=600506.732
N=1191984.139

STREET (BT ROAD)

STOP

FIG:16.01
ADVANCE DIRECTION SIGN

XXXXX
XXXX
XXXXXX
XXXX

E=600493.514
N=1191991.131

FIG:15.33
PEDESTRIAN
CROSSING

FIG:14.01
STOP

E=600509.598
N=1192009.895

CH:2600.000

HOUSE

(G+1)

PAVED SHOULDER

FOOTPATH CUM DRAIN

E=600529.345
N=1191951.118

R15

STOP

FIG:14.01
STOP

STOP

FIG:15.33
PEDESTRIAN
CROSSING

E=600548.795
N=1191968.108

FIG:16.01
ADVANCE DIRECTION SIGN

POND

TO KEEZHILLAM
(BT ROAD)

HOUSE

(G+1)

E=600532.338
N=1191979.207

FIG:16.04
FLAG TYPE
DIRECTION

E=600521.555
N=1191990.346

FIG:15.33
PEDESTRIAN
CROSSING

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	DVB	NCB		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: JUNCTION DEVELOPMENT AT CH:2550.000

COP: IRC

SCALE: 1:250

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDJ003

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\JUNCTION\DDJ003-R0-DVB-JUNCTION DEVELOPMENT 2-550.DWG

TBNA

ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

ROAD SIGNS PLAN

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF119-RD-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

CH:0.000

CH:100.000

CH:200.000

CH:300.000

CH:400.000

CH:500.000

PC 345.661

PT 351.105

PC 488.652

KM STONE

FILLING STATION (FUEL PUMP)
FIG:13.04

INDIAN OIL FUEL STATION

SCHOOL AHEAD
FIG:15.34

HORN PROHIBITED
FIG:14.18

200m STONE

HOUSE

STREET (BT ROAD)

POONU BAKERY & FRUITS

MES COLLEGE GROUND

STOP
FIG:14.01
STOP

PEDESTRIAN CROSSING
FIG:15.33

MES PONNANI COLLEGE

SPEED LIMIT
FIG:14.37

80

C-WALL

BISMI INDUSTRIES

KMS

HOUSE (G+1)

FENCE

TO URODE NAGAR (BT ROAD)

START OF THE PROJECT

MATCH LINE

N

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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DRIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 0.000 TO CH: 0.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF101

REV: 0

DDF001

plot scale 50mm

TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF119-RG-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

PONNANI

PADINJAREKARABEACH

PC 4.488.652

CH:500.000

PT 510.547

CH:600.000

PC 667.034

CH:700.000

PT 730.997

CH:800.000

PC 914.744

CH:900.000

PC 954.849

CH:1000.000

BT ROAD

STREET (BT ROAD)

MES PONNANI COLLEGE

KSRTC BUS DEPOT

FEDERAL BANK ATM

CHOICE LADIES AND KIDS FASHION

KAFFENO CAFE

WELL

WALL

C-WALL

FENCE

HOUSE

SHOP

BANK ATM

PUNJAB NATIONAL BANK

20cm STONE

KM STONE

HMS

OBJECT HAZARD LEFT

REF:15.76

OBJECT HAZARD LEFT

INDUSTRIAL AREA

REF:17.17

MATCH LINE

80

SPEED LIMIT

REF:14.37

STR. NO.	1/1
PROPOSED CHAINAGE	589.891
SPAN	1x1.30 SLAB CULVERT
PROPOSED	WIDENING

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 0.500 TO CH: 1.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF102

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF110-RD-DVB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

TB HOSPITAL PONNANI

KARUNYA COMMUNITY PHARMACY

POPULAR HYUNDAI FESTIVE COUNTER

RISWANA TEA STALL

SHOP

STREET (BT ROAD)

CH:1000.000

CH:1100.000

CH:1200.000

CH:1300.000

CH:1400.000

CH:1500.000

PC 1084.343

PT 1091.829

PC 1325.944

KM STONE

200m STONE

HM

FIGTIGT HOSPITAL

MATCH LINE

HOUSE

HOUSE (G+1)

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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ORIG. SIZE A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 1.000 TO CH: 1.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF103

REV: 0

plot scale 50mm

AUTO PATH I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF110-RD-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 1.500 TO CH: 2.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF104

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF110-R0-DVB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

MALAPPURAM

CH:2000.000

PVT 203.593

CH:2100.000

TS 2100.194

SC 2135.194

CS 2179.470

CH:2200.000

ST 2214.470

TS 2264.216

SC 2289.216

CH:2300.000

CS 2303.038

ST 2328.038

TS 2369.371

SC 2389.371

CH:2400.000

CS 2437.515

SC 2467.515

CH:2500.000

CHEVRON SPACING C/C 80m ON CURVE 150m BEFORE CURVE

CHEVRON SPACING C/C 30m ON CURVE

CHEVRON SPACING C/C 30m ON CURVE

FIG 15.72 SINGLE CHEVRON

FIG 15.37 SPEED LIMIT SIGN

40

KM STONE

200m STONE

HM

DB FIG 15.37 LEFT HAZARD

SIDE ROAD LEFT

MATCH LINE

MATCH LINE

C-WALL

POND

TANK

TOILET

FACTORY

GOVT BUILDING

STR. NO.	3/1
PROPOSED CHAINAGE	2380.474
SPAN	1x1.0 SLAB CULVERT
PROPOSED	WIDENING

HIP CHAINAGE :		2+157.332	
E=600676.903		N=1191613.076	
R (m)	600.000	Ls (m)	35.000
Lc (m)	44.277	D (deg)	7.570
Design Speed (V) : 80 KMPH			

HIP CHAINAGE :		2+296.127	
E=600619.958		N=1191739.818	
R (m)	-180.000	Ls (m)	25.000
Lc (m)	13.821	D (deg)	12.357
Design Speed (V) : 40 KMPH			

HIP CHAINAGE :		2+418.443	
E=600546.671		N=1191838.671	
R (m)	150.000	Ls (m)	30.000
Lc (m)	38.145	D (deg)	26.029
Design Speed (V) : 40 KMPH			

AMLET ROAD

STREET (BT ROAD)

STREET (CEMENT ROAD)

U/C

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 2.000 TO CH: 2.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

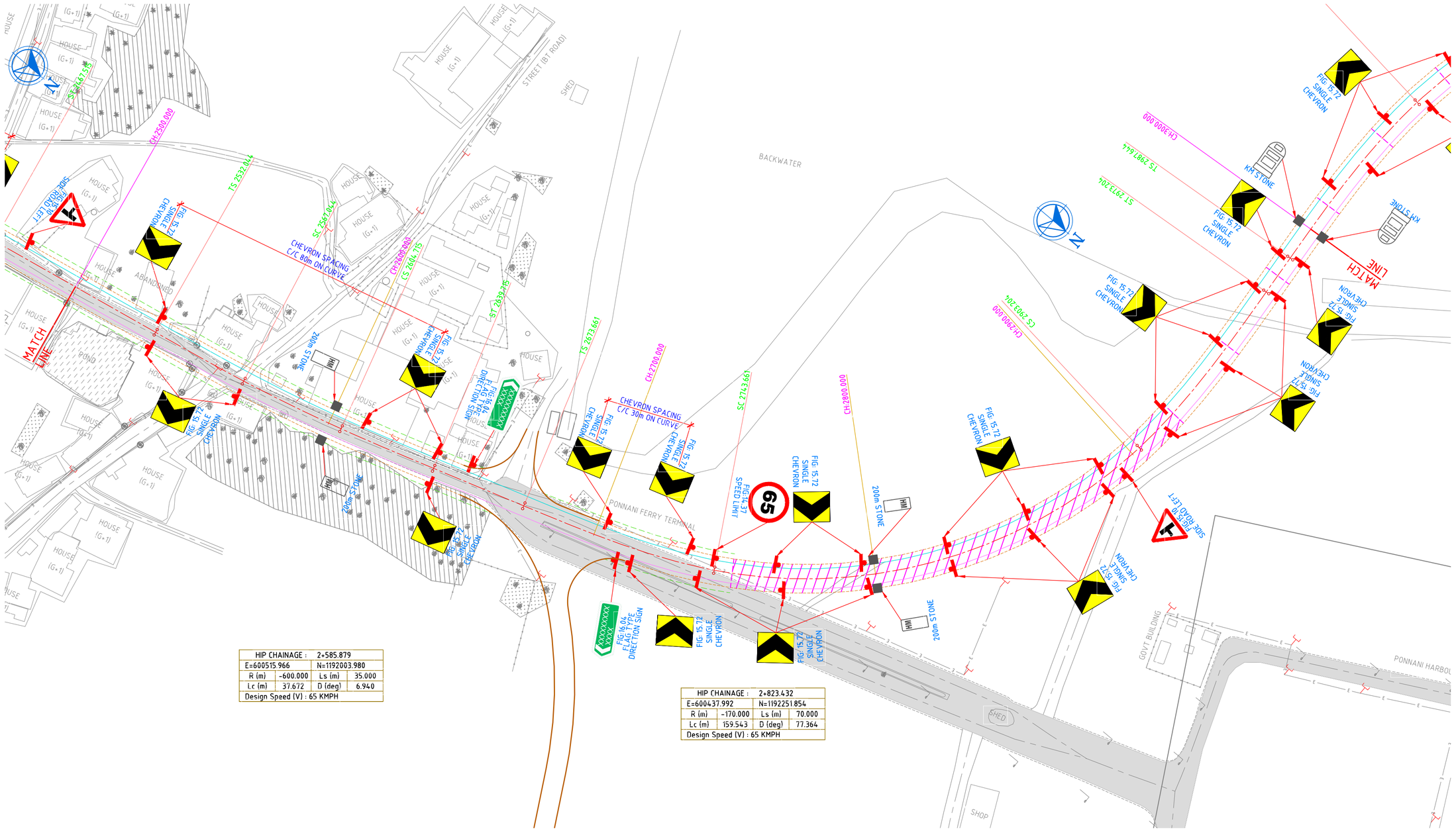
DRAWING NO: DDF105

REV: 0

plot scale 50mm

TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF110-R0-DVB-STRIP PLAN KM 0.000 TO KM 4.800.DWG



NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED: INIT.	CHECKED: SIGN.	APPROVED: INIT.	APPROVED: SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 2.500 TO CH: 3.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF106

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF119-RG-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

CH:3100.000

SC 3057.644

CS 3142.456

CH:3200.000

ST 3212.456

PC 3218.051

CH:3300.000

CH:3400.000

PT 3482.150

CH:3500.000

TS

FIG: 15.72 SINGLE CHEVRON

KM STONE

MATCH LINE

FIG: 15.72 SINGLE CHEVRON

200m STONE

CHEVRON SPACING C/C 30m ON CURVE 60m BEFORE CURVE

HOUSE

TO PONNANI - PURATHUR JJENKAR TERMINAL

PONNANI - PURATHUR JENKAR TERMINAL

SEPTIC TANK

SUMP

TO BEACH (MUD ROAD)

N

HIP CHAINAGE : 3+100.050			
E=600133.839		N=1192226.176	
R (m)	170.000	Ls (m)	70.000
Lc (m)	84.811	D (deg)	52.177
Design Speed (V) : 65 KMPH			

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 3.000 TO CH: 3.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF107

REV: 0

plot scale 50mm

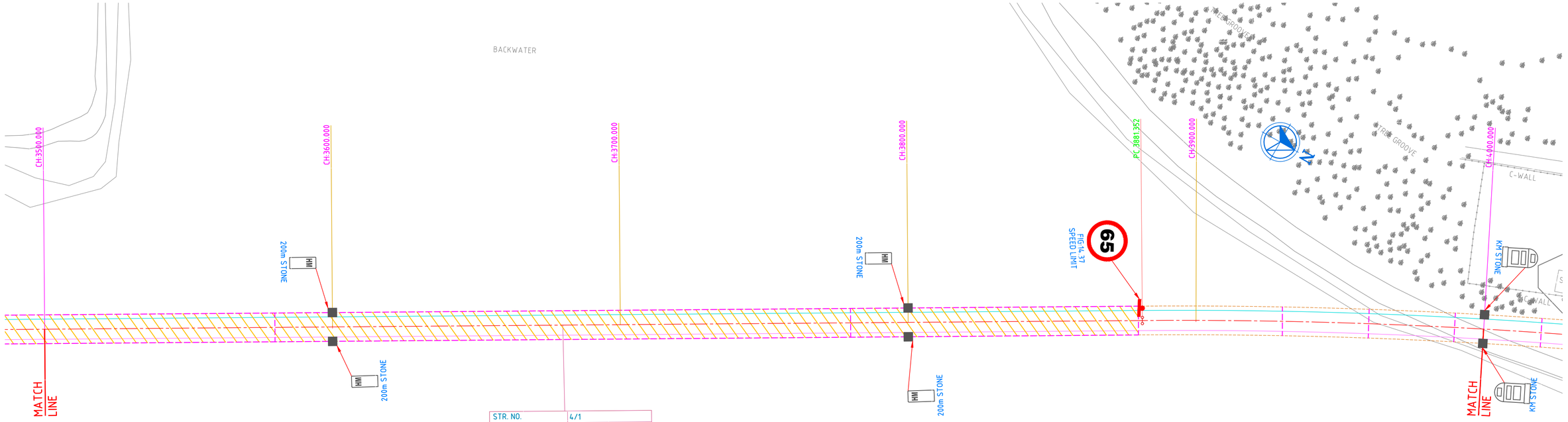
AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF110-RD-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

BACKWATER



STR. NO.	4/1
PROPOSED CHAINAGE	3680.000
PROPOSED	CABLE STAYED BRIDGE
SPAN	1x100+1x200.00+1x100

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 3.500 TO CH: 4.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

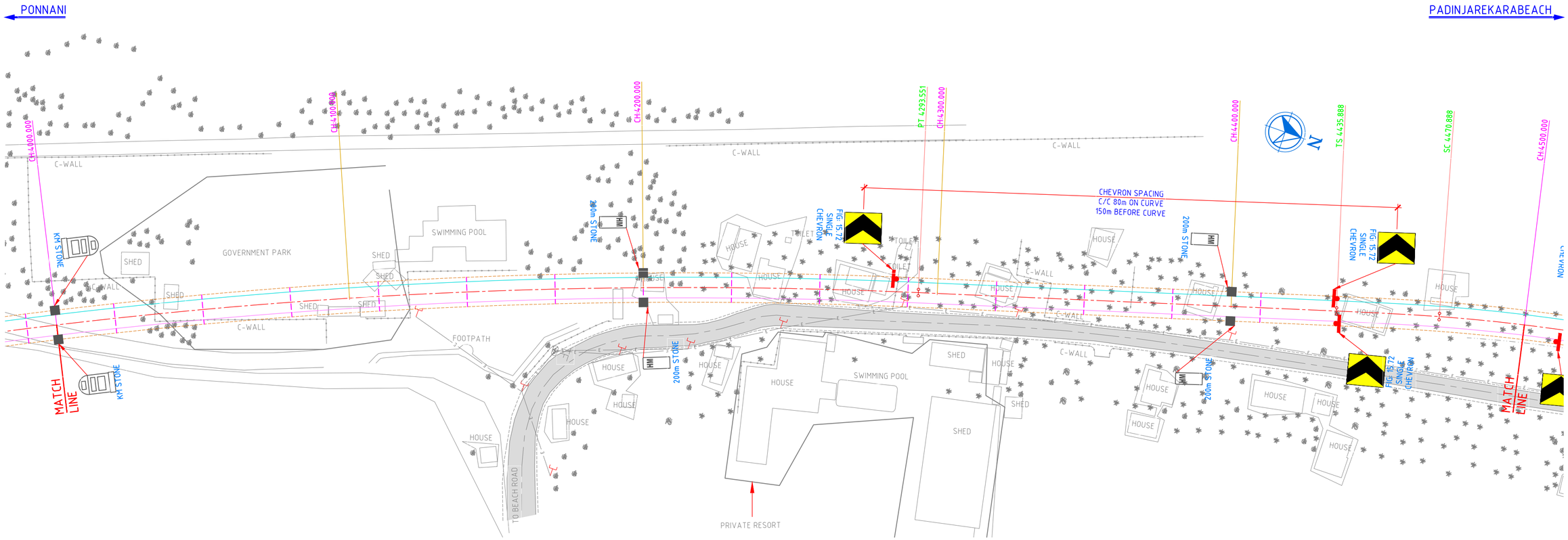
DRAWING NO: DDF108

REV: 0

plot scale 50mm

TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF119-RD-DYB-STRIP PLAN KM 0.000 TO KM 4.000.DWG



NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 4.000 TO CH: 4.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF109

REV: 0

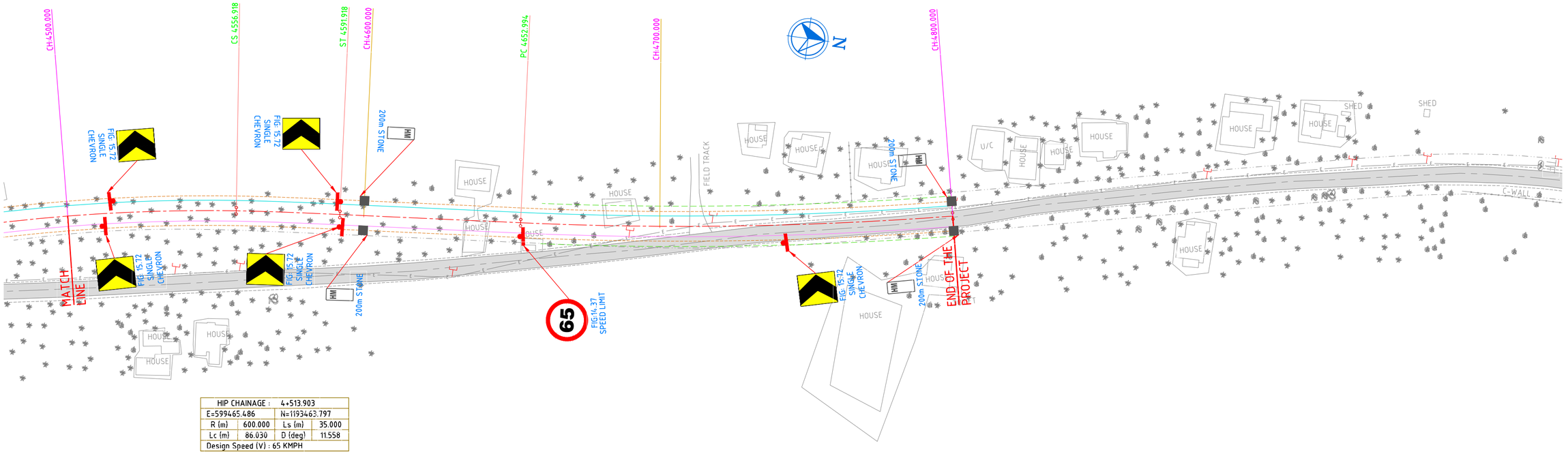
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF119-RD-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH



HIP CHAINAGE :		4+513.903	
E=599465.486		N=1193463.797	
R (m)	600.000	Ls (m)	35.000
Lc (m)	86.030	D (deg)	11.558
Design Speed (V) : 65 KMPH			

NOTES:

1. ALL DIMENSIONS AND CHAINAGES ARE IN METERS UNLESS OTHERWISESPECIFIED.
2. ROAD SIGNS PLAN SHALL FOLLOW IRC:67-2012 SPECIFICATIONS.
3. FOR MARKING REFER TYPICAL DRAWINGS.

DRAWING NO.	TITLE
	REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ROAD SIGNS PLAN FROM CH: 4.500 TO CH: 4.800

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDF110

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\DDF101-DDF119-RG-DYB-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

TYPICAL DRAWINGS FOR ROAD SIGNS

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\TYPICAL DRAWINGS\DDF001-R0-MSJ-TYPICAL ROAD SIGNS.DWG

TBNA

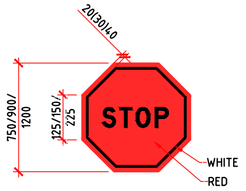


FIG: 14.01 OF IRC:67-2012

STOP

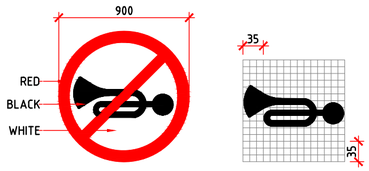


FIG: 14.18 OF IRC:67-2012

HORN PROHIBITED

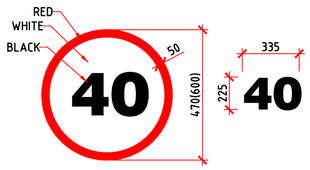


FIG: 14.37 OF IRC:67-2012

SPEED LIMIT

FIG NO	DESIGN SPEED (KMPH)	SIZE	REGULATORY SIGNS	MANDATORY SIGNS			
14.37			DIAMETER(mm)	DIAMETER(mm)	BORDER (mm)	OBLIQUE (mm)	FONT SIZE (mm)
A	UP TO 65	SMALL	600	600	50	50	100
B	66-80	MEDIUM	750	750	60	60	125

REGULATORY SIGNS

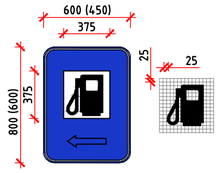


FIG: 17.06 OF IRC:67-2012

FILLING STATION

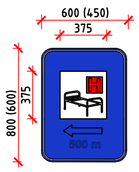


FIG: 17.07 OF IRC:67-2012

HOSPITAL

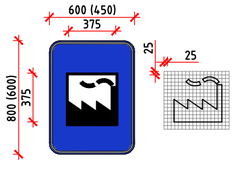


FIG: 17.17 OF IRC:67-2012

INDUSTRIAL AREA

FACILITY SIGNS

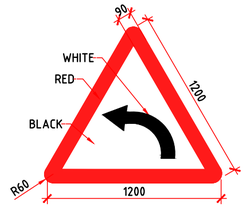


FIG: 15.01 OF IRC:67-2012

LEFT HAND CURVE

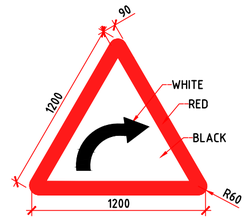


FIG: 15.02 OF IRC:67-2012

RIGHT HAND CURVE

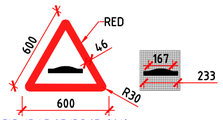


FIG: 15.47 OF IRC:67-2012

SPEED BREAKER

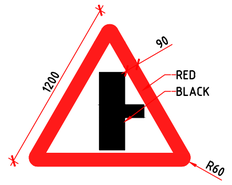
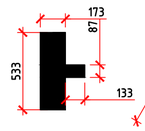


FIG: 15.09 OF IRC:67-2012

SIDE ROAD RIGHT



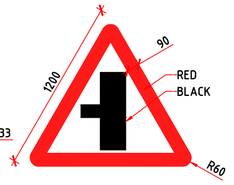
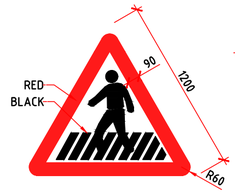


FIG: 15.10 OF IRC:67-2012

SIDE ROAD LEFT



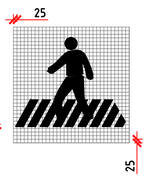


FIG: 15.33 OF IRC:67-2012

PEDESTRIAN CROSSING

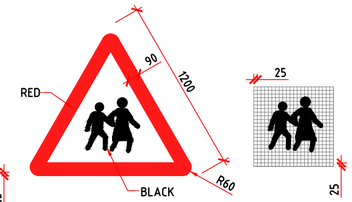


FIG: 15.34 OF IRC:67-2012

SCHOOL AHEAD

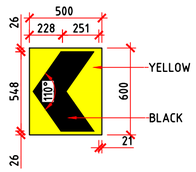


FIG: 15.72 OF IRC:67-2012

SINGLE CHEVRON (NORMAL)

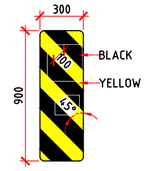


FIG: 15.76 OF IRC:67-2012

ONEWAY HAZARD MARKER (LEFT)

WARNING SIGNS

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
2. ALL ROAD SIGNS ARE IN ACCORDANCE WITH IRC-67-2012, "CODE OF PRACTICE FOR ROAD SIGNS".
3. TEXT FOR SIGN BOARDS SHALL BE AS PER IRC:30-1968, "STANDARD LETTERS AND NUMERICAL OF DIFFERENT HEIGHTS FOR USE IN HIGHWAY SIGNS".
4. FOR DETAILED CHARACTERISTICS OF THE ROAD SIGNS RELEVANT IRC CODES & MOST GUIDELINES SHALL BE REFERRED.
5. DIMENSIONS ARE AS PER DESIGN SPEED.
6. DIMENSIONS IN THE BRACKET INDICATES SPEED LESS THAN 100 kmph.

NOTES:

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	SJK	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: TYPICAL ROAD SIGNS

COP: IRC

SCALE: 1:30

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

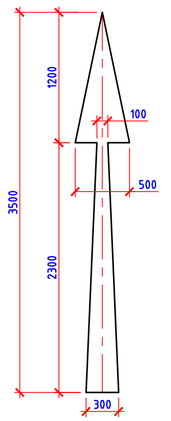
DRAWING NO: DDF001

REV: 0

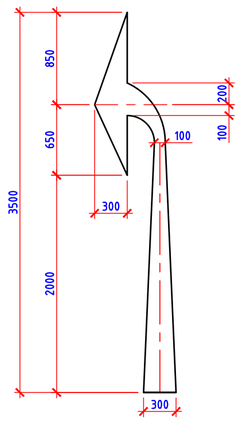
plot scale 50mm

AUTO PATH:I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\TYPICAL DRAWINGS\DDF001-R0-MS-TYPICAL ROAD SIGNS.DWG

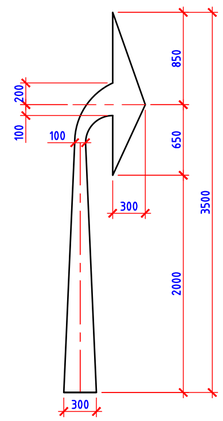
TBNA



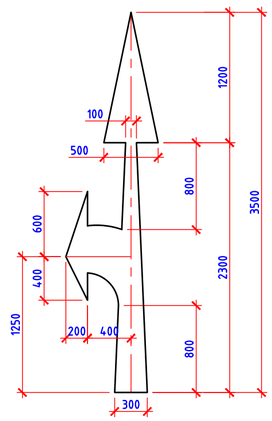
STRAIGHT ARROW
AM-01



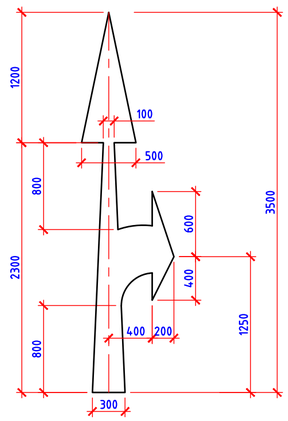
LEFT ARROW
AM-02



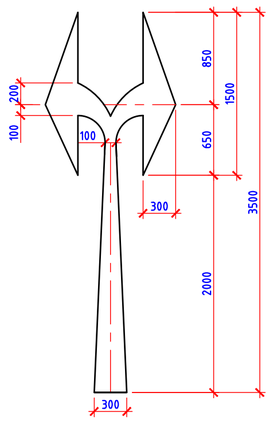
RIGHT ARROW
AM-03



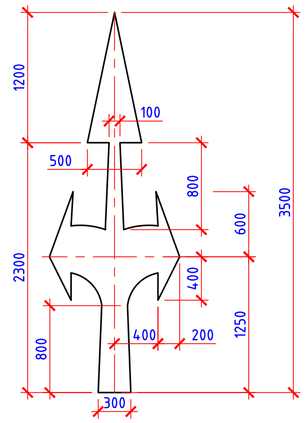
STRAIGHT & LEFT ARROW
AM-04



STRAIGHT & RIGHT ARROW
AM-05



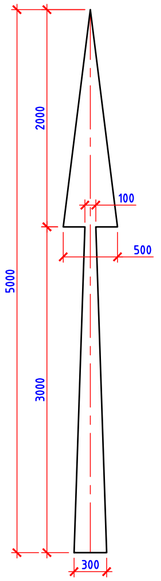
RIGHT & LEFT ARROW
AM-06



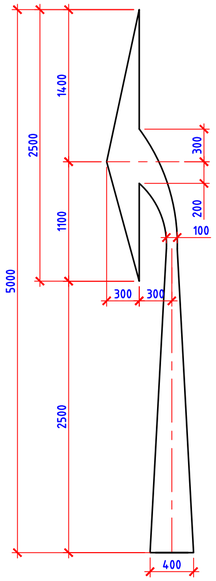
STRAIGHT & BOTH ARROW
AM-07

ARROW MARKING FOR ROUTE DIRECTION FOR DESIGN SPEED OF 50 KM/HR. OR LESS

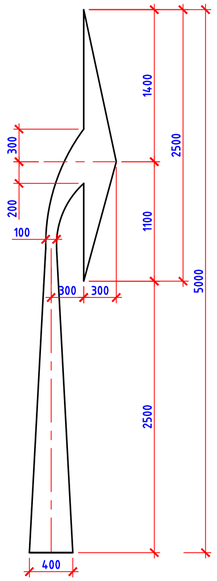
(ALL THE ARROWS ARE IN WHITE COLOUR)



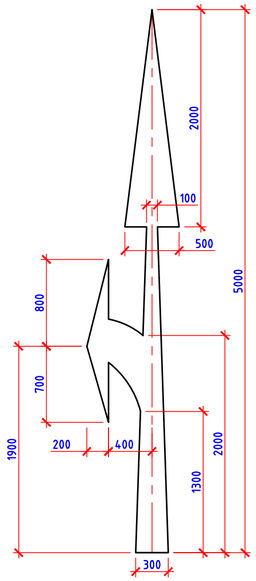
STRAIGHT ARROW
AM-08



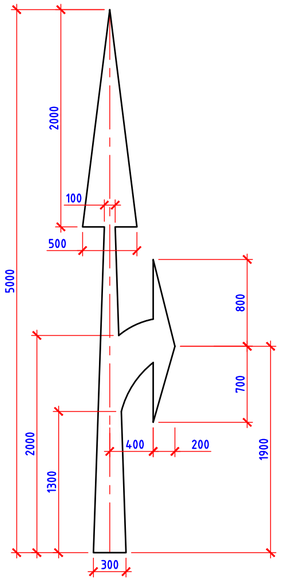
LEFT ARROW
AM-09



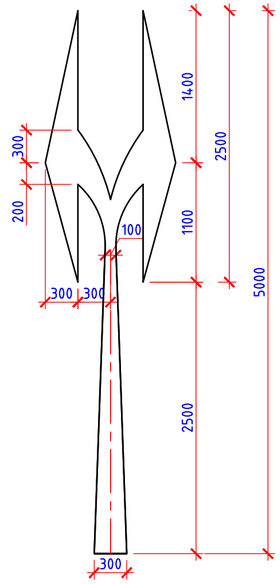
RIGHT ARROW
AM-10



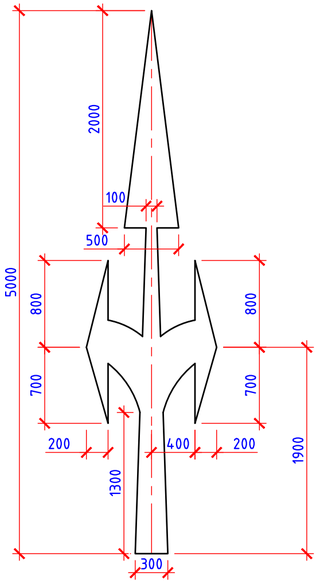
STRAIGHT & LEFT ARROW
AM-11



STRAIGHT & RIGHT ARROW
AM-12



LEFT & RIGHT ARROW
AM-25



STRAIGHT & BOTH ARROW
AM-26

ARROW MARKING FOR ROUTE DIRECTION FOR DESIGN SPEED MORE THAN 50 KM/HR.

(ALL THE ARROWS ARE IN WHITE COLOUR)

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. SPECIFICATIONS AND DIMENSIONS ARE IN ACCORDANCE WITH IRC:35-2015 -"CODE OF PRACTICE FOR ROAD MARKINGS".
3. ROAD MARKING SHALL BE HOT APPLIED THERMO PLASTIC MATERIALS WITH GLASS REFLECTORIZING BEADS AS PER CLAUSE 803 OF MORTH SPECIFICATIONS.
4. MARKING COLOUR ON RIGID PAVEMENT SHALL BE ACCORDING TO CLAUSE 3.8.2 OF IRC:35-2015.

NOTES:

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	INIT.	SIGN. (CHECKED)	INIT.	SIGN. (APPROVED)
0	200313	4	FIRST SUBMISSION	HMS	SJK	NCB		NCB	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: DIRECTIONAL ARROWS FOR ROADS

COP: IRC

SCALE: 1:40

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO.: DDF002

REV.: 0

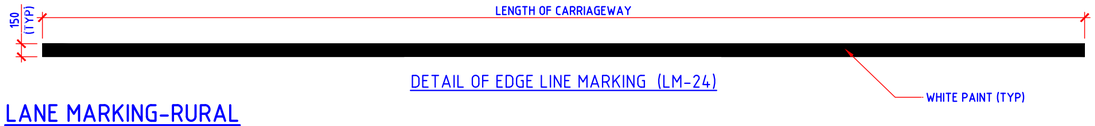
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\TYPICAL DRAWINGS\DDF002-R0-MS-DIRECTIONAL ARROWS.DWG

TBNA

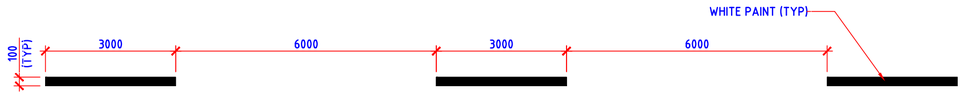
MAIN CARRIAGEWAY

EDGE LINE MARKING

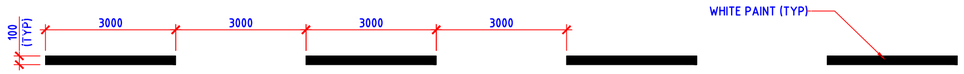


DETAIL OF EDGE LINE MARKING (LM-24)

LANE MARKING-RURAL

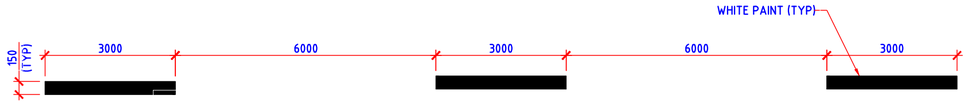


LANE MARKING ON STRAIGHT REACHES IN (RURAL SECTION) (LM-01)

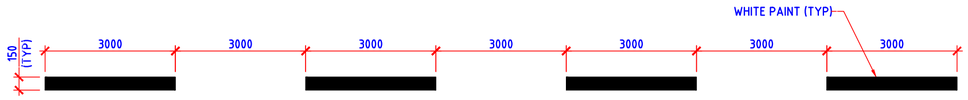


LANE MARKING FOR CURVES & AT APPROACH ROADS TO INTERSECTIONS (RURAL SECTION) (LM-11)

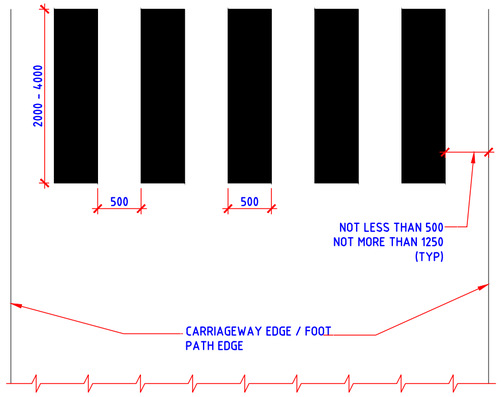
LANE MARKING-URBAN



LANE MARKING ON STRAIGHT REACHES IN (URBAN SECTION) (LM-02)



LANE MARKING FOR CURVES & AT APPROACH ROADS TO INTERSECTIONS (URBAN SECTION) (LM-12)



PEDESTRIAN CROSSING MARKING (BM01 / BM02 / BM03)

NOTES:-
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. LANE MARKINGS & OBJECT MARKINGS SHALL BE DONE WITH HOT THERMOPLASTIC PAINT WITH GLASS REFLECTORIZING BEADS AND SHALL BE IN ACCORDANCE WITH CLAUSE-803 OF "MOST" SPECIFICATION REVISION V, 2013.
3. ALL MARKINGS SHALL BE IN ACCORDANCE WITH IRC:35-2015 AND TYPE DESIGNS FOR INTERSECTIONS ON NATIONAL HIGHWAYS ("MOST" 1995).

NOTES:

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
0	200313	4	FIRST SUBMISSION	HMS	SJK	NCB	NCB

REVISIONS

DRAWING NO. | TITLE

REFERENCE DRAWINGS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING | ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE | PROJECT NO: C1193601

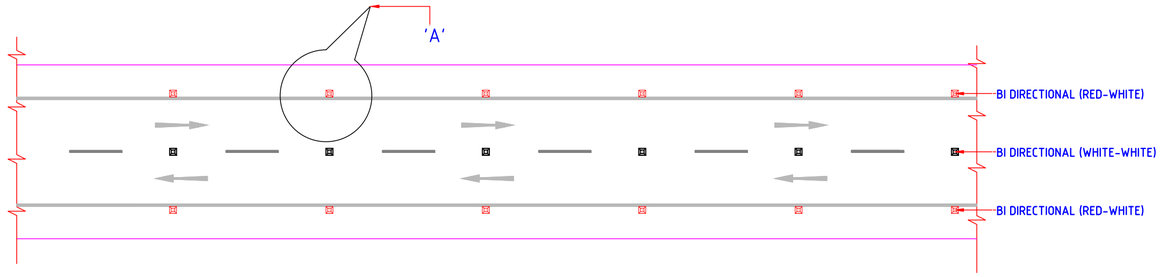
TITLE: TYPICAL DETAILS OF ROAD MARKINGS | COP: IRC | SCALE: NTS

L&T Infra Engineering | L&T Infrastructure Engineering Ltd. | DRAWING NO: DDF003 | REV: 0

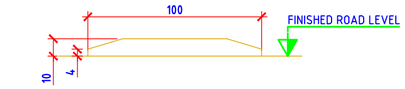
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\TYPICAL DRAWINGS\DDF003-R0-MSI-ROAD MARKINGS.DWG

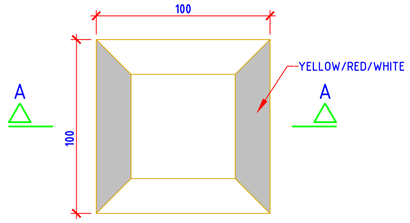
TBNA



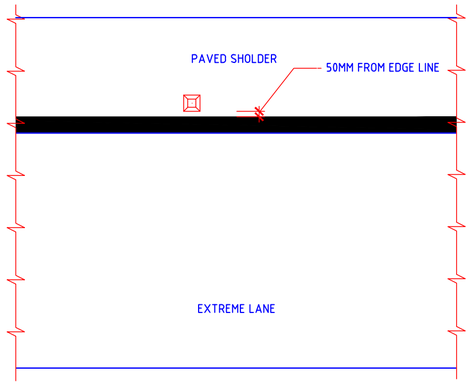
ROAD STUDS FOR CARRIAGEWAY
SCALE 1:250



SECTION - AA
SCALE 1:4



DETAIL OF STUD
SCALE 1:4



DETAIL 'A'
SCALE 1:40

WARRANTS FOR ROAD STUDS

SI. NO.	ROAD CATEGORY	TRAFFIC MOVEMENT	CARRIAGE WAY	NORMAL SECTION			WARNING SECTION			NO OVERTAKING SECTION		
				CENTRE LINE	EDGE LINE	TRAFFIC LANE LINE	CENTRE LINE	EDGE LINE	TRAFFIC LANE LINE	CENTRE LINE	EDGE LINE	TRAFFIC LANE LINE
1	TWO LANE ROAD WITH PAVED SHOULDER	TWO WAY	>7m	WHITE WHITE BI-DIRECTIONAL AT 18m INTERVAL (OPTIONAL)	RED-WHITE BI-DIRECTIONAL AT 18m INTERVAL (OPTIONAL)	NA	WHITE WHITE BI-DIRECTIONAL AT 9m INTERVAL (DESIRABLE)	RED-WHITE BI-DIRECTIONAL AT 9m INTERVAL (DESIRABLE)	NA	YELLOW YELLOW BI-DIRECTIONAL AT 6m INTERVAL (DESIRABLE)	RED-WHITE BI-DIRECTIONAL AT 9m INTERVAL (DESIRABLE)	NA

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETER UNLESS OTHERWISE SPECIFIED.
2. ROAD STUDS SHALL BE FIXED ON THE ROAD SURFACE USING ADHESIVES.
3. REFER IRC:35-2015 FOR THE SECTIONS TO BE PROVIDED WITH ROAD STUDS.
4. REFER SEPARATE DRAWING FOR ROAD MARKINGS.
5. LOCATION OF ROAD STUDS WILL BE PROVIDED IN SCHEDULE OF ROAD STUDS.

DRAWING NO. | TITLE
REFERENCE DRAWINGS

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	SJK	NCB		NCB	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2
PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.
PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE
PROJECT NO: C1193601
TITLE: TYPICAL DETAILS OF ROAD STUDS
COP: IRC
SCALE: AS SHOWN
L&T Infra Engineering
L&T Infrastructure Engineering Ltd.
DRAWING NO: DDF004
REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\ROAD FURNITURE\TYPICAL DRAWINGS\DDF004-R0-MSJ-DETAILS OF ROAD STUDS 10WG

TBNA

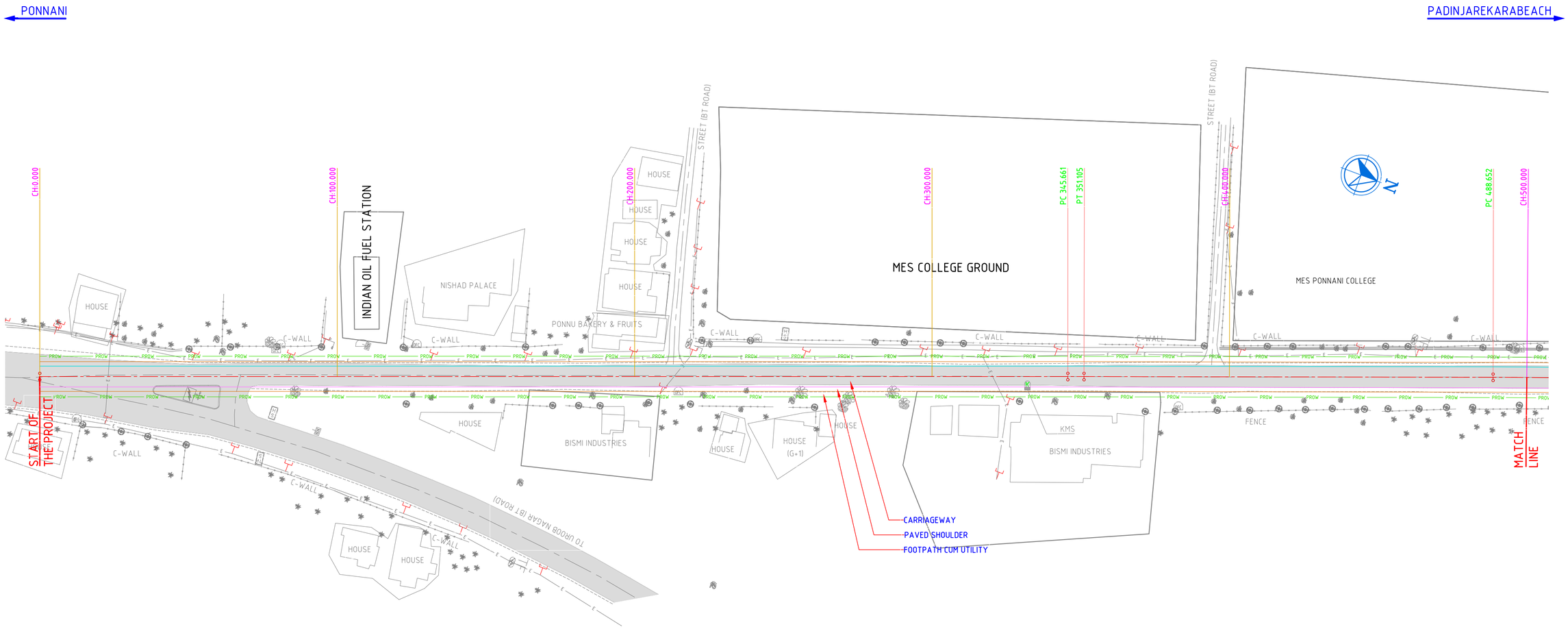
ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

STRIP PLAN

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110- STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 0.000 TO CH: 0.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS101

REV: 0

DDS001

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110- STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

STR. NO.	1/1
PROPOSED CHAINAGE	589.891
SPAN	1x1.30 SLAB CULVERT
PROPOSED	WIDENING

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 0.500 TO CH: 1.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS102

REV: 0

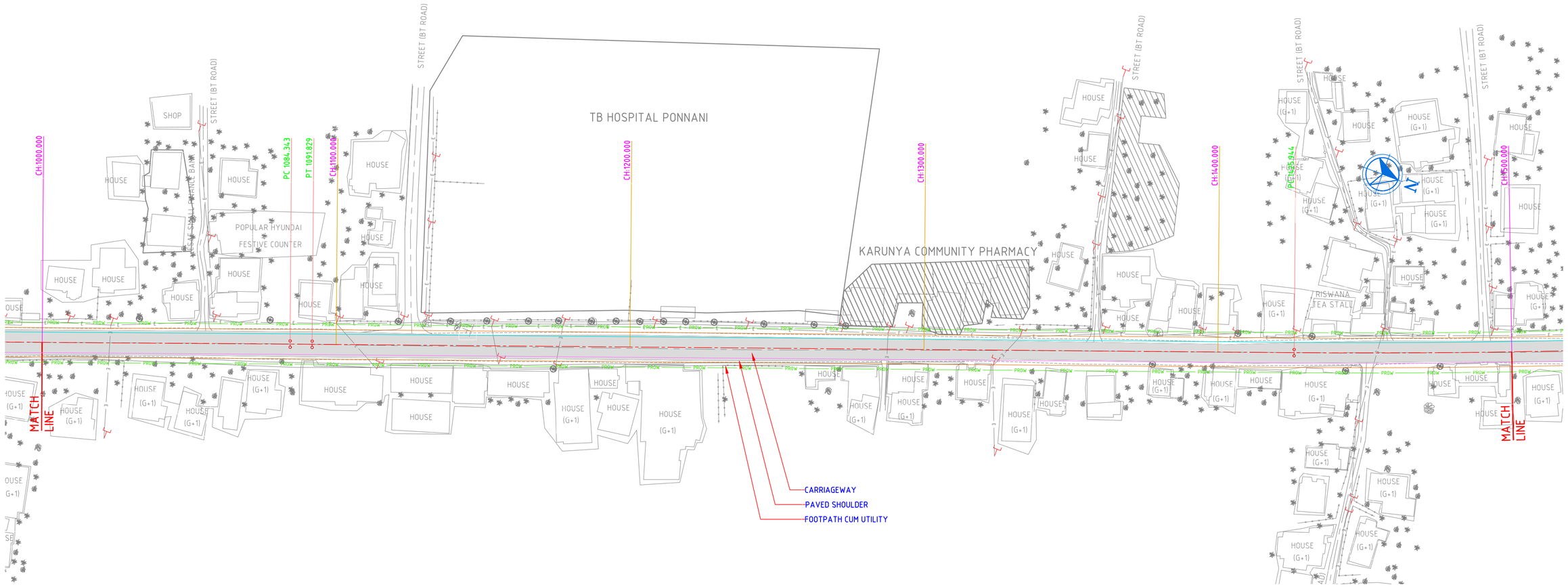
plot scale 50mm

TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110-STRIP PLAN KM 0.000 TO KM 4.800.DWG

PONNANI

PADINJAREKARABEACH



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

REV.	YYMMDD	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

DRAWING NO.	TITLE
	REFERENCE DRAWINGS

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DRG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 1.000 TO CH: 1.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS103

REV: 0

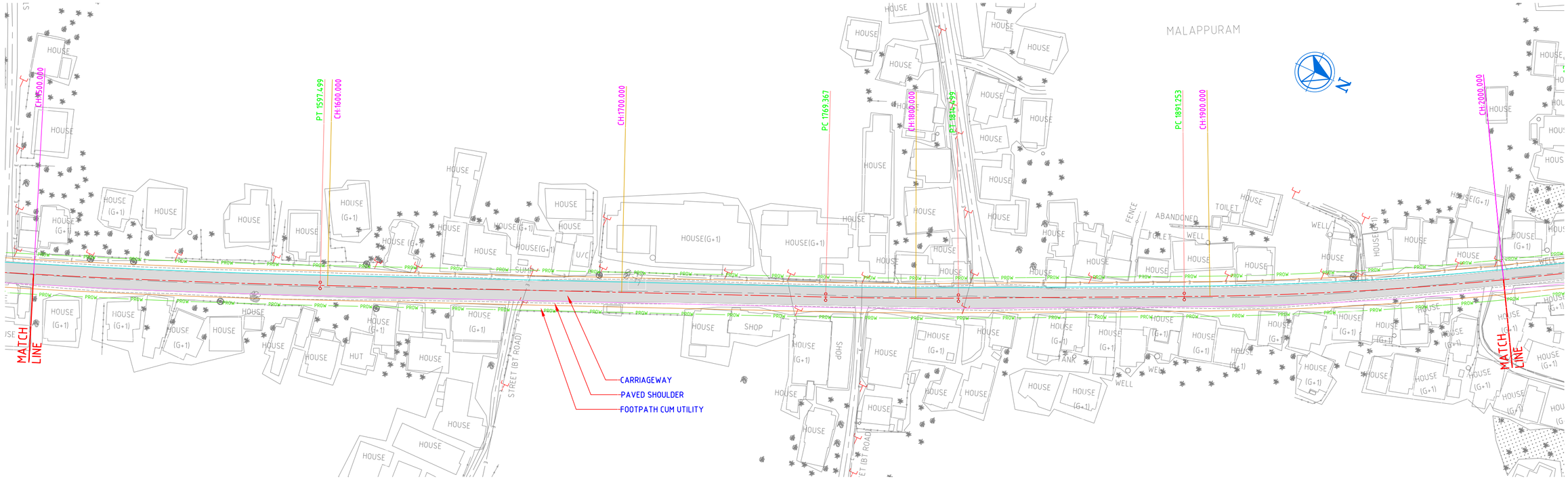
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE: A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 1.500 TO CH: 2.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS104

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH

MALAPPURAM

STREET (CEMENT ROAD)

STREET (BT)

GOVT BUILDING

FACTORY

TANK

POND

C-WALL

WELL

SHED

U/C

AMLB I ROAD

CH:2000.000

PVI 2031.593

CH:2100.000

TS 2100.194

SC 2135.194

CS 2179.470

CH:2200.000

ST 2214.470

SC 2269.216

TS 2284.216

CH:2300.000

CS 2303.038

ST 2328.038

TS 2369.811

SC 2395.371

CH:2400.000

CS 2437.515

ST 2467.515

CH:2500.000

MATCH LINE

MATCH LINE

STR. NO.	3/1
PROPOSED CHAINAGE	2380.474
SPAN	1x1.0 SLAB CULVERT
PROPOSED	WIDENING

CARRIAGEWAY

PAVED SHOULDER

FOOTPATH CUM UTILITY

HOUSE (G+1)

PROW

BDDW

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 2.000 TO CH: 2.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS105

REV: 0

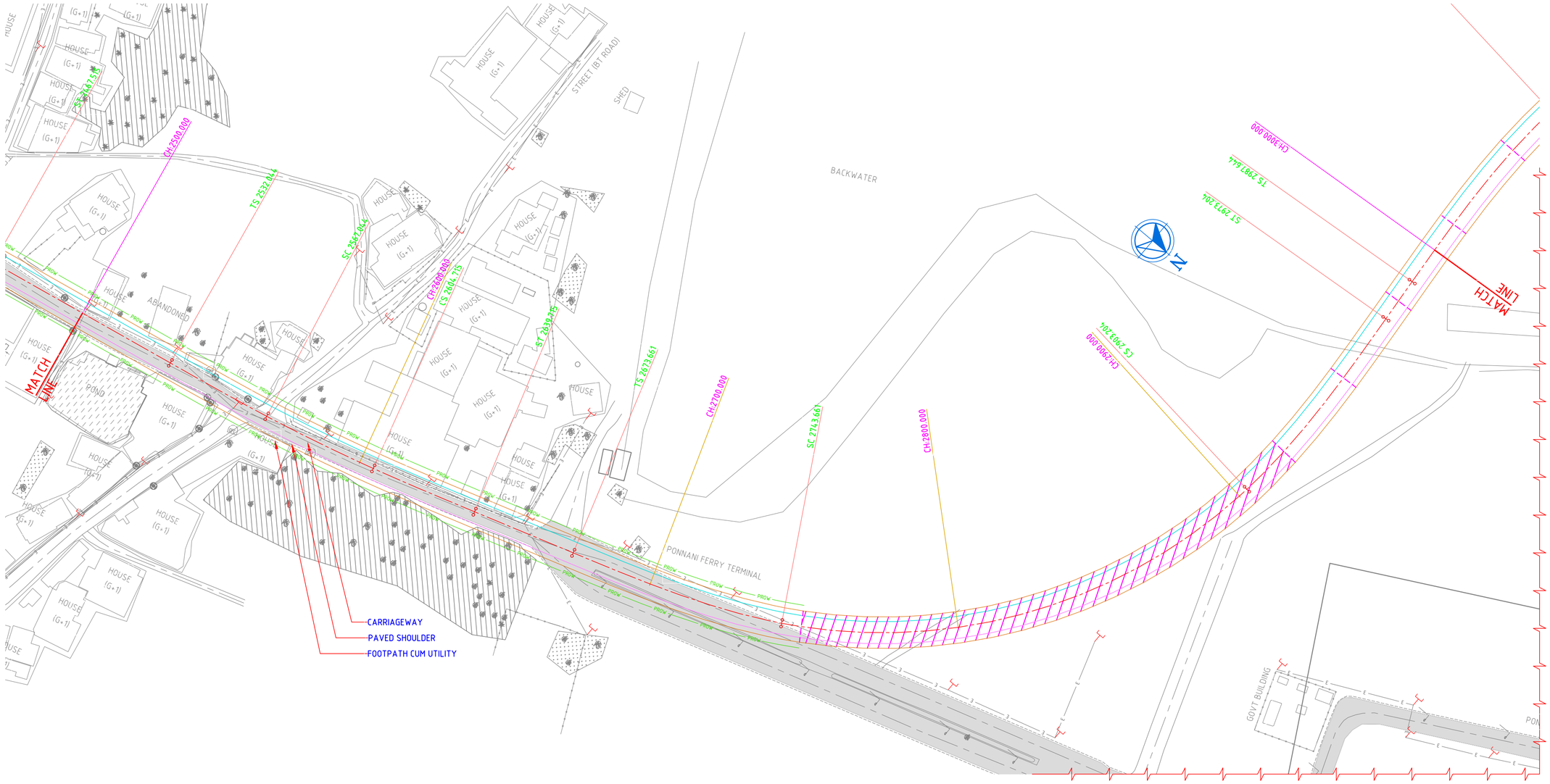
plot scale 50mm

TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110-STRIP PLAN KM 0.000 TO KM 4.800.DWG

PONNANI

PADINJAREKARABEACH



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
REFERENCE DRAWINGS	

REVISIONS

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	NCB INIT.	NCB SIGN.	NCB INIT. CHECKED	NCB SIGN. APPROVED
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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ORIG. SIZE A2

PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 2.500 TO CH: 3.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS106

REV: 0

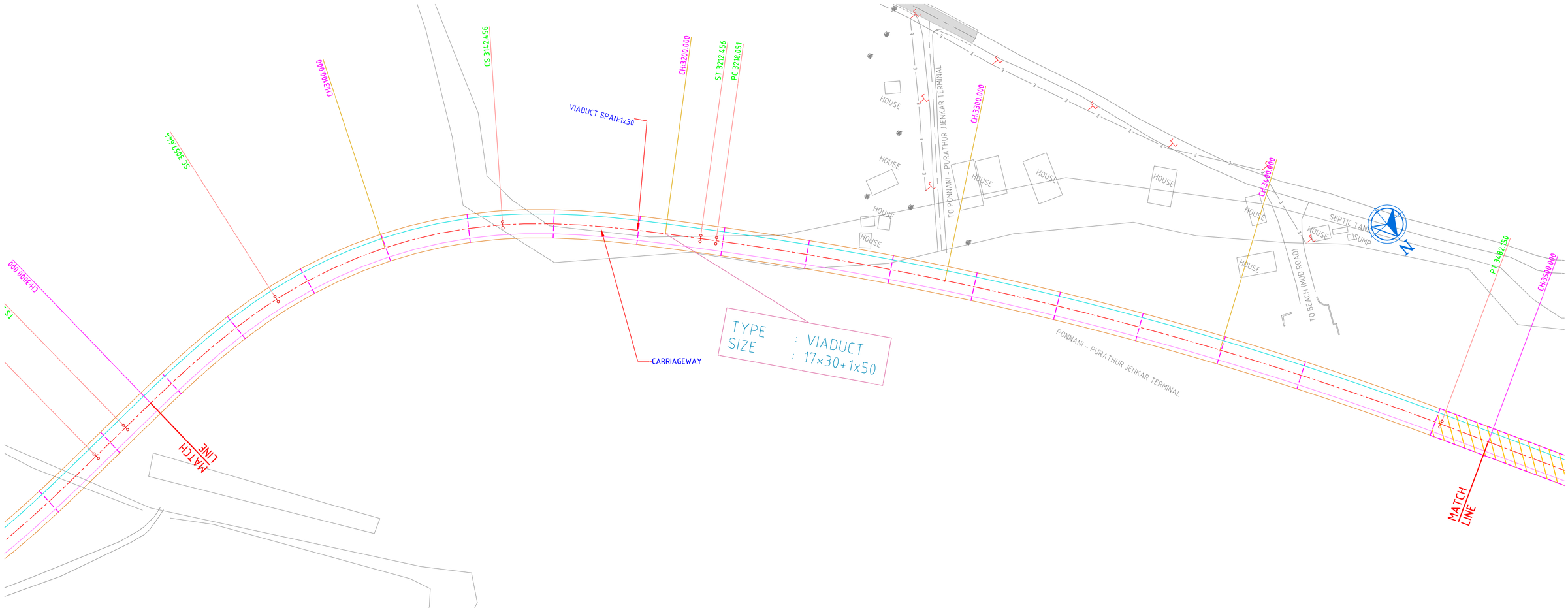
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

DRAWING NO. | TITLE

REFERENCE DRAWINGS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 3.000 TO CH: 3.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

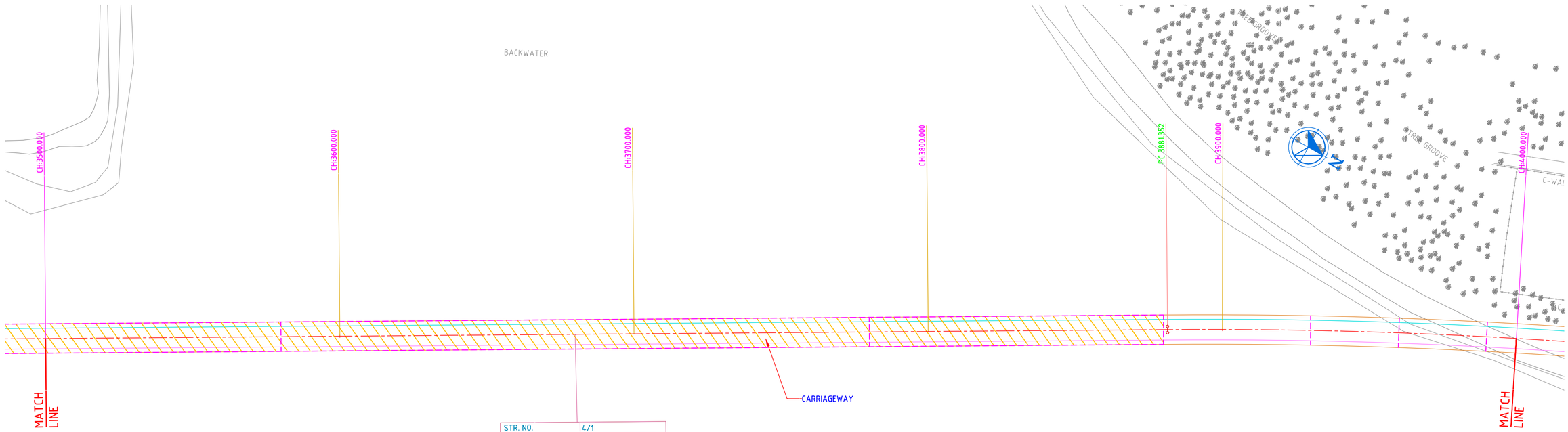
DRAWING NO: DDS107

REV: 0

plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110-STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA



STR. NO.	4/1
PROPOSED CHAINAGE	3680.000
PROPOSED	CABLE STAYED BRIDGE
SPAN	1x100+1x200.00+1x100

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	INIT. CHECKED	SIGN.	INIT. APPROVED	SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING | ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 3.500 TO CH: 4.000

COP: IRC

SCALE: 1:1000

L&T Infra Engineering | L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS108 | REV: 0

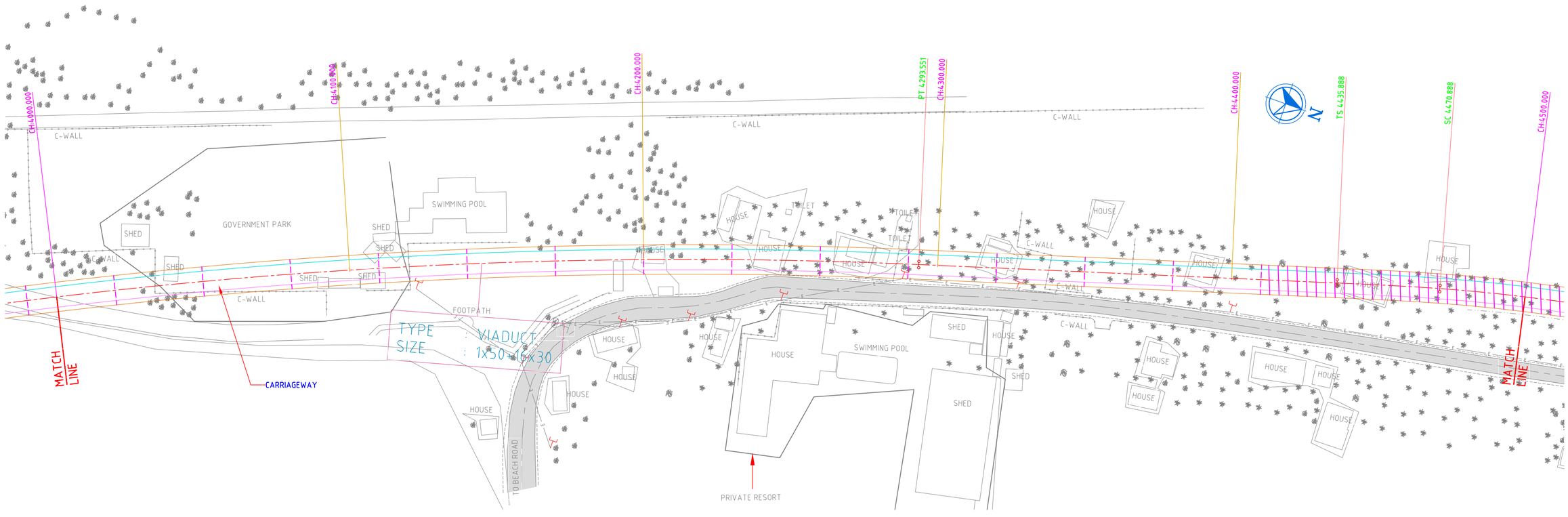
plot scale 50mm

TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110- STRIP PLAN KM 0.000 TO KM 4.800.DWG

PONNANI

PADINJAREKARABEACH



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
	REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 4.000 TO CH: 4.500

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS109

REV: 0

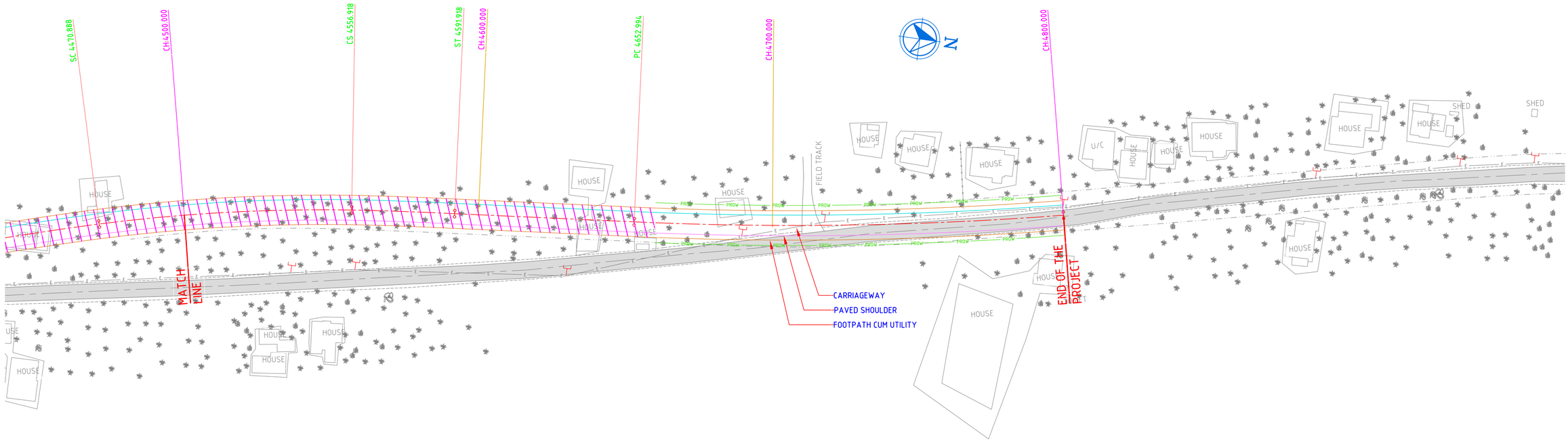
plot scale 50mm

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110- STRIP PLAN KM 0.000 TO KM 4.800.DWG

TBNA

PONNANI

PADINJAREKARABEACH



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

DRAWING NO.	TITLE
	REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200313	4	FIRST SUBMISSION	HMS	MSJ	NCB		NCB	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDERING

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PATH: REFER BOTTOM LEFT CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: STRIP PLAN FROM CH: 4.500 TO CH: 4.800

COP: IRC

SCALE: 1:1000

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDS110

REV: 0

plot scale 50mm

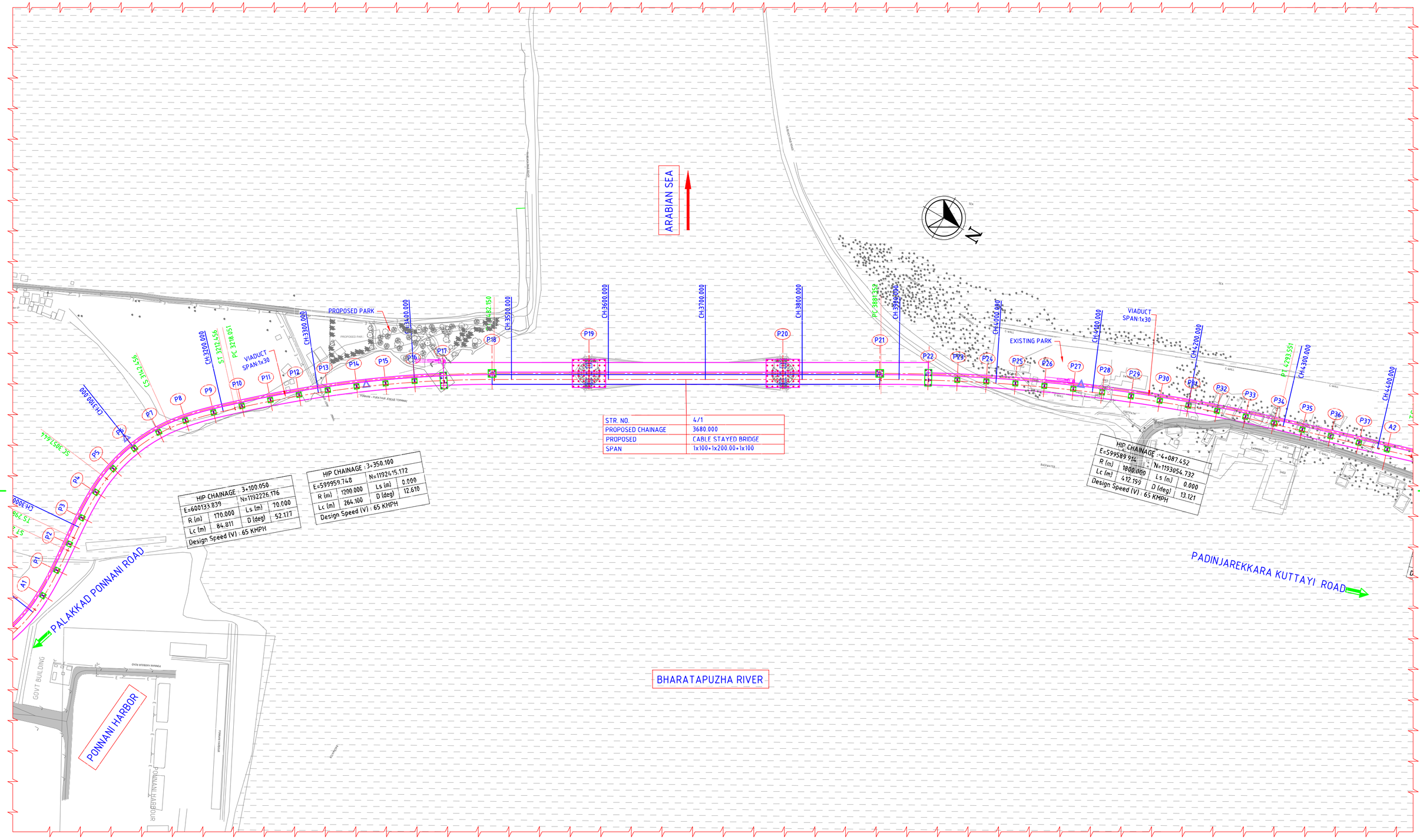
TBNA

AUTO PATH: I:\ROADS & AIRPORTS\PROJECTS\PROJECTS 2019-2020\PONNANI DPR\DRAWINGS\STRIP PLAN\DDS101-DDS110- STRIP PLAN KM 0.000 TO KM 4.800.DWG

ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

DPR FOR PONNANI CABLE STAYED BRIDGE

STRUCTURAL DRAWINGS



HIP CHAINAGE : 3+100.050			
E=600133.839		N=1192226.176	
R (m)	170.000	Ls (m)	70.000
Lc (m)	84.811	D (deg)	52.177
Design Speed (V) : 65 KMPH			

HIP CHAINAGE : 3+350.100			
E=599959.748		N=1192415.172	
R (m)	1200.000	Ls (m)	0.000
Lc (m)	264.100	D (deg)	12.610
Design Speed (V) : 65 KMPH			

STR. NO.	4/1
PROPOSED CHAINAGE	3680.000
PROPOSED	CABLE STAYED BRIDGE
SPAN	1x100+1x200.00+1x100

HIP CHAINAGE : 4+087.452			
E=599589.942		N=1193054.732	
R (m)	1800.000	Ls (m)	0.000
Lc (m)	412.199	D (deg)	13.121
Design Speed (V) : 65 KMPH			

GENERAL LAYOUT OF SITE PLAN

(SCALE 1:2500)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. THE LEVELS PRESENTED IN DRAWING ARE WITH RESPECT TO MEAN SEA LEVELS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 502	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	120312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

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PATH:REFER LEFT BOTTOM CORNER OF THE DRAWING

DRG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: KEY PLAN

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

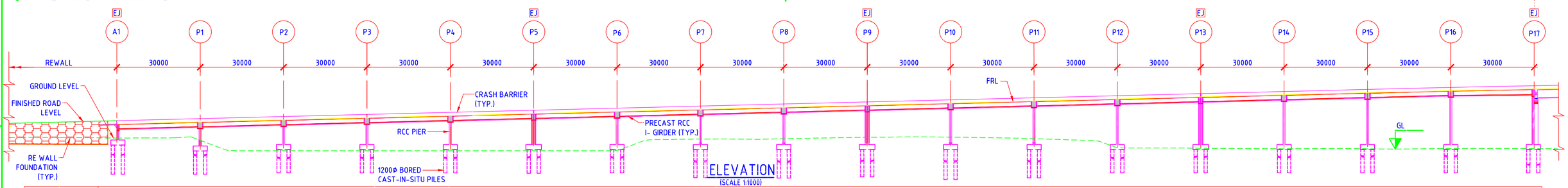
DRAWING NO: DDG 501

REV: 0

plot scale 50mm

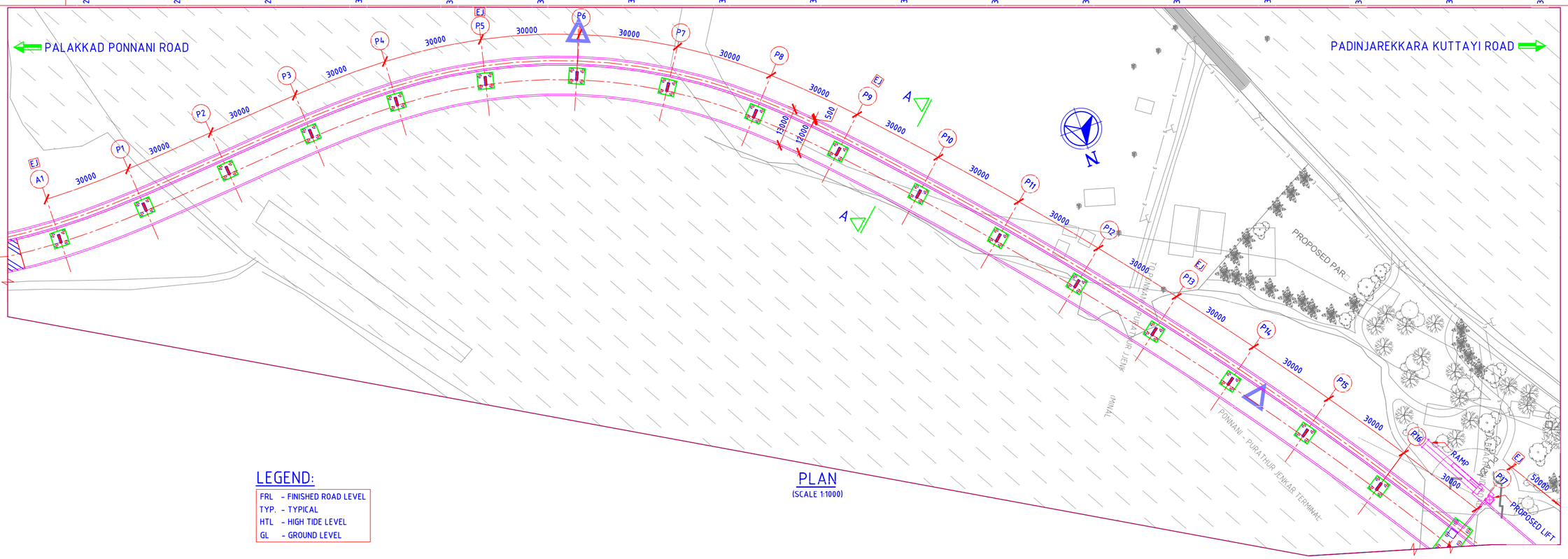
AUTO PATH: J:\BRIDGES\12019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R21\DDG 501 TO 505-R2-VKL-GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE DWG

TBNA



ELEVATION
(SCALE 1:1000)

FINISHED ROAD LEVEL AT PROPOSED CENTER LINE (m)	7.000	7.750	8.500	9.250	10.000	10.750	11.500	12.250	13.000	13.750	14.500	15.250	16.000	16.750	17.500	18.250	18.968	19.581
GL BELOW PROPOSED CENTER LINE	1.974	-0.285	-2.608	-2.608	-2.608	-2.608	-2.608	1.549	1.717	2.204	2.282	1.709	-1.608	-1.708	-1.908	-1.908	-1.808	-1.858
HORIZONTAL SCHEMATIC	L= 70.000	L= 14.441	L= 70.000	L= 70.000	R= 170.000 L= 84.811					L= 70.000	L= 5.595	R= 1200.000 L= 264.100						
VERTICAL SCHEMATIC	G= 2.500% L= 495.392																	
SUPER ELEVATION LEFT RIGHT	e=5.000% / e=5.000%																	
CHAINAGE	2920.000	2950.000	2980.000	3010.000	3040.000	3070.000	3100.000	3130.000	3160.000	3190.000	3220.000	3250.000	3280.000	3310.000	3340.000	3370.000	3400.000	3430.000



PLAN
(SCALE 1:1000)

LEGEND:

FRL	- FINISHED ROAD LEVEL
TYP.	- TYPICAL
HTL	- HIGH TIDE LEVEL
GL	- GROUND LEVEL

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. THE LEVELS PRESENTED IN DRAWING ARE WITH RESPECT TO MEAN SEA LEVELS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 501	KEY PLAN

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:REFER LEFT BOTTOM CORNER OF THE DRAWING

ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE - PLAN & ELEVATION

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 502

REV: 0

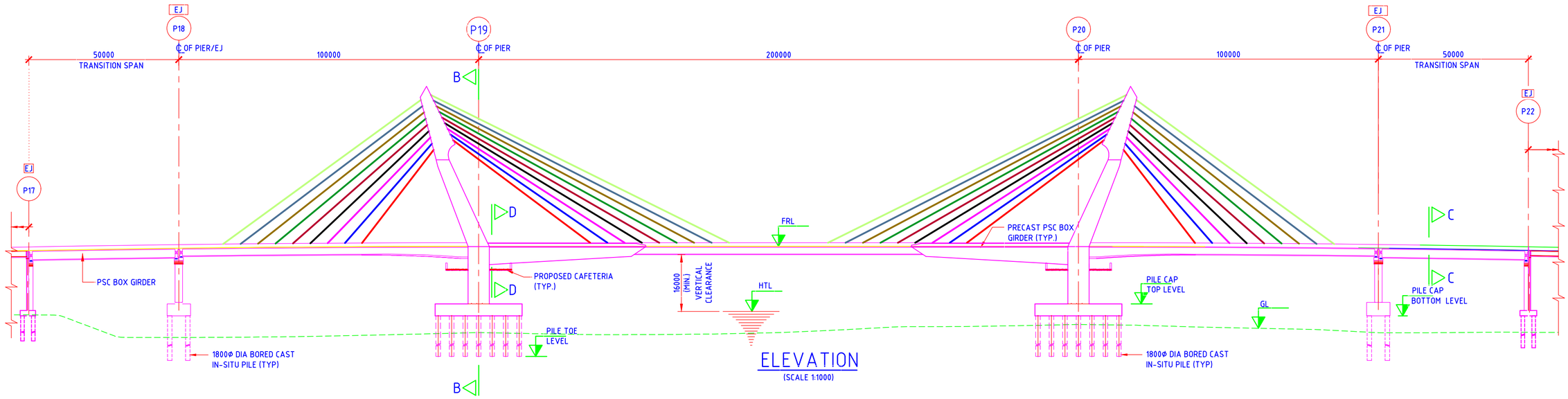
plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R2\DDG 501 TO 505-R2-VKL-GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE .DWG

TBNA

PALAKKAD PONNANI ROAD

PADINJAREKKARA KUTTAYI ROAD

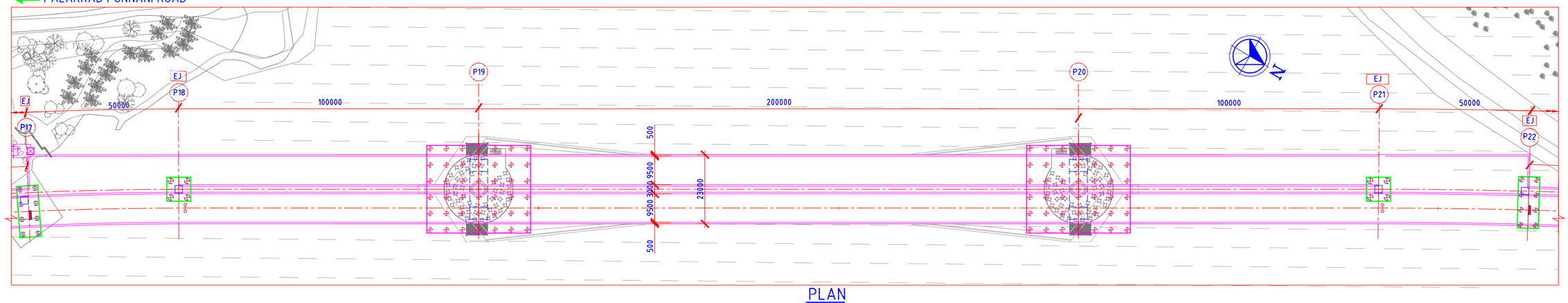


ELEVATION
(SCALE 1:1000)

FINISHED ROAD LEVEL AT PROPOSED CENTER LINE (m)	20.087	20.361	20.586	20.763	20.891	20.970	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	21.000	20.978	20.908	20.789	20.621	20.405	20.139
GL BELOW PROPOSED CENTER LINE	-9.408	-9.408	-9.308	-9.108	-8.708	-8.258	-7.758	-8.158	-8.458	-8.408	-8.208	-7.758	-6.908	-5.808	-5.758	-5.458	-5.058	-5.308	-5.908	-6.308	-6.758	-7.808	-7.808
HORIZONTAL SCHEMATIC											L= 399.202												
VERTICAL SCHEMATIC			R= -8200.004 L= 205.000						G= 0.000% L= 198.840													R= -8199.919 L= 205.000	
SUPER ELEVATION LEFT RIGHT								e=2.500%									e=2.500%						
CHAINAGE	3460.000	3480.000	3500.000	3520.000	3540.000	3560.000	3580.000	3600.000	3620.000	3640.000	3660.000	3680.000	3700.000	3720.000	3740.000	3760.000	3780.000	3800.000	3820.000	3840.000	3860.000	3880.000	3900.000

PALAKKAD PONNANI ROAD

PADINJAREKKARA KUTTAYI ROAD



PLAN
(SCALE 1:1000)

LEGEND:

FRL	- FINISHED ROAD LEVEL
TYP.	- TYPICAL
HTL	- HIGH TIDE LEVEL
GL	- GROUND LEVEL

NOTES:

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3. THE LEVELS PRESENTED IN DRAWING ARE WITH RESPECT TO MEAN SEA LEVELS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 502	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 501	KEYPLAN

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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ORIG. SIZE: A2

PATH:REFER LEFT BOTTOM CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE - PLAN & ELEVATION

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 503 REV: 0

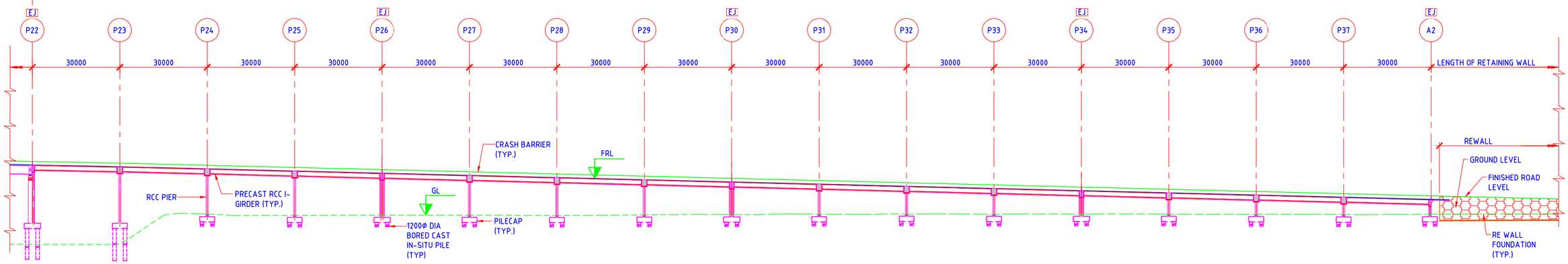
plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R2\DDG 501 TO 505-R2-VKL-GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE.DWG

TBNA

PALAKKAD PONNANI ROAD

PADINJAREKKARA KUTTAYI ROAD



ELEVATION
(SCALE 1:1000)

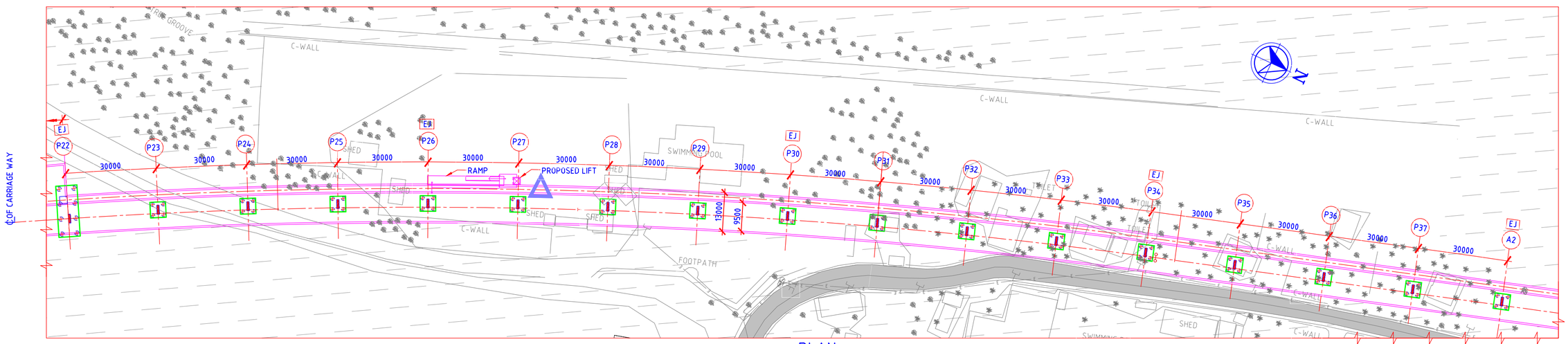
	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31	P32	P33	P34	P35	P36	P37	A2
FINISHED ROAD LEVEL AT PROPOSED CENTER LINE (m)	19.6480	19.0489	18.3420	17.592	16.842	16.092	15.342	14.592	13.842	13.092	12.342	11.592	10.842	10.092	9.342	8.592	7.842
GROUND LEVEL BELOW PROPOSED CENTER LINE	-7.658	-7.708	2.653	2.376	2.412	2.410	2.369	2.487	2.536	2.719	2.774	2.677	2.759	2.728	2.639	2.572	2.694
HORIZONTAL SCHEMATIC		R= 1800.000 L= 412.199						R= 1800.000 L= 412.199						L= 142.337			
VERTICAL SCHEMATIC		G= -2.500% L= 542.113						G= -2.500% L= 542.113									
SUPER ELEVATION LEFT RIGHT								e=2.500%									
CHAINAGE	3930.000	3960.000	3990.000	4020.000	4050.000	4080.000	4110.000	4140.000	4170.000	4200.000	4230.000	4260.000	4290.000	4320.000	4350.000	4380.000	4410.000

LEGEND:

FRL	- FINISHED ROAD LEVEL
TYP.	- TYPICAL
HTL	- HIGH TIDE LEVEL
GL	- GROUND LEVEL

PALAKKAD PONNANI ROAD

PADINJAREKKARA KUTTAYI ROAD



PLAN
(SCALE 1:1000)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. THE LEVELS PRESENTED IN DRAWING ARE WITH RESPECT TO MEAN SEA LEVELS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 502	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 501	KEY PLAN

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\BRIDGES\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R2\DDG 501 TO 505-R2-VKL-GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE.DWG

DRG. SIZE: A2
BOTTOM CORNER OF THE DRAWING

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE - PLAN & ELEVATION

COP: IRC

SCALE: AS SHOWN

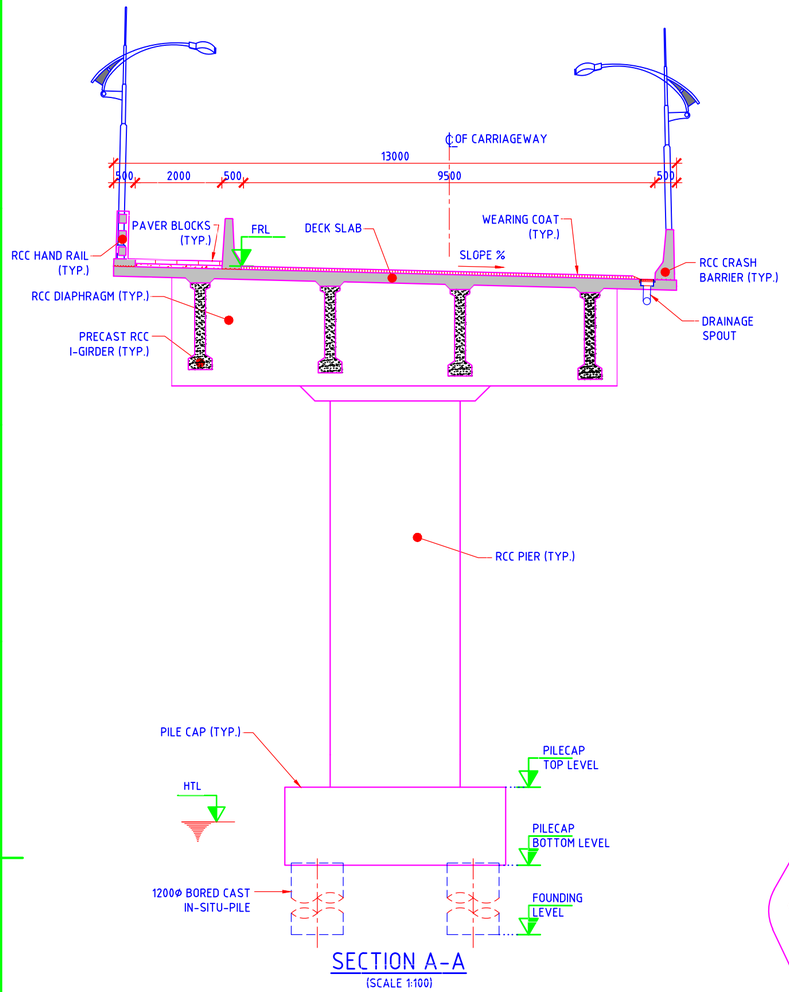
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

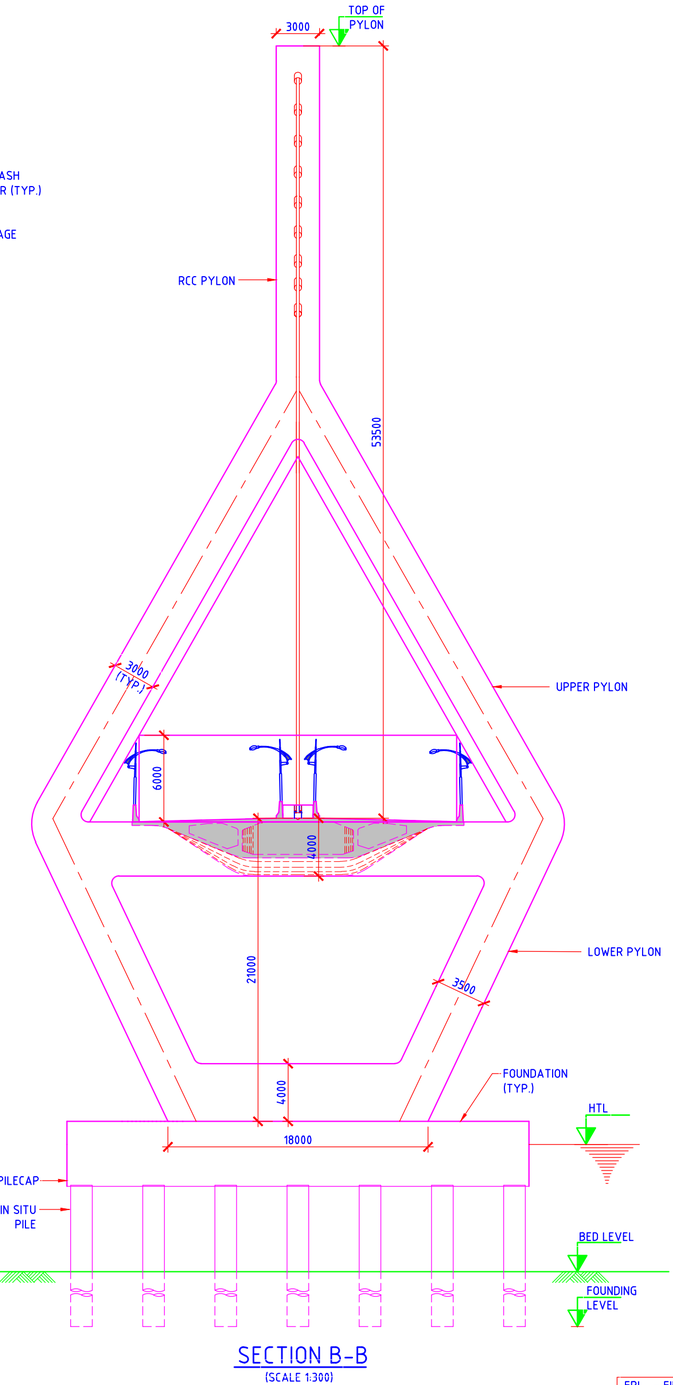
DRAWING NO: DDG 504 REV: 0

plot scale 50mm

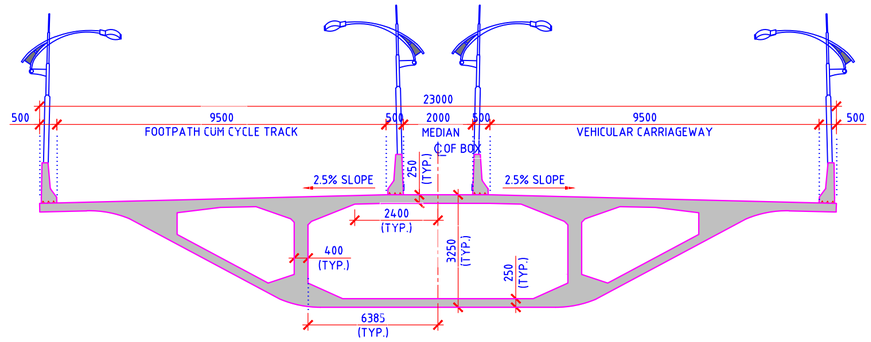
TBNA



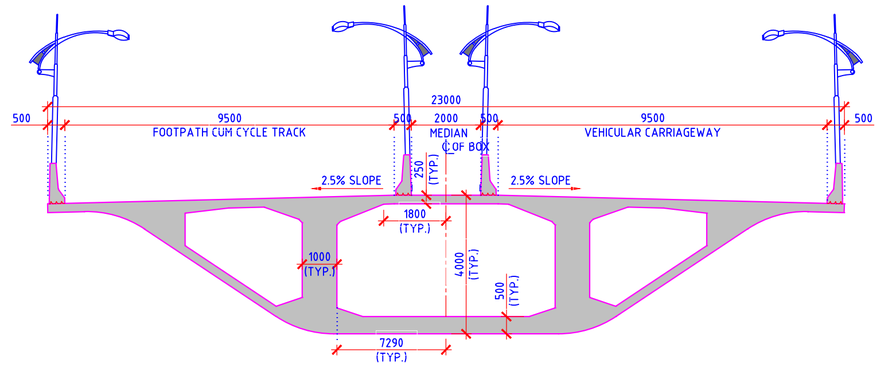
SECTION A-A
(SCALE 1:100)



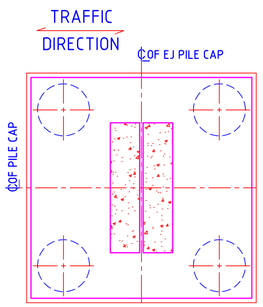
SECTION B-B
(SCALE 1:300)



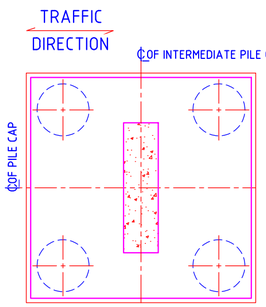
SECTION C-C
(SCALE 1:125)



SECTION D-D
(SCALE 1:125)



TYPICAL DETAILS OF FOUNDATION AT EJ PIER LOCATION
(SCALE 1:100)



TYPICAL DETAILS OF FOUNDATION AT INTERMEDIATE PIER LOCATION
(SCALE 1:100)

FRL - FINISHED ROAD LEVEL
LTL - LOW TIDE LEVEL
TYP. - TYPICAL
HTL - HIGH TIDE LEVEL

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. THE LEVELS PRESENTED IN DRAWING ARE MEAN SEA LEVELS.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 502	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 501	KEY PLAN

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:REFER LEFT BOTTOM CORNER OF THE DRAWING

DRG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: GENERAL ARRANGEMENT SECTIONS

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 505

REV: 0

plot scale 50mm

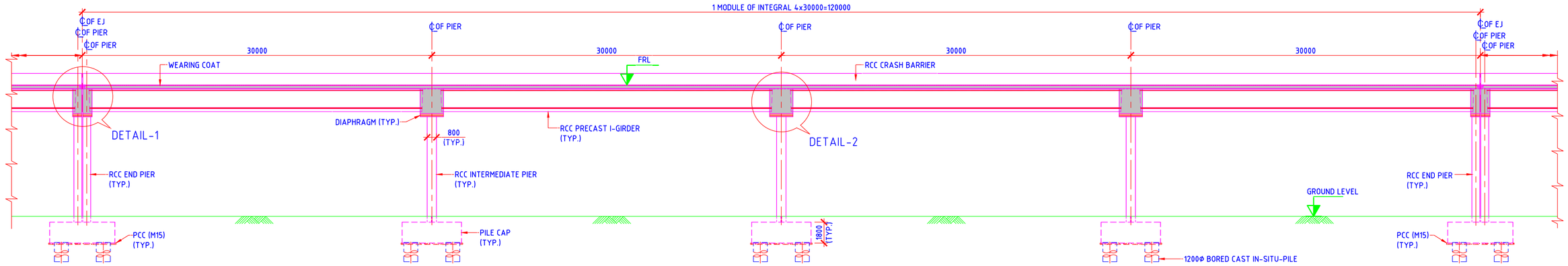
AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\R7\DDG 501 TO 505-R2-VKL-GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE .DWG

TBNA

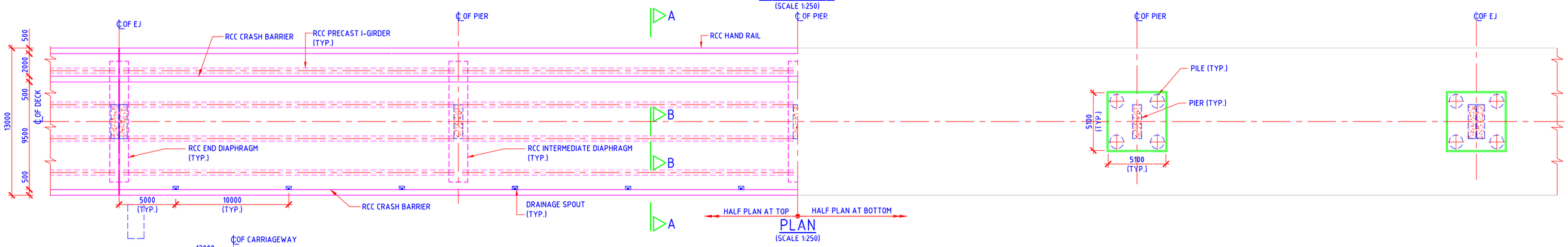
PALAKKAD PONNANI ROAD

PADINJAREKKARA KUTTAYI

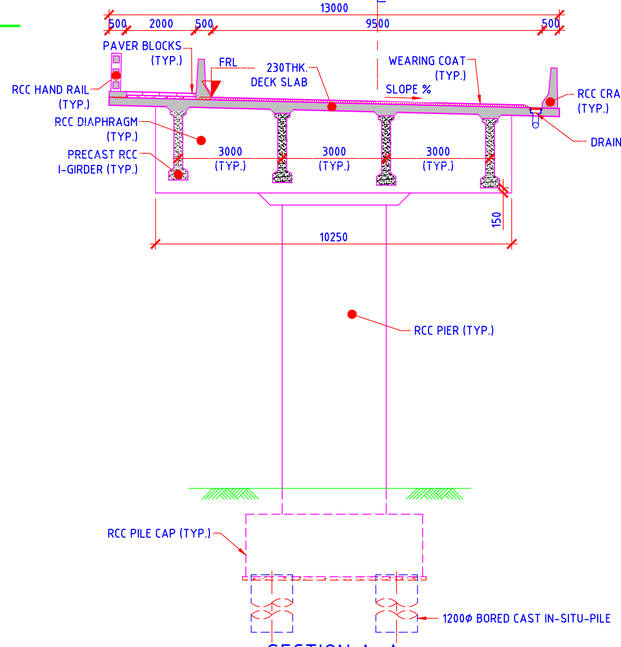
1 MODULE OF INTEGRAL 4x30000=120000



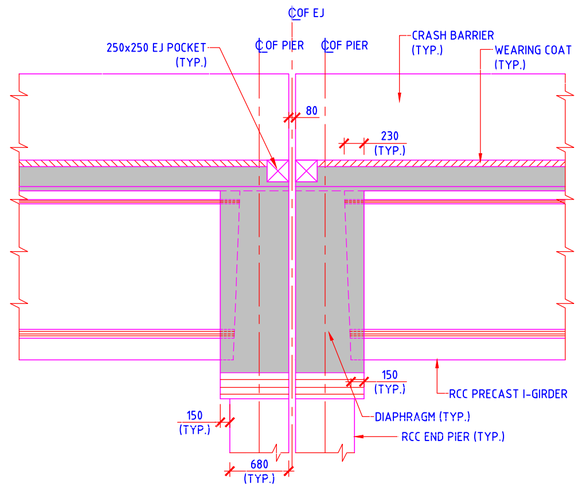
ELEVATION
(SCALE 1:250)



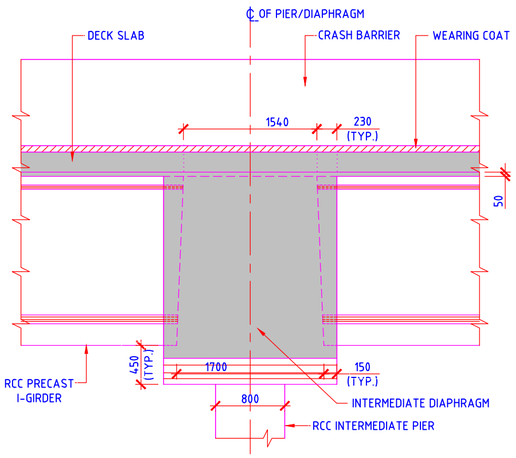
PLAN
(SCALE 1:250)



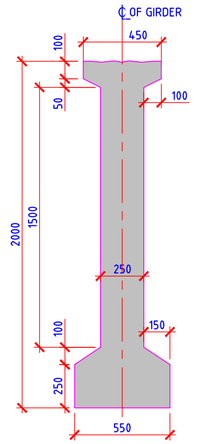
SECTION A-A
(SCALE 1:125)



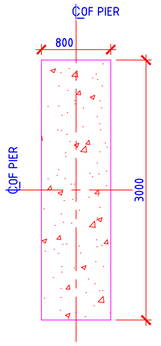
DETAIL- 1
(SCALE 1:50)



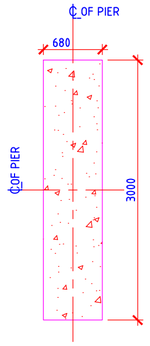
DETAIL- 2
(SCALE 1:50)



SECTION B-B
(SCALE 1:25)



INTERMEDIATE PIER
(SCALE 1:50)



END PIER
(SCALE 1:50)

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. MINIMUM GRADE OF CONCRETE:-
   - RCC I-GIRDER -M45.
   - DECK SLAB -M45.
   - DIAPHRAGM -M45.
   - PIER & PIER CAP -M35.
   - PILE & PILE CAP -M35.
   - PCC -M15.
   - 5. SEISMIC ZONE-III
   - 6. EXPOSURE CONDITION - SEVERE.
4. REINFORCEMENT GRADE SHALL BE Fe500D.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	PDP	PYK	NRY		PML	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: ORIG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE — PROJECT NO: C1193601

TITLE: GENERAL ARRANGEMENT DRAWING FOR VIADUCT 4x30m — COP: IRC — SCALE: AS SHOWN

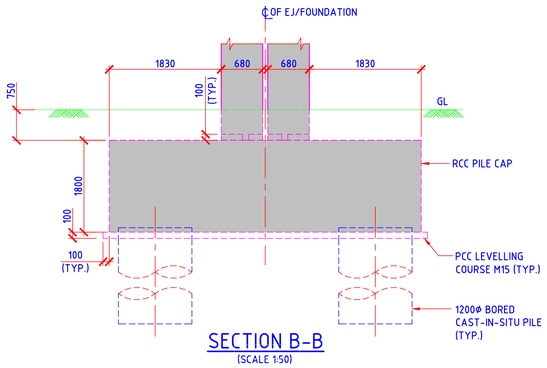
L&T Infra Engineering — L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 506 — REV: 0

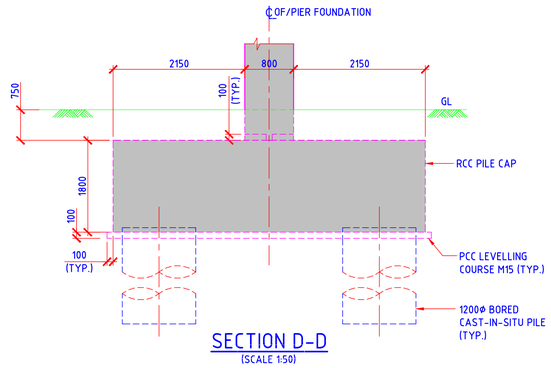
plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R2\DDI 506-R2-VKL-GENERAL ARRANGEMENT DRAWING FOR LX30M.DWG

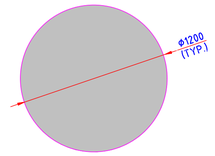
TBNA



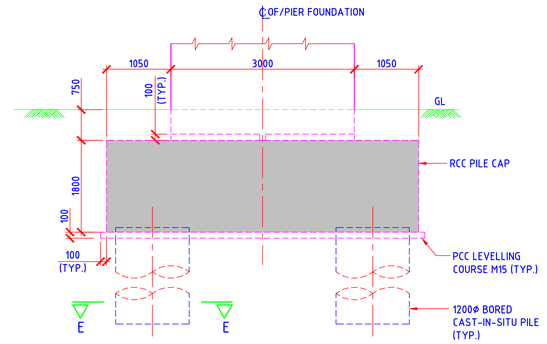
SECTION B-B
(SCALE 1:50)



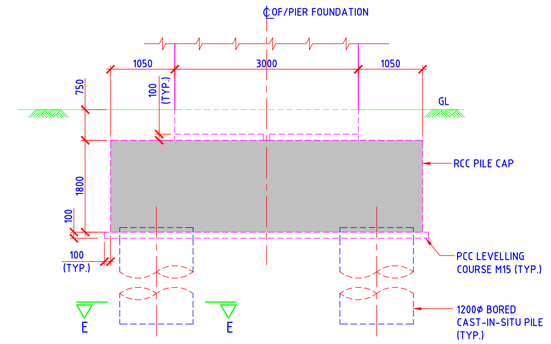
SECTION D-D
(SCALE 1:50)



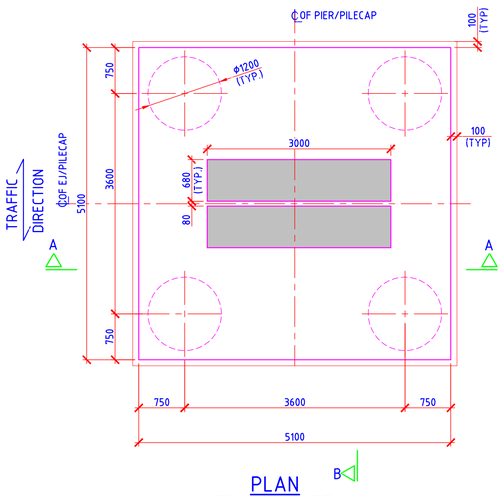
SECTION E-E
(SCALE 1:25)



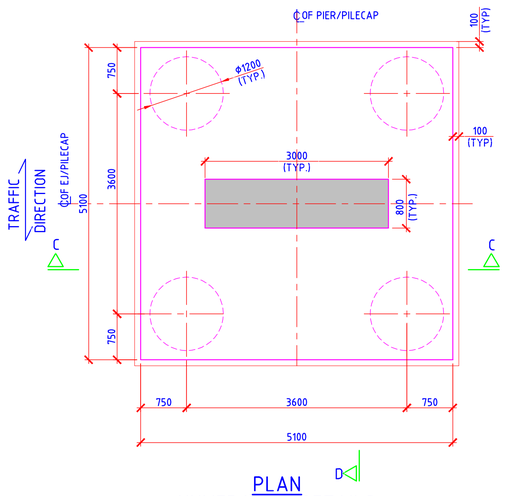
SECTION A-A
(SCALE 1:50)



SECTION C-C
(SCALE 1:50)



PLAN
NUMERATION DETAILS
OF PILE & PILE CAP FOR EJ PIERS
(SCALE 1:50)



PLAN
NUMERATION DETAILS
OF PILE & PILE CAP FOR INTERMEDIATE PIERS
(SCALE 1:50)

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETER UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 508	RC DETAILS OF PILE & PILE CAP FOR EJ & INTERMEDIATE PIER FOR 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED PML	CHECKED KGN	APPROVED ANB	APPROVED CKT
0	200312	4	FIRST SUBMISSION			INIT. SIGN.	INIT. SIGN.	INIT. SIGN.	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: \\Bridges\2019\C1193601-DPR - PONNANI CABLE STAYED\ ORIGINAL SIZE: A1

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION DETAILS OF PILE & PILECAP AT EJ & INTERMEDIATE PIER LOCATION FOR 4x30m (TYP.)

COP: IRC

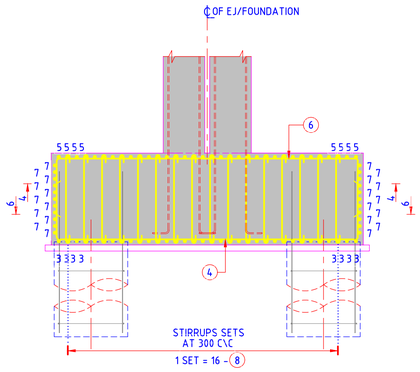
SCALE: AS SHOWN

L&T Infra Engineering

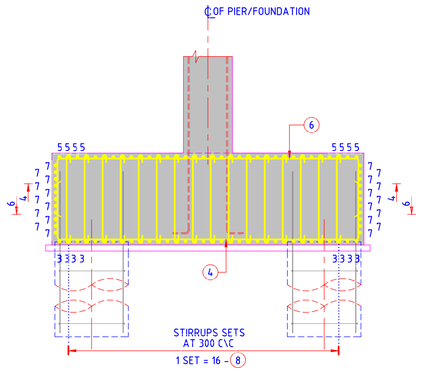
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 507 REV: 0

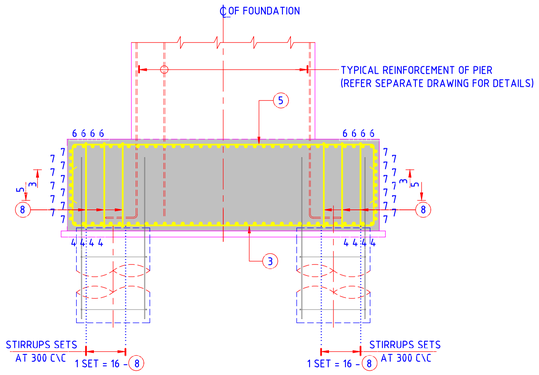
plot scale 50mm



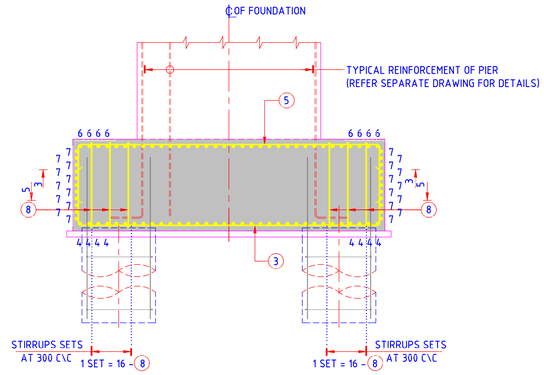
SECTION B-B
(PIER RC DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE 1:50)



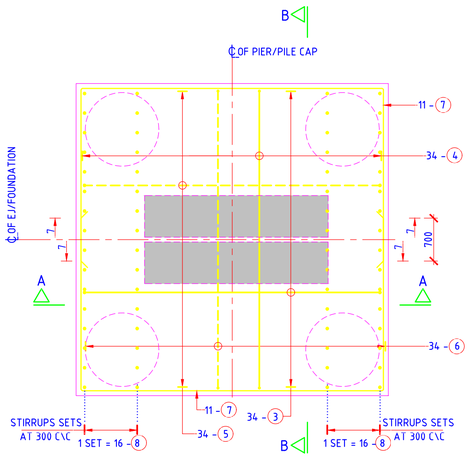
SECTION D-D
(PIER RC DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE 1:50)



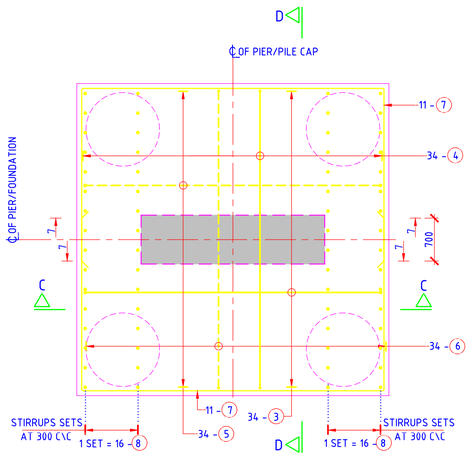
SECTION A-A
(PIER RC DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE 1:50)



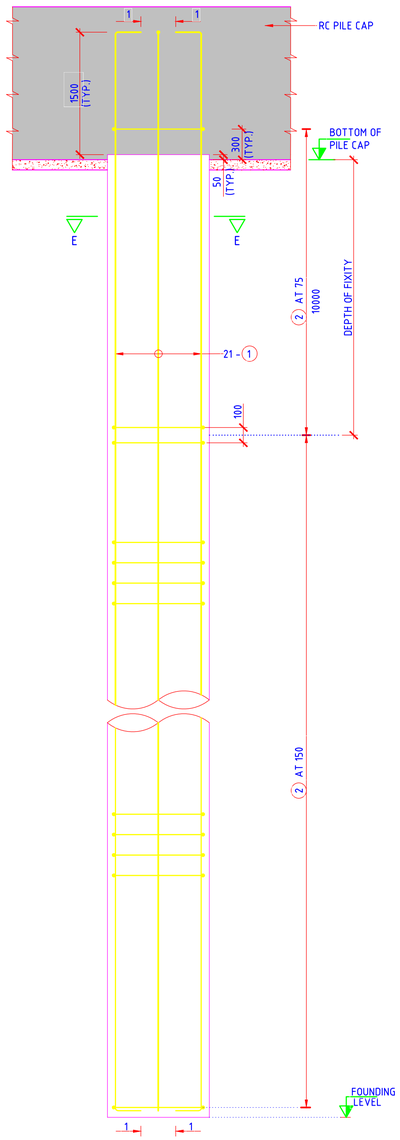
SECTION C-C
(PIER RC DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE 1:50)



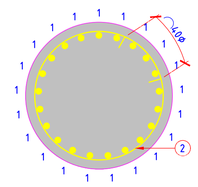
PLAN
RC DETAILS OF PILE CAP FOR EJ PIER
(SCALE 1:50)



PLAN
RC DETAILS OF PILE CAP FOR INTERMEDIATE PIER
(SCALE 1:50)



RC DETAILS OF PILE
(SCALE 1:30)



SECTION E-E
(SCALE 1 : 25)

SCHEDULE OF REINFORCEMENT :

BAR MARK	BAR DESCRIPTION	SHAPE & DIMENSION
1	Y20	160, 160
2	Y10	
3	Y25	4900, 1300
4	Y25	4900, 1300
5	Y16	4900, 1300
6	Y16	4900, 1300
7	Y12	4900, 2650, 100
8	Y10	1650, 100

LAST BAR MARK USED 8

LEGEND:

TOP REINFORCEMENT
BOTTOM REINFORCEMENT
CONSTRUCTION JOINT

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETER UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE M35 FOR PILE CAP & PILE.
4. GRADE OF REINFORCEMENT SHALL BE Fe500 CONFORMING TO IS:1786 (LATEST)
5. MINIMUM CLEAR COVER TO THE REINFORCEMENT SHALL BE 75mm FOR PILE & PILE CAP.
6. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION AND LAPS SHALL BE STAGGERED.
7. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 507	NUMERATION DETAILS OF PILE & PILE CAP FOR EJ & INTERMEDIATE PIER FOR 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CKT	PML INIT.	PML SIGN.	KGN INIT.	KGN SIGN.
0	200312	4	FIRST SUBMISSION	ANB		CHECKED			APPROVED	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\[ORIGINAL SIZE-A1] C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RC DETAILS OF PILE & PILECAP AT EJ & INTERMEDIATE PIER LOCATION FOR 4x30m (TYP.)

COP: IRC

SCALE: AS SHOWN

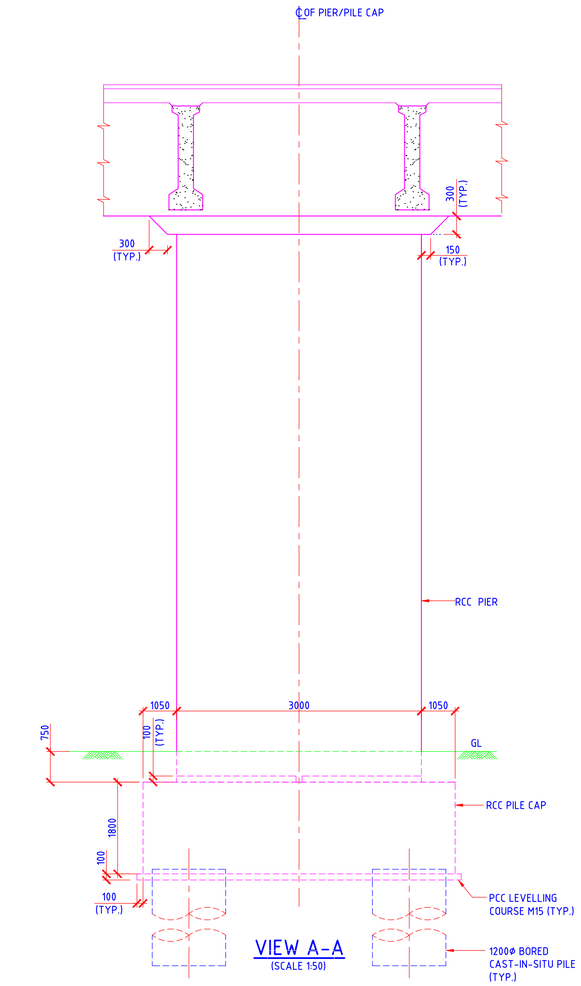
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

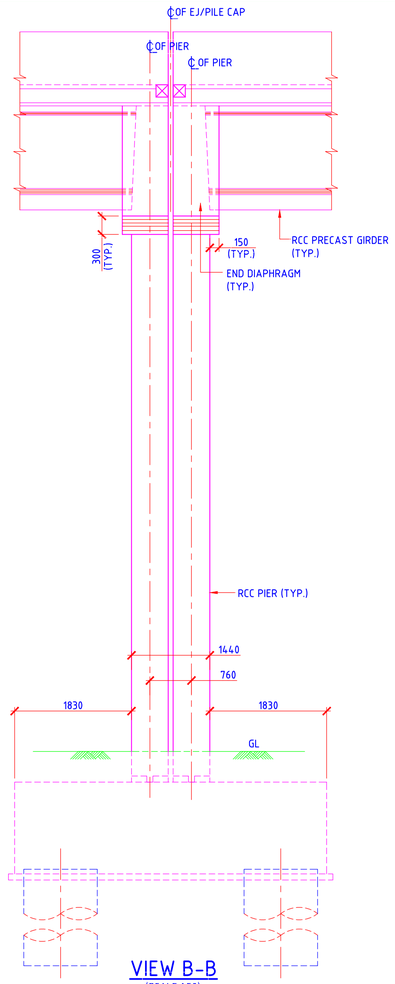
DRAWING NO: DDI 508

REV: 0

plot scale 50mm

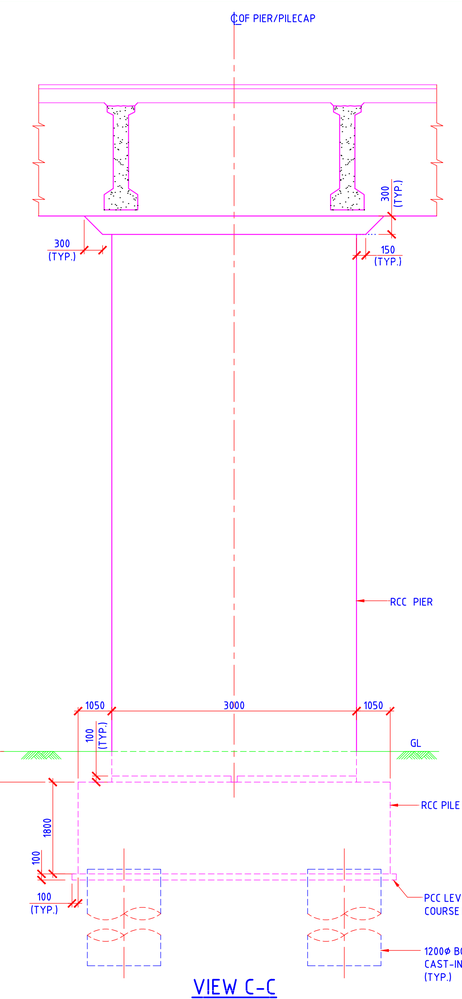


VIEW A-A
(SCALE 1:50)

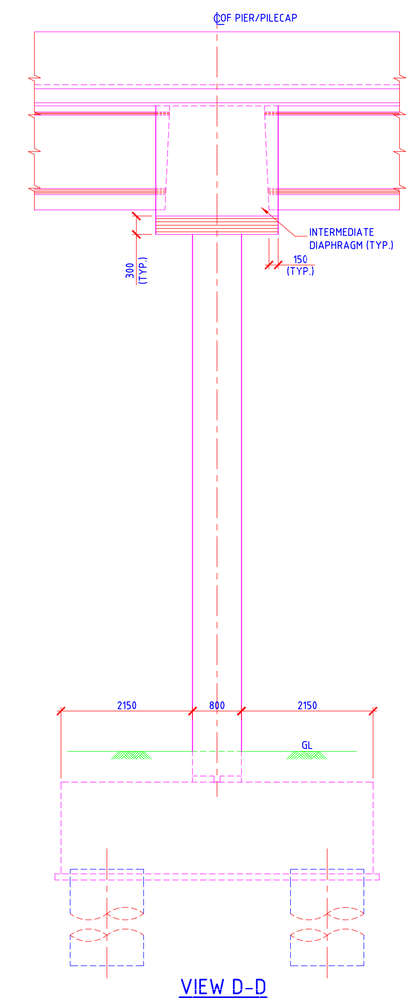


VIEW B-B
(SCALE 1:50)

PLAN
(SCALE 1:50)



VIEW C-C
(SCALE 1:50)



VIEW D-D
(SCALE 1:50)

PLAN
(SCALE 1:50)

NUMERATION DETAILS OF PIER AT EJ LOCATION

NUMERATION DETAILS OF PIER AT INTERMEDIATE LOCATION

LEGEND
CONSTRUCTION JOINT

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS ARE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 513	NUMERATION AND RC DETAILS OF DIAPHRAGM AT EJ LOCATION 4x30m
DDI 512	RC DETAILS OF RCC PRECAST GIRDERS 4x30m
DDI 510	RC DETAILS OF PIER AT EJ & INTERMEDIATE PIER LOCATIONS FOR 4x30m (TYP.)
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	PDP	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: \\Bridges\2019\[ORIGINAL SIZE: A1] C1193601-DPR-PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION DETAILS OF PIER AT EJ & INTERMEDIATE PIER LOCATIONS FOR 4x30m (TYP.)

COP: IRC

SCALE: AS SHOWN

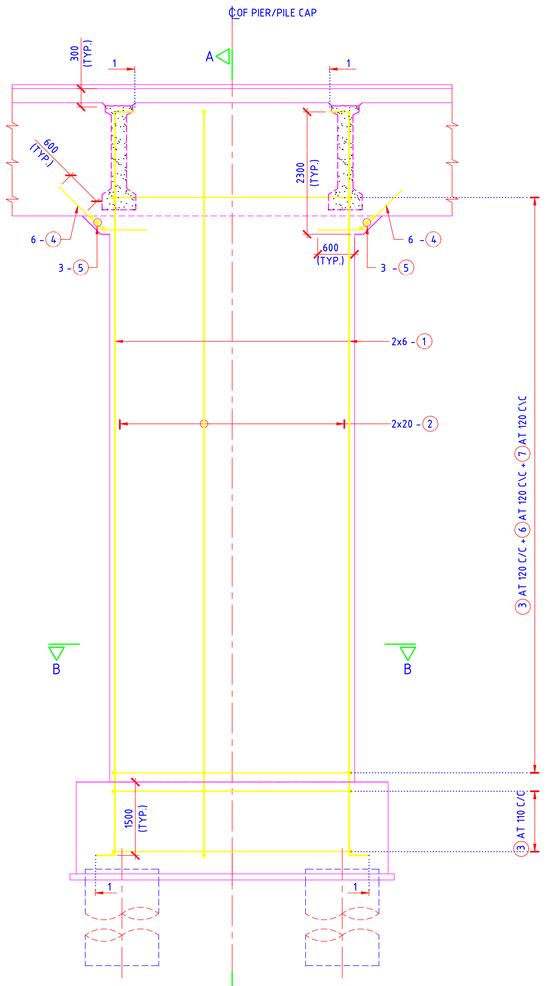
L&T Infra Engineering

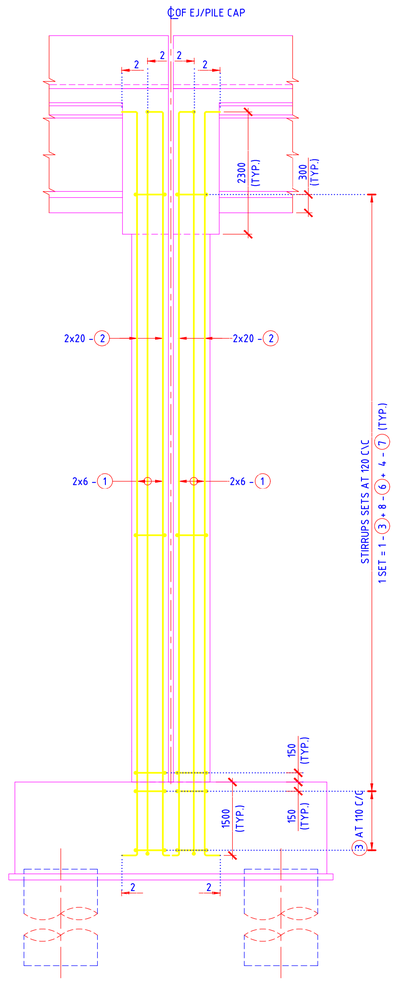
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 509

REV: 0

plot scale 50mm



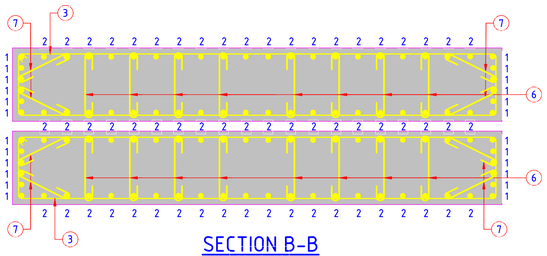


RC DETAILS OF SINGLE PIER

(DIAPHRAGM & PILECAP RC DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE 1:50)

SECTION A-A

(SCALE 1:50)



SECTION B-B

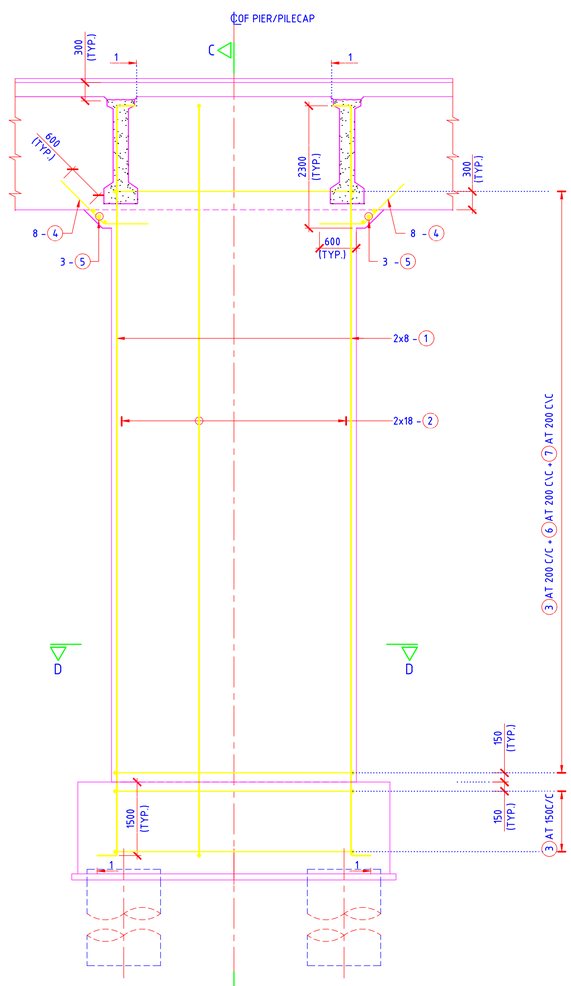
(SCALE 1:25)

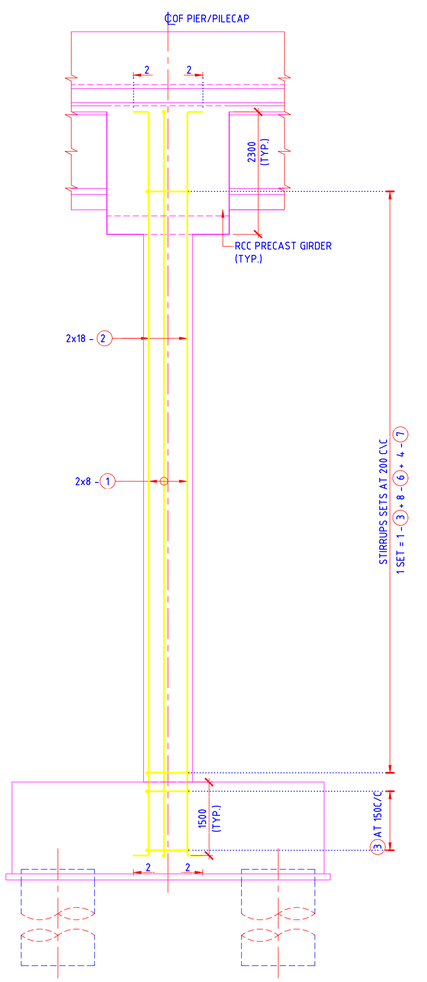
SCHEDULE OF REINFORCEMENT FOR EJ PIER:

BAR MARK	DIA OF BAR	SHAPE & DIMENSION
(1)	Y40	200 / 200
(2)	Y32	150 / 150
(3)	Y16	2910 / 590
(4)	Y12	1000 / 700
(5)	Y10	100 / 100
(6)	Y10	100 / 100
(7)	Y10	100 / 100

LAST BAR MARK USED (7)

RC DETAILS OF EJ PIERS



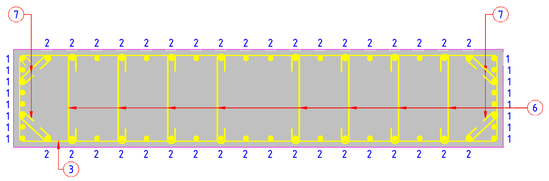


RC DETAILS OF PIER

(DIAPHRAGM & PILECAP RC DETAILS ARE NOT SHOWN FOR CLARITY)
(SCALE 1:50)

SECTION C-C

(SCALE 1:50)



SECTION D-D

(SCALE 1:25)

SCHEDULE OF REINFORCEMENT FOR INTERMEDIATE PIER:

BAR MARK	DIA OF BAR	SHAPE & DIMENSION
(1)	Y40	200 / 200
(2)	Y20	150 / 150
(3)	Y16	2910 / 710
(4)	Y12	1000 / 700
(5)	Y10	100 / 100
(6)	Y10	100 / 100
(7)	Y10	100 / 100

LAST BAR MARK USED (7)

LEGEND:-

CONSTRUCTION JOINT

RC DETAILS OF INTERMEDIATE PIERS

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS ARE FOLLOWED.
3. GRADE OF CONCRETE FOR PIER IS M35 .
4. GRADE OF REINFORCEMENT IS Fe500 CONFORMING TO IS:1786 (LATEST)
5. MINIMUM CLEAR COVER TO THE REINFORCEMENT FOR PIER IS 50mm .
6. NOT MORE THAN 50% OF BARS ARE LAPPED AT A SECTION AND LAPS ARE STAGGERED.
7. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 514	NUMERATION AND RC DETAILS OF INTERMEDIATE DIAPHRAGM 4x30m
DDI 512	RC DETAILS OF RCC PRECAST GIRDERS 4x30m
DDI 509	NUMERATION DETAILS OF PIER AT EJ & INTERMEDIATE PIER LOCATIONS FOR 4x30m (TYP.)
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED PML	CHECKED KGN
0	200312	4	FIRST SUBMISSION	PDP	CKT		

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\[ORIGINAL SIZE-A1 C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RC DETAILS OF PIER AT EJ & INTERMEDIATE PIER LOCATIONS FOR 4x30m (TYP.)

COP: IRC

SCALE: AS SHOWN

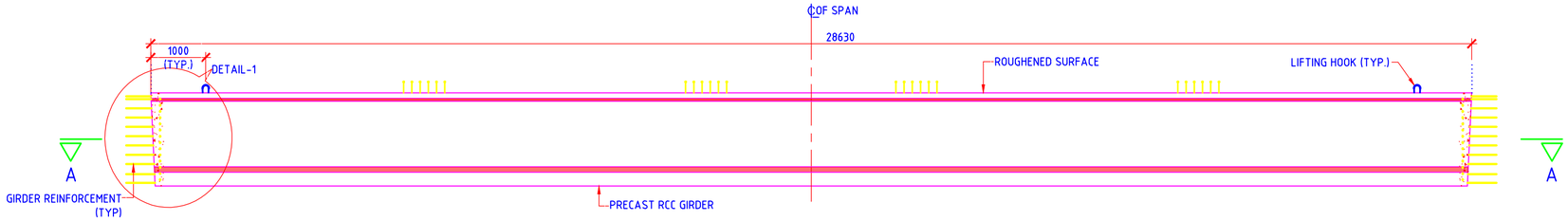
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

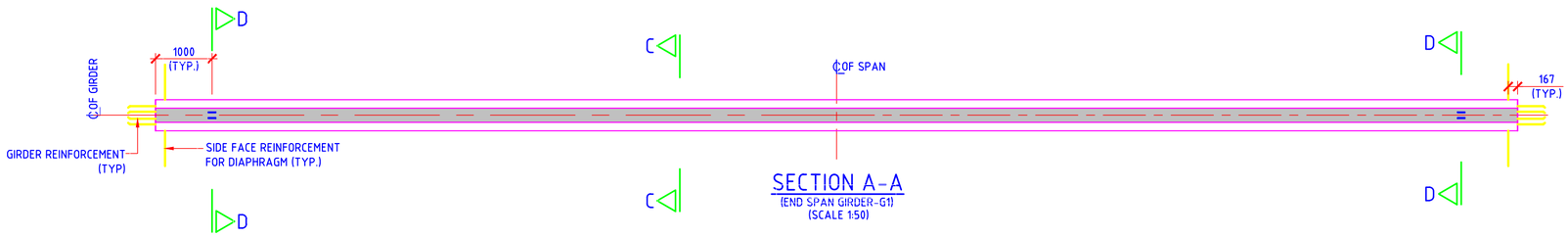
DRAWING NO: DDI 510

REV: 0

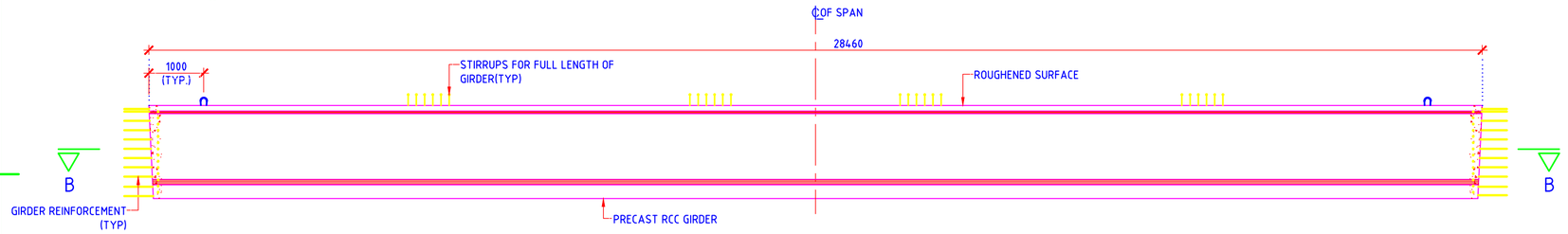
plot scale 50mm



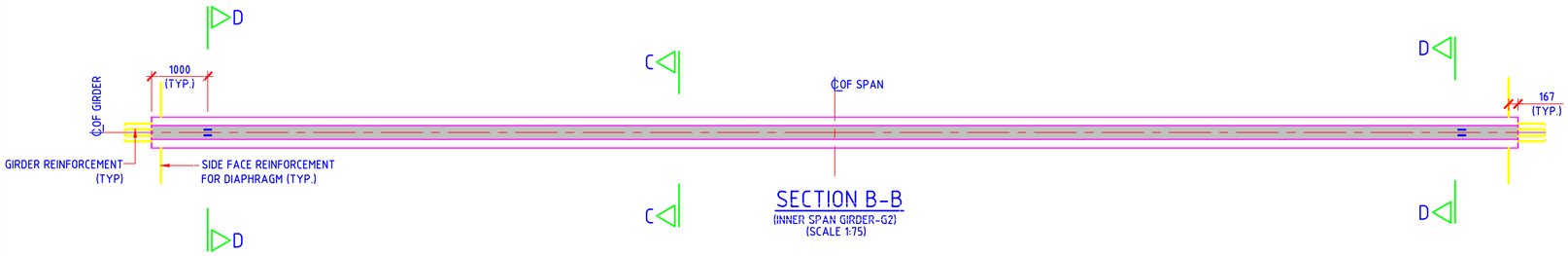
ELEVATION
(END SPAN GIRDER-G1)
(SCALE 1:50)



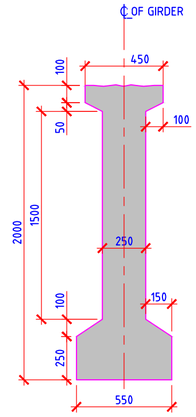
SECTION A-A
(END SPAN GIRDER-G1)
(SCALE 1:50)



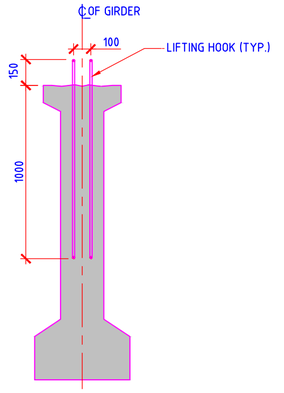
ELEVATION
(INNER SPAN GIRDER-G2)
(SCALE 1:75)



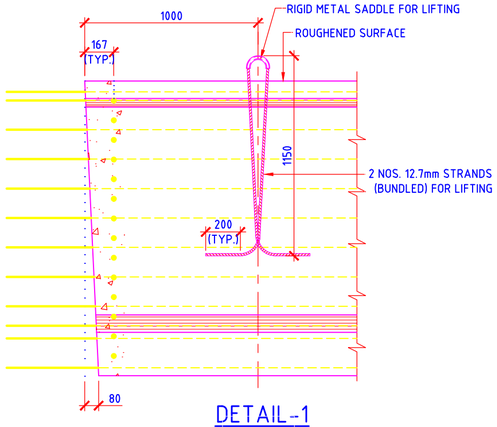
SECTION B-B
(INNER SPAN GIRDER-G2)
(SCALE 1:75)



SECTION C-C
(SCALE 1:25)



SECTION D-D
(SCALE 1:25)



DETAIL-1
(SCALE 1:25)

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE M45.
4. THE GIRDER SHALL BE LIFTED THROUGH LIFTING HOOKS ONLY.
5. THE GIRDERS SHALL BE LIFTED FROM CASTING BED, AFTER ACHIEVING A STRENGTH OF MINIMUM 40 MPa OR 14 DAYS AFTER CASTING THE GIRDER WHICHEVER IS LATER.
6. REFER SEPARATE DRAWING FOR CONSTRUCTION SEQUENCE.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 516	CONSTRUCTION METHODOLOGY FOR TYPICAL 4x30m
DDI 512	RC DETAILS OF RCC PRECAST GIRDERS 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	PDP	CKT	PML	ex	KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\BrIdges\2019\C1193601-DPR -PONNANI CABLE

DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION DETAILS OF RCC PRECAST GIRDERS -4x30m (TYP.)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

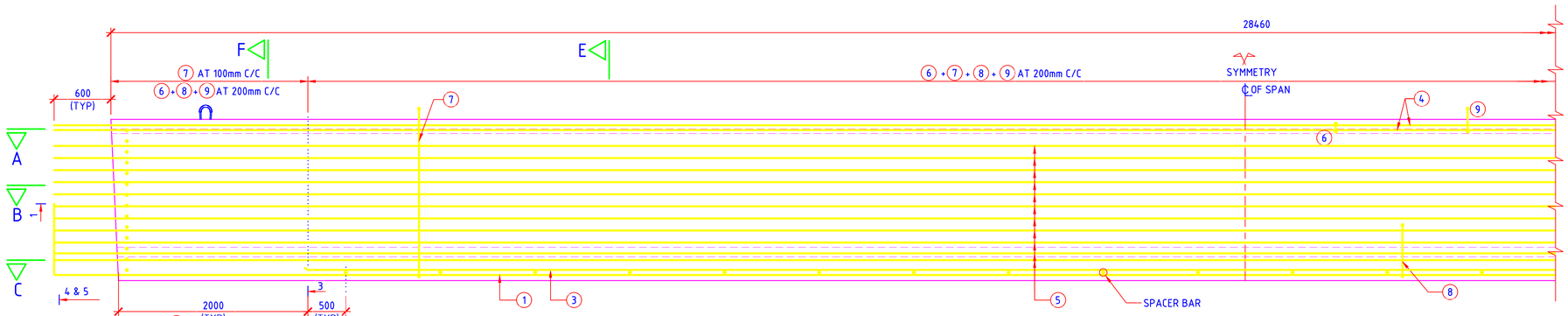
DRAWING NO: DDI 511

REV: 0

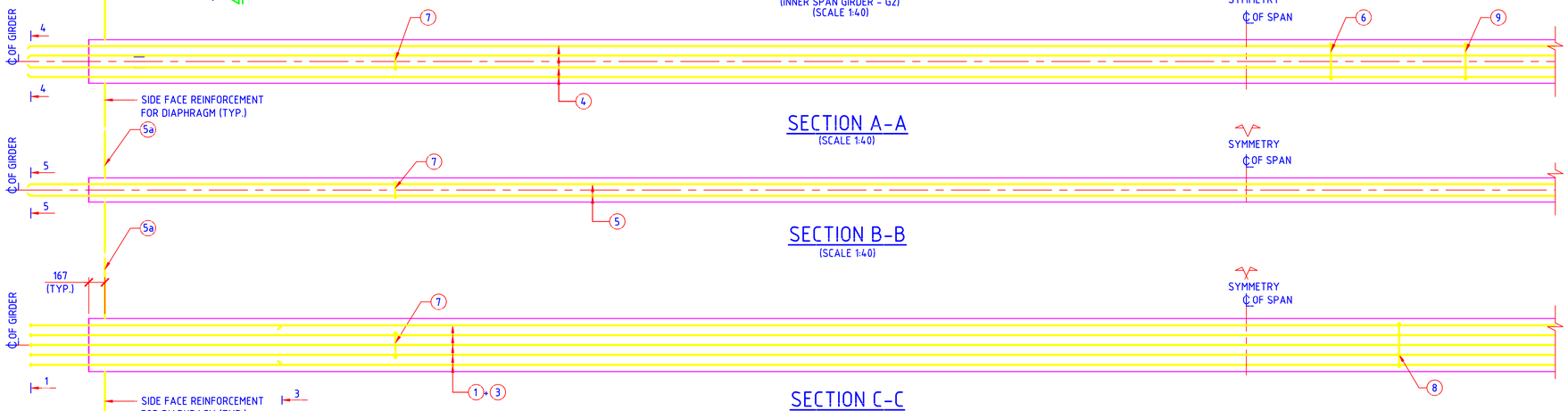
plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\R0\DDI 511-R0-VKL-NUMERATION DETAILS OF RCC PRECAST GIRDERS 4X30M.DWG

TBNA



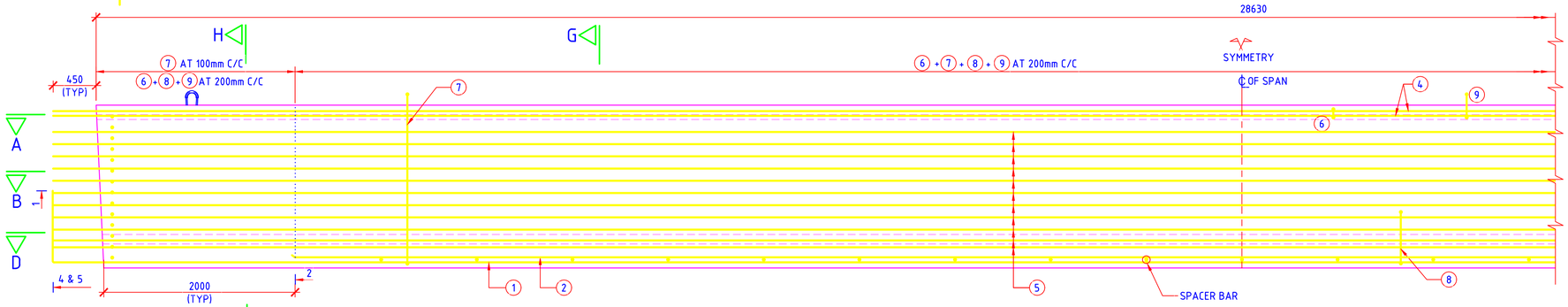
SECTIONAL ELEVATION
(INNER SPAN GIRDER - G2)
(SCALE 1:40)



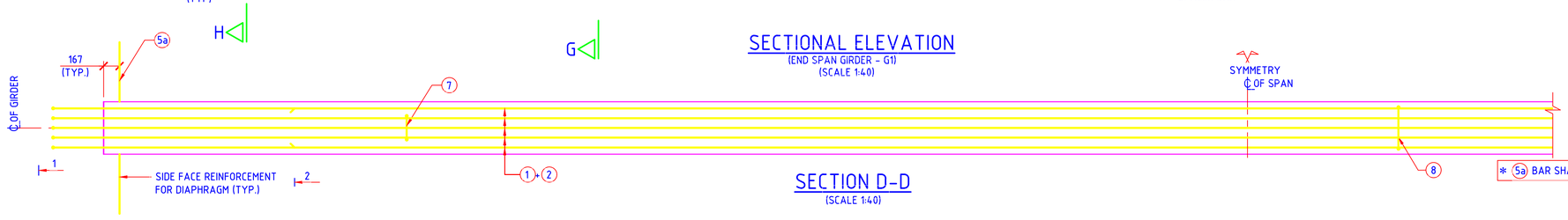
SECTION A-A
(SCALE 1:40)

SECTION B-B
(SCALE 1:40)

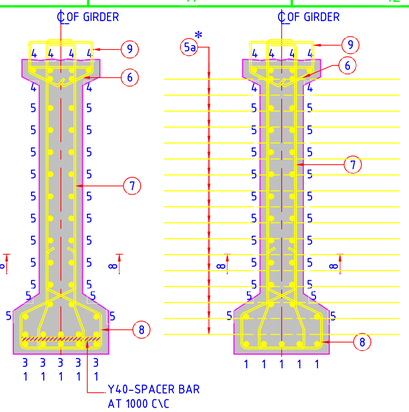
SECTION C-C
(SCALE 1:40)



SECTIONAL ELEVATION
(END SPAN GIRDER - G1)
(SCALE 1:40)

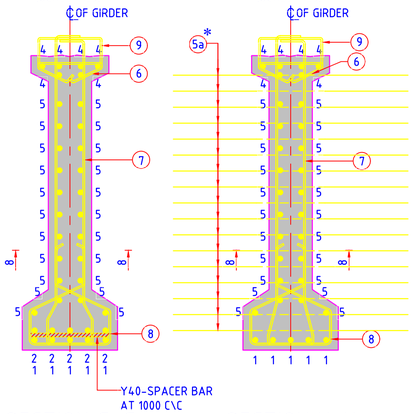


SECTION D-D
(SCALE 1:40)



SECTION E-E
(SCALE 1:25)

SECTION F-F
(SCALE 1:25)



SECTION G-G
(SCALE 1:25)

SECTION H-H
(SCALE 1:25)

SCHEDULE OF REINFORCEMENT:

BAR MARK	BAR DESCRIPTION	SHAPE & DIMENSION
1	5 - Y40	750
2	5 - Y40	
3	5 - Y32	
4	6 - Y12	
5	2X11 - Y10	
5a	17 - Y12 AT 120	3200
6	Y10	370
7	Y12	190, 2190
8	Y10	530, 160, 250, 470
9	Y10	370, 280

LAST BAR MARK USED 9

* 5a BAR SHALL BE BEND 90° ON OUTER FACE OF END GIRDER

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE M45.
4. GRADE OF REINFORCEMENT SHALL BE Fe500 CONFORMING TO IS:1786 (LATEST).
5. MINIMUM CLEAR COVER TO THE REINFORCEMENT SHALL BE 50mm.
6. THE GIRDER SHALL BE LIFTED THROUGH LIFTING HOOKS ONLY.
7. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.
8. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION. LAPS SHALL BE STAGGERED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 516	CONSTRUCTION METHODOLOGY FOR TYPICAL 4x30m
DDI 511	NUMERATION DETAILS OF RCC PRECAST GIRDERS 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m)

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED: PML (INIT.)	CHECKED: ex (SIGN.)	APPROVED: KGN (INIT.)	APPROVED: (SIGN.)
0	200312	4	FIRST SUBMISSION	PDP	CKT				

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\Bridges\2019\C1193601-DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\80\DDI 512-R0-VKL-RC DETAILS OF RCC PRECAST GIRDERS 4X30M.DWG

DRG. SIZE: A2

C1193601-DPR-PONNANI CABLE

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RC DETAILS OF RCC PRECAST GIRDERS -4x30m

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

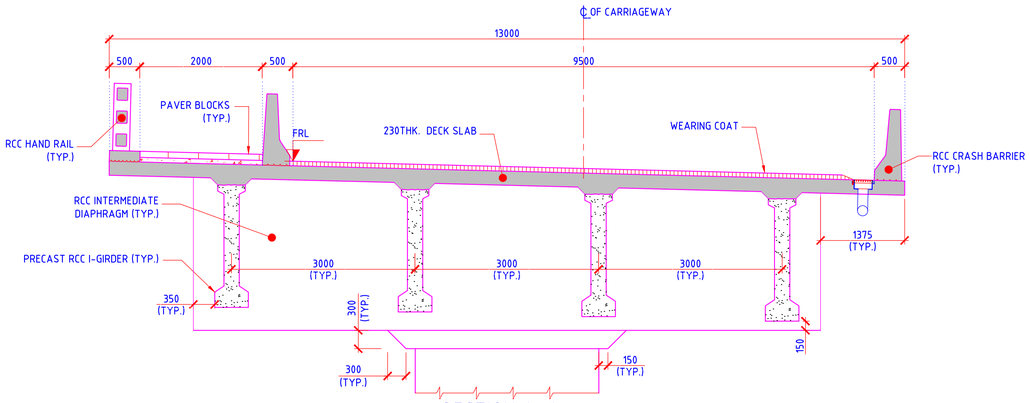
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 512

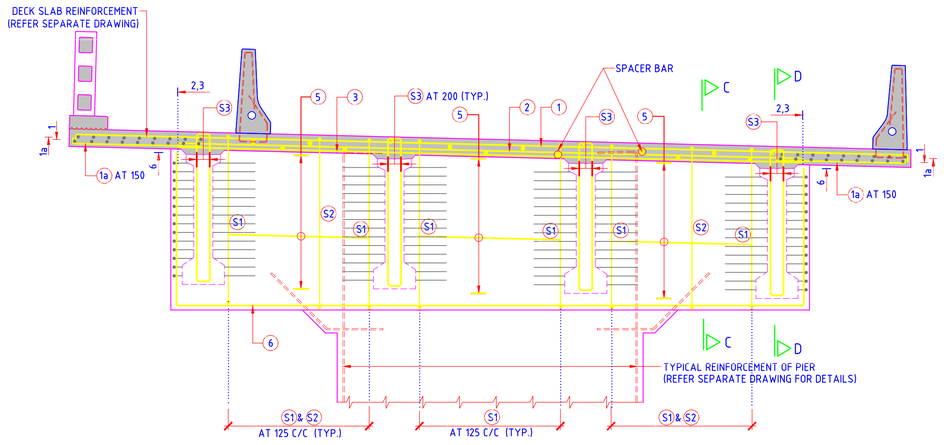
REV: 0

plot scale 50mm

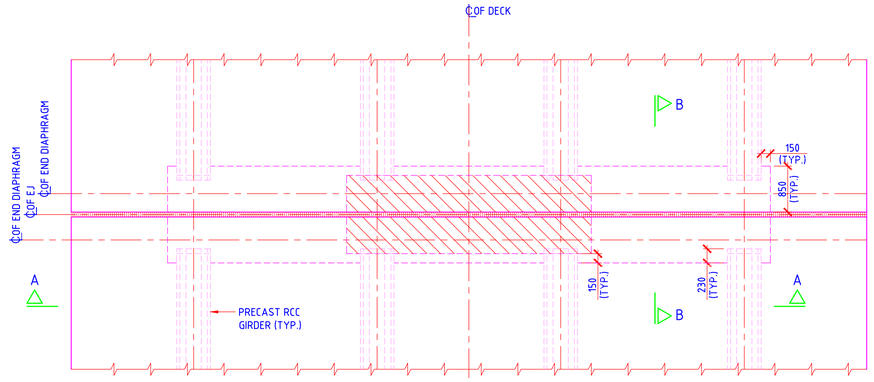
TBNA



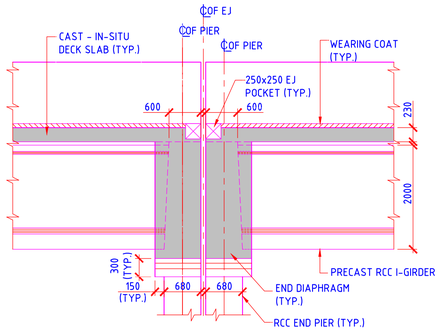
SECTION A-A
(SCALE 1:50)



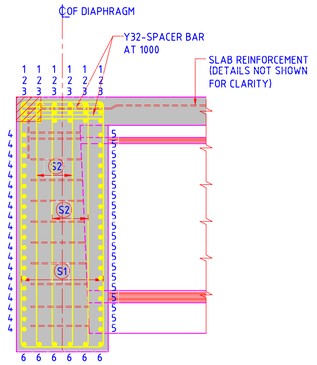
SECTION E-E
(DECK SLAB & PIER REINFORCEMENT ARE NOT SHOWN FOR CLARITY)
(SCALE 1:40)



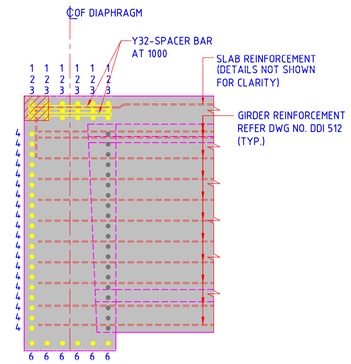
PLAN OF END DIAPHRAGM
(SCALE 1:50)



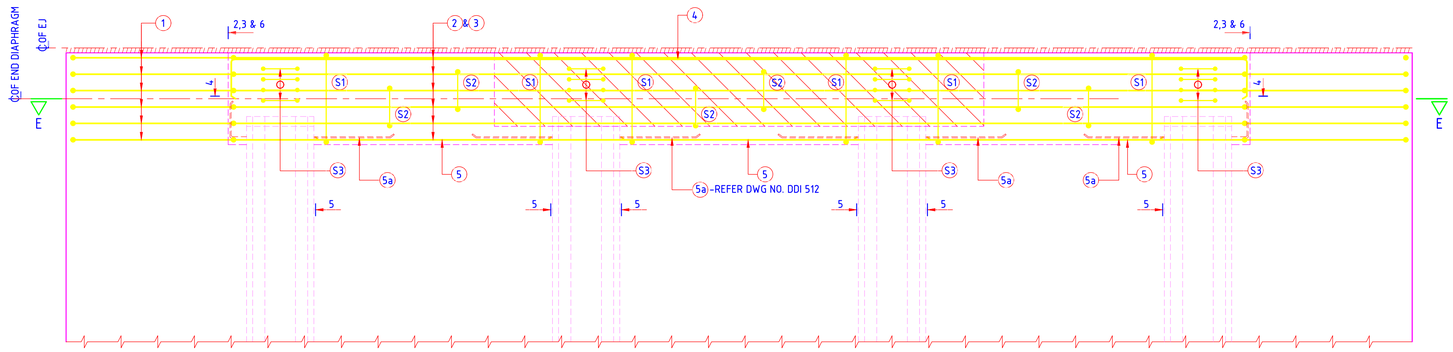
SECTION B-B
(SCALE 1:50)



SECTION C-C
(SCALE 1:25)



SECTION D-D
(S3 IS NOT SHOWN FOR CLARITY)
(SCALE 1:25)



PLAN AT TOP
(SCALE 1:25)

SCHEDULE OF REINFORCEMENT:

BAR MARK	BAR DESCRIPTION	SHAPE & DIMENSION
1	6-Y32	100 — 100
1a	Y12	100 — 1800
2	6-Y32	
3	6-Y25	
4	20-Y12	580
5	20-Y12	
6	6-Y20	2200
S1	Y10	740 — 2290
S2	Y10	295 — 2290
S3	Y16	160 — 2185

LAST BAR MARK USED 6 & S3

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE FOR DIAPHRAGM SHALL BE M45.
4. GRADE OF REINFORCEMENT SHALL BE Fe500 CONFORMING TO IS:1786 (LATEST).
5. MINIMUM CLEAR COVER TO THE REINFORCEMENT SHALL BE 45mm.
6. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.
7. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION. LAPS SHALL BE STAGGERED.
8. REFER SEPARATE DRAWING FOR CONSTRUCTION SEQUENCE.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 516	CONSTRUCTION METHODOLOGY FOR TYPICAL 4x30m
DDI 515	NUMERATION & RC DETAILS OF CAST-IN-SITU DECK SLAB 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED: PML	CHECKED: KGN
0	200312	4	FIRST SUBMISSION	PDP	CKT	PML	KGN

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: \\Bridges\2019\ORIGINAL SIZE: A1
C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION AND RC DETAILS OF DIAPHRAGM AT EJ LOCATION 4x30m (TYP.)

COP: IRC

SCALE: AS SHOWN

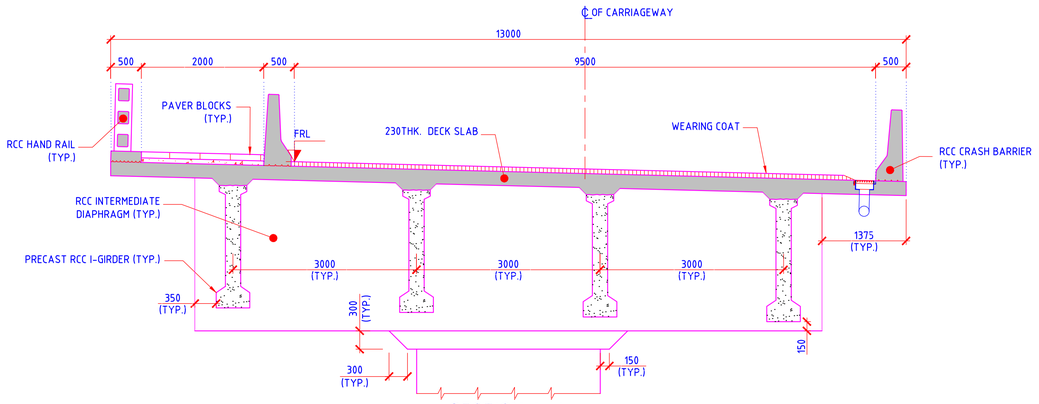
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

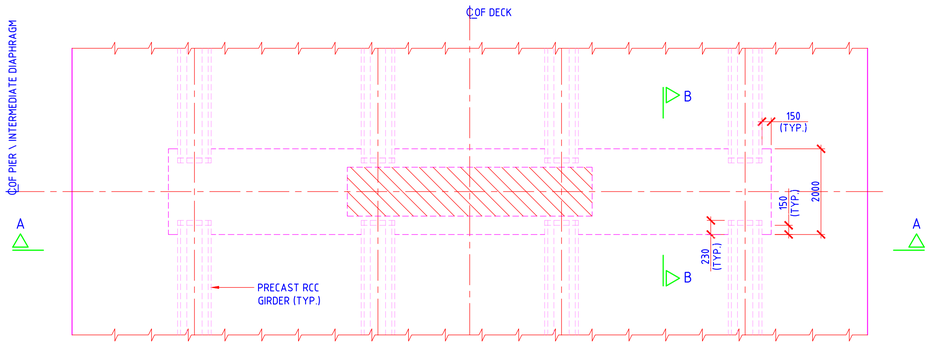
DRAWING NO: DDI 513

REV: 0

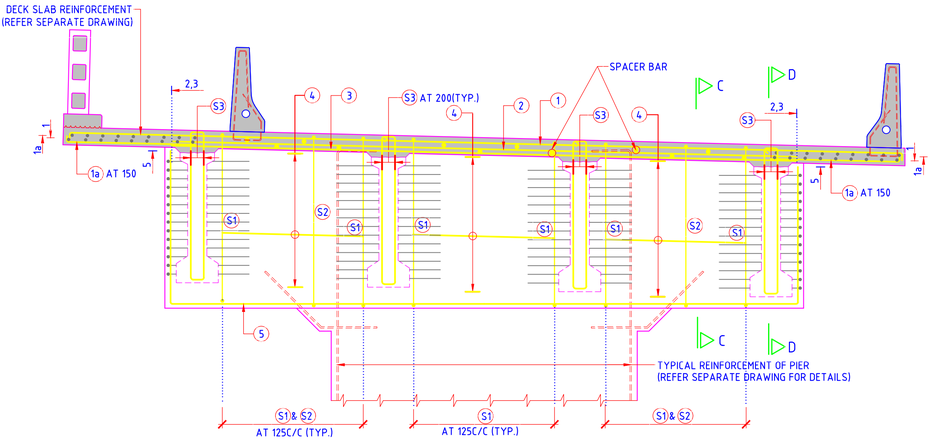
plot scale 50mm



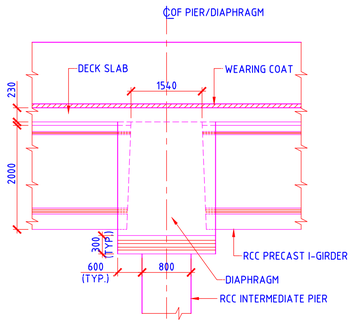
SECTION A-A
(SCALE 1:50)



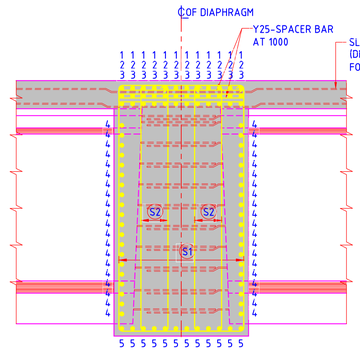
PLAN OF INTERMEDIATE DIAPHRAGM
(SCALE 1:50)



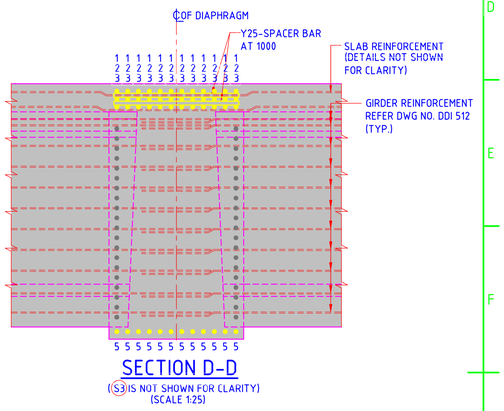
SECTION E-E
(DECK SLAB & PIER REINFORCEMENT NOT SHOWN FOR CLARITY)
(SCALE 1:40)



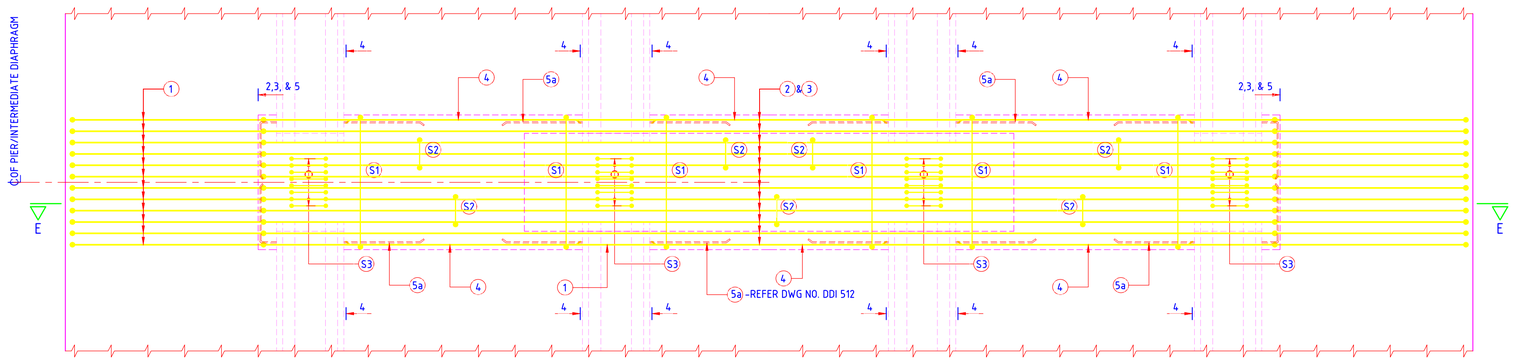
SECTION- B-B
(SCALE 1:50)



SECTION C-C
(SCALE 1:25)



SECTION D-D
(S3 IS NOT SHOWN FOR CLARITY)
(SCALE 1:25)



PLAN AT TOP
(SCALE 1:25)

SCHEDULE OF REINFORCEMENT :

BAR MARK	BAR DESCRIPTION	SHAPE & DIMENSION
1	12-Y25	100 / 100
1a	Y12	100 / 1800
2	12-Y25	
3	12-Y25	
4	2x20 - Y12	
5	12-Y20	2200
S1	Y12	1920 / 2290
S2	Y12	288 / 2290
S3	Y16	160 / 2185

LAST BAR MARK USED 5 & S3

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE FOR DIAPHRAGM SHALL BE M45.
4. GRADE OF REINFORCEMENT SHALL BE Fe500 CONFORMING TO IS:1786 (LATEST).
5. MINIMUM CLEAR COVER TO THE REINFORCEMENT SHALL BE 45mm.
6. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.
7. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION. LAPS SHALL BE STAGGERED.
8. REFER SEPARATE DRAWING FOR CONSTRUCTION SEQUENCE.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 516	CONSTRUCTION METHODOLOGY FOR TYPICAL 4x30m
DDI 515	NUMERATION & RC DETAILS OF CAST-IN-SITU DECK SLAB 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED PML INIT.	CHECKED PML SIGN.	APPROVED KGN INIT.	APPROVED KGN SIGN.
0	200312	4	FIRST SUBMISSION	PDP	CKT	PML	ev	KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\BRidges\2019\C1193601-DPR - PONNANI CABLE STAYED\ORIGINAL SIZE - A1

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

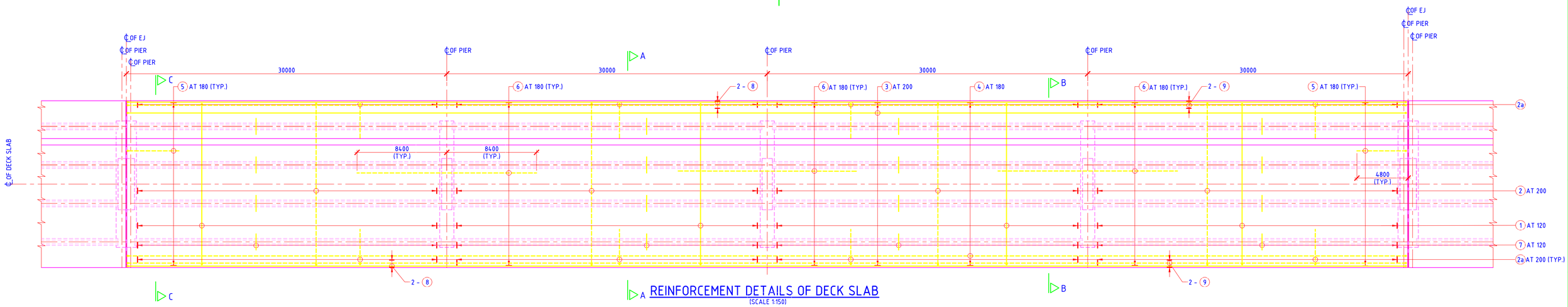
PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE — PROJECT NO: C1193601

TITLE: NUMERATION AND RC DETAILS OF INTERMEDIATE DIAPHRAGM 4x30m (TYP.) — COP: IRC — SCALE: AS SHOWN

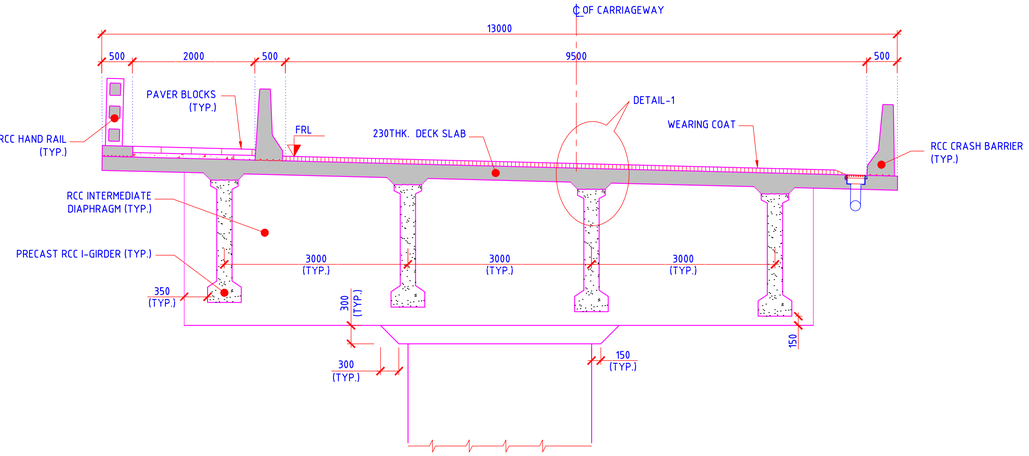
L&T Infra Engineering — L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 514 — REV: 0

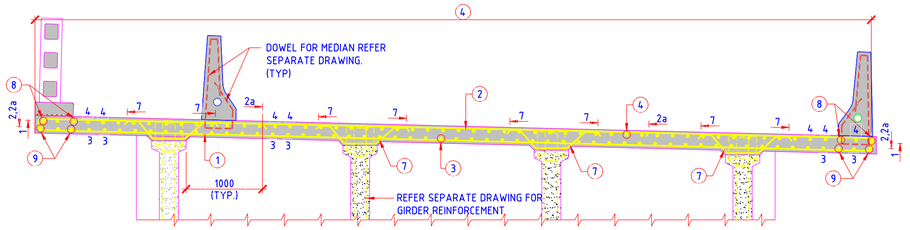
plot scale 50mm



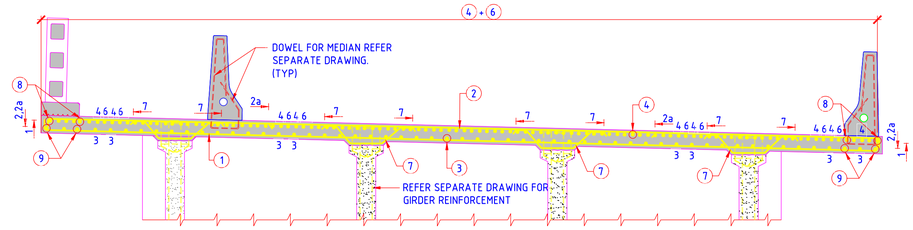
REINFORCEMENT DETAILS OF DECK SLAB
(SCALE 1:150)



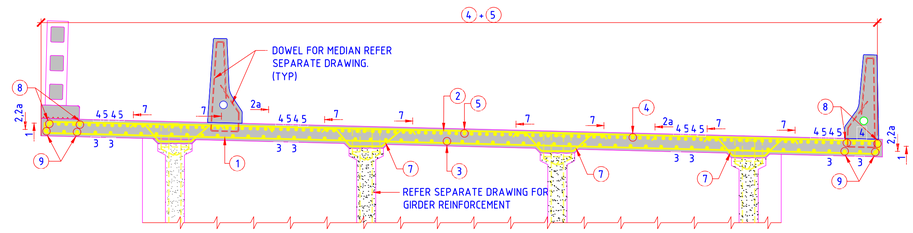
CROSS SECTION OF SUPER STRUCTURE
(SCALE 1:50)



SECTION A-A
(SCALE 1:40)



SECTION B-B
(SCALE 1:40)

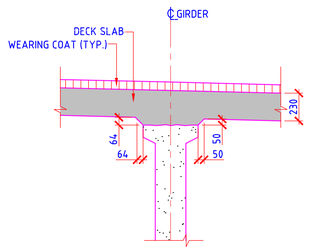


SECTION C-C
(SCALE 1:40)

SCHEDULE OF REINFORCEMENT :

BAR MARK	BAR DESCRIPTION	SHAPE & DIMENSION
1	Y12	100
2	Y12	100
2a	Y20	100
3	Y10	100
4	Y16	500
5	Y12	500
6	Y25	
7	Y10	100, 450, 350
8	Y16	100
9	Y16	100

LAST BAR MARK USED 9



DETAIL-1
(SCALE 1:25)

LEGEND:
TOP REINFORCEMENT
BOTTOM REINFORCEMENT

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE MENTIONED.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE FOR DECK SLAB SHALL BE M45.
4. GRADE OF REINFORCEMENT SHALL BE Fe500 CONFORMING TO IS:1786 (LATEST).
5. MINIMUM CLEAR COVER TO THE REINFORCEMENT SHALL BE 45mm.
6. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.
7. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION. LAPS SHALL BE STAGGERED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 513	NUMERATION AND RC DETAILS OF DIAPHRAGM AT EJ LOCATION 4x30m
DDI 514	NUMERATION AND RC DETAILS OF INTERMEDIATE DIAPHRAGM 4x30m
DDI 512	RC DETAILS OF RCC PRECAST GIRDERS 4x30m
DDI 506	GENERAL ARRANGEMENT DRAWING FOR 4x30m

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	PDP CHECKED	CKT CHECKED	PML INIT.	PML SIGN.	KGN INIT.	KGN SIGN.
0	200312	4	FIRST SUBMISSION	PDP	CKT	PML		KGN			

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\Bridges\2019\C1193601-DPR - PONNANI CABLE STAYED | ORIGINAL SIZE: A1

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION AND RC DETAILS OF CAST IN SITU DECK SLAB-4X30m UNIT (TYP.)

COP: IRC

SCALE: AS SHOWN

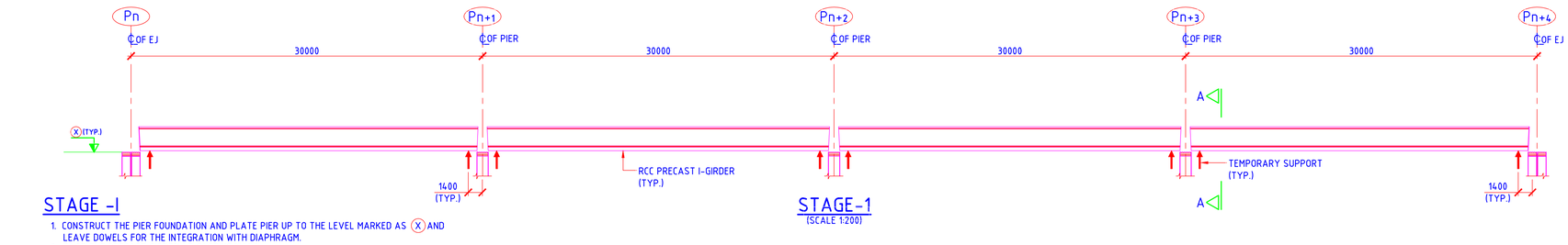
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 515 REV: 0

plot scale 50mm

AUTO PATH: L:\BRIDGES\DPR\C1193601 - DPR-PONNANI CABLE STAYED-BRIDGE\WORKING\DRAWINGS\DGN\PT DDI\C1193601-DDI-515-001-VAL-NUMERATION AND RC DETAILS OF DECK SLAB-V4.DWG

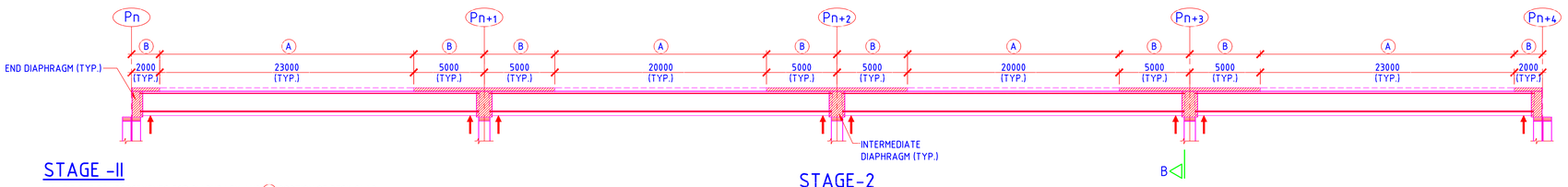


STAGE -I

1. CONSTRUCT THE PIER FOUNDATION AND PLATE PIER UP TO THE LEVEL MARKED AS (X) AND LEAVE DOWELS FOR THE INTEGRATION WITH DIAPHRAGM.
2. CAST THE PRECAST GIRDER AT CASTING YARD.
3. TRANSPORT THE GIRDER TO SITE AFTER ACHIEVING STRENGTH OF 45 MPa OR 28 DAYS AFTER CASTING THE GIRDER WHICHEVER IS LATER.
4. ERECT THE GIRDER OVER TEMPORARY SUPPORTS AS SHOWN.
5. ERECT FORM WORK FOR DIAPHRAGMS & AT LOCATIONS MARKED (B) OVER GIRDERS FOR IN SITU DECK SLAB.

STAGE-1

(SCALE 1:200)

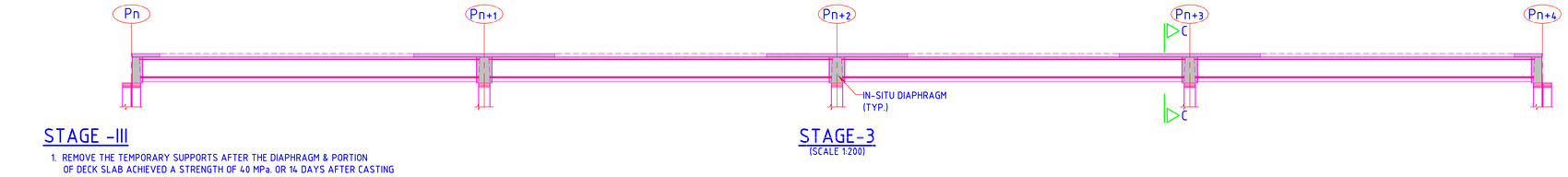


STAGE -II

1. TIE THE REINFORCEMENTS FOR DIAPHRAGM AND (B) PORTION OF DECK SLAB.
2. CAST THE DIAPHRAGMS AND IN-SITU PORTION OF DECK SLAB SHOWN AS (B).
3. LAYING THE REINFORCEMENT FOR (A) IN-SITU DECK SLAB FROM PORTION (B).

STAGE-2

(SCALE 1:200)

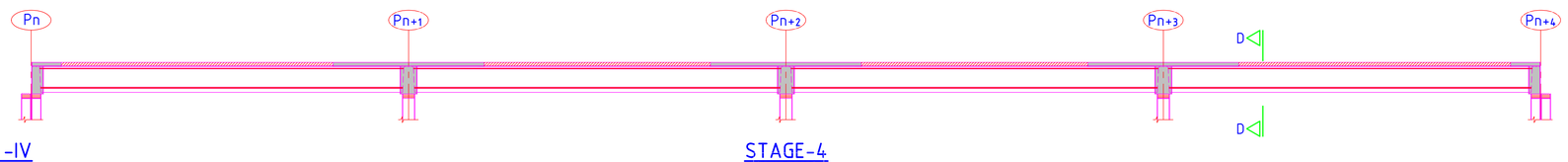


STAGE -III

1. REMOVE THE TEMPORARY SUPPORTS AFTER THE DIAPHRAGM & PORTION OF DECK SLAB ACHIEVED A STRENGTH OF 40 MPa. OR 14 DAYS AFTER CASTING THE DIAPHRAGM & DECK SLAB WHICHEVER IS LATER.
2. ERECT FORM WORK FOR DECK SLAB OVER GIRDERS IN LOCATIONS MARKED (A).
3. PLACE REINFORCEMENT FOR THE IN-SITU PORTION OF DECK SLAB.

STAGE-3

(SCALE 1:200)

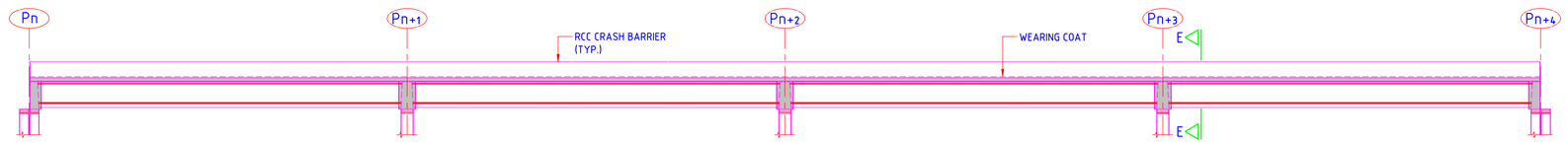


STAGE -IV

1. POUR THE GREEN CONCRETE ABOVE LOCATIONS MARKED (A)

STAGE-4

(SCALE 1:200)

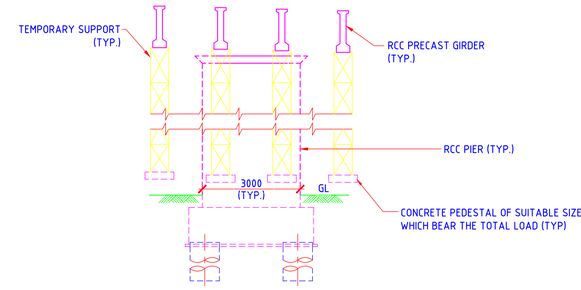


STAGE -V

1. CAST WEARING COAT, MEDIAN & RCC CRASH BARRIERS AFTER 28 DAYS OF STAGE-IV.

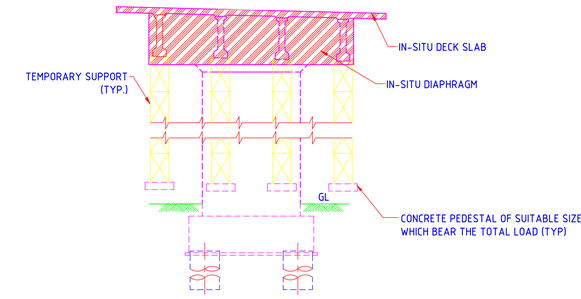
STAGE-5

(SCALE 1:200)



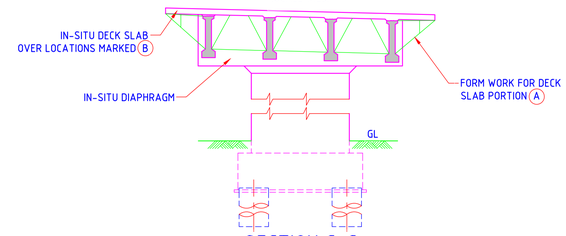
SECTION A-A

(SCALE 1:125)



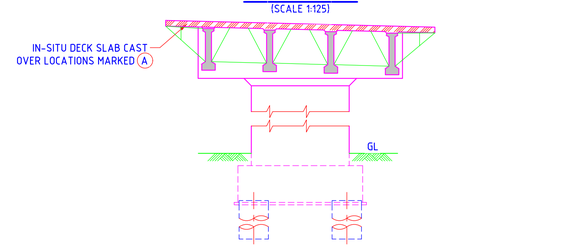
SECTION B-B

(SCALE 1:125)



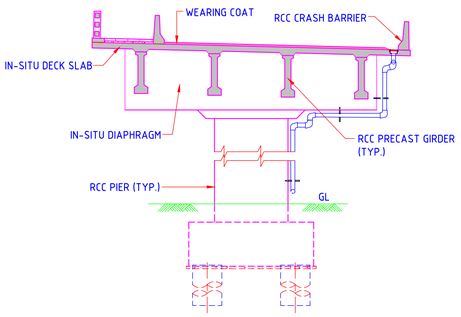
SECTION C-C

(SCALE 1:125)



SECTION D-D

(SCALE 1:125)



SECTION E-E

(SCALE 1:125)

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. TEMPORARY SUPPORT/ARRANGEMENT SHOWN ARE INDICATIVE ONLY.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 506	GENERAL ARRANGEMENT DRAWING FOR 4×30m
DDG 505	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 5 OF 5)
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 4 OF 5)
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 3 OF 5)
DDG 502	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 2 OF 5)
DDG 501	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE (SHEET 1 OF 5)

REVISIONS

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED: PML	CHECKED: INIT.	CHECKED: SIGN.	APPROVED: INIT.	APPROVED: SIGN.
0	200312	4	FIRST SUBMISSION	PDP	CKT	PML			KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: \Bridges\2019\C1193601-DPR-PONNANI CABLE STAYED\C1193601-DPR-PONNANI CABLE STAYED_CONSTRUCTION METHODOLOGY FOR TYPICAL 4X30M.DWG

ORIGINAL SIZE: A1

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: CONSTRUCTION METHODOLOGY FOR TYPICAL 4x30m

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

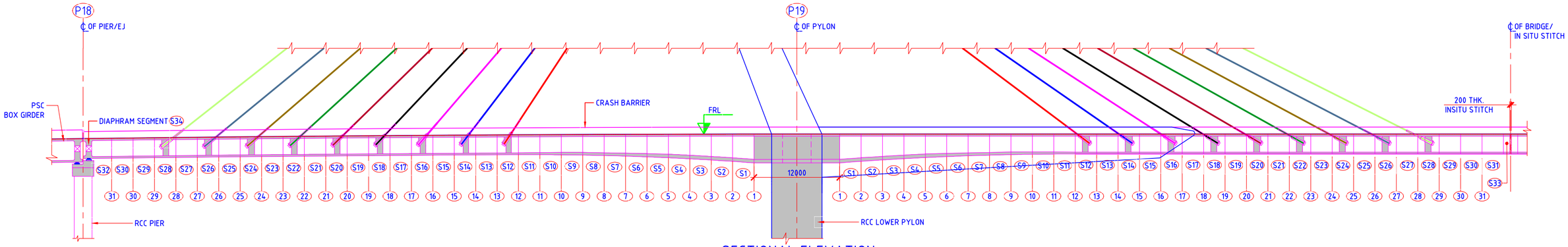
DRAWING NO: DDI 516

REV: 0

plot scale 50mm

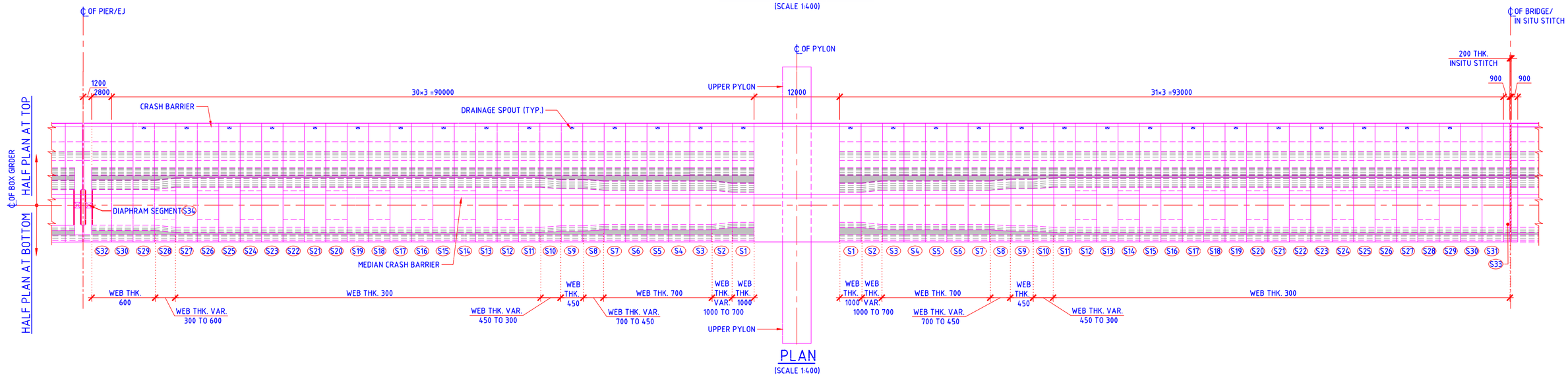
PALAKKAD PONNANI ROAD

PADINJAREKKARA KUTTAYI ROAD



SECTIONAL ELEVATION

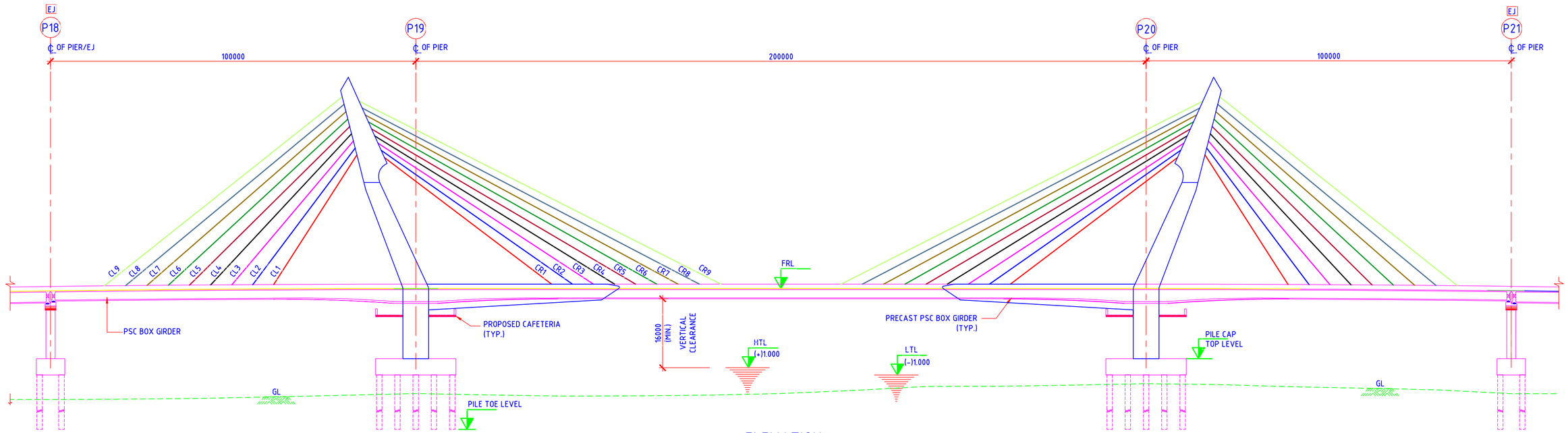
(SCALE 1:400)



PLAN

(SCALE 1:400)

| | | |



ELEVATION
(SCALE 1:800)

CABLE NAME	NO.OF STRANDS
CL1	34
CL2	34
CL3	39
CL4	53
CL5	53
CL6	58
CL7	58
CL8	62
CL9	78
CR1	43
CR2	43
CR3	59
CR4	64
CR5	66
CR6	73
CR7	78
CR8	95
CR9	114

THE NO. OF STRANDS MENTIONED IN CABLES ARE TENTATIVE IT MAY CHANGE IN DETAILED DESIGN.

LEGEND:

℄ - CENTER LINE
VAR. - VARIES
THK. - THICK
FRL - FINISHED ROAD LEVEL
(TYP.) - TYPICAL
HTL - HIGH TIDE LEVEL
LTL - LOW TIDE LEVEL

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

DRAWING NO. | TITLE
REFERENCE DRAWINGS

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	ex	KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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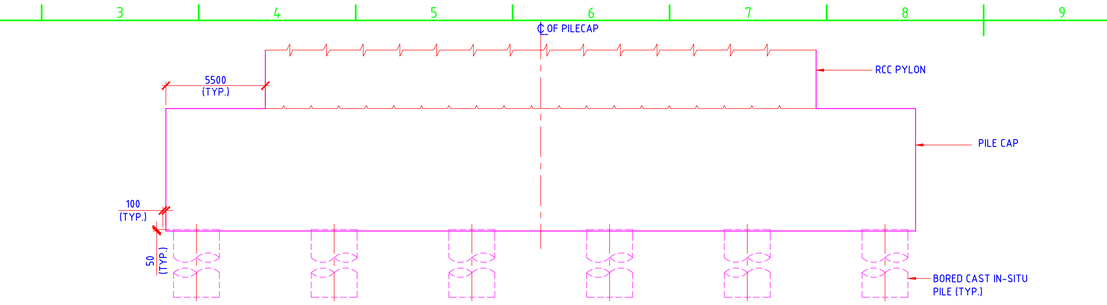
PATH: J:\BridgeS\2019\C1193601\DPR\DRAWINGS\DRAFT GAD\RAD\DDI 518-RB-VKL-STAY CABLE FOR MAIN BRIDGE.DWG
DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.
PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE
PROJECT NO: C1193601
TITLE: STAY CABLE FOR MAIN BRIDGE
COP: IRC
SCALE: AS SHOWN
L&T Infra Engineering
L&T Infrastructure Engineering Ltd.
DRAWING NO: DDI 518
REV: 0

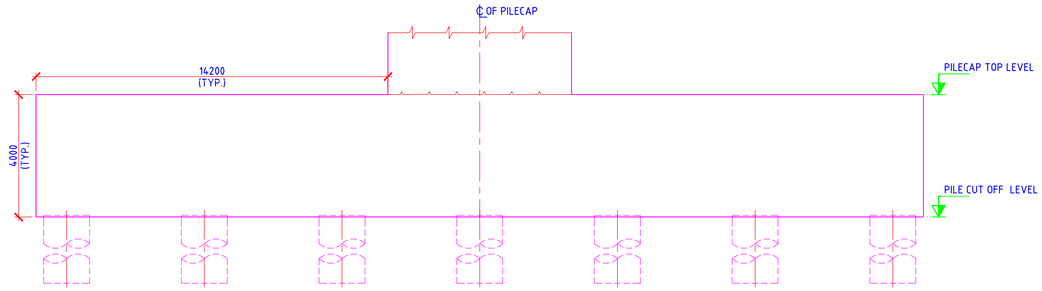
plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\RAD\DDI 518-RB-VKL-STAY CABLE FOR MAIN BRIDGE.DWG

TBNA

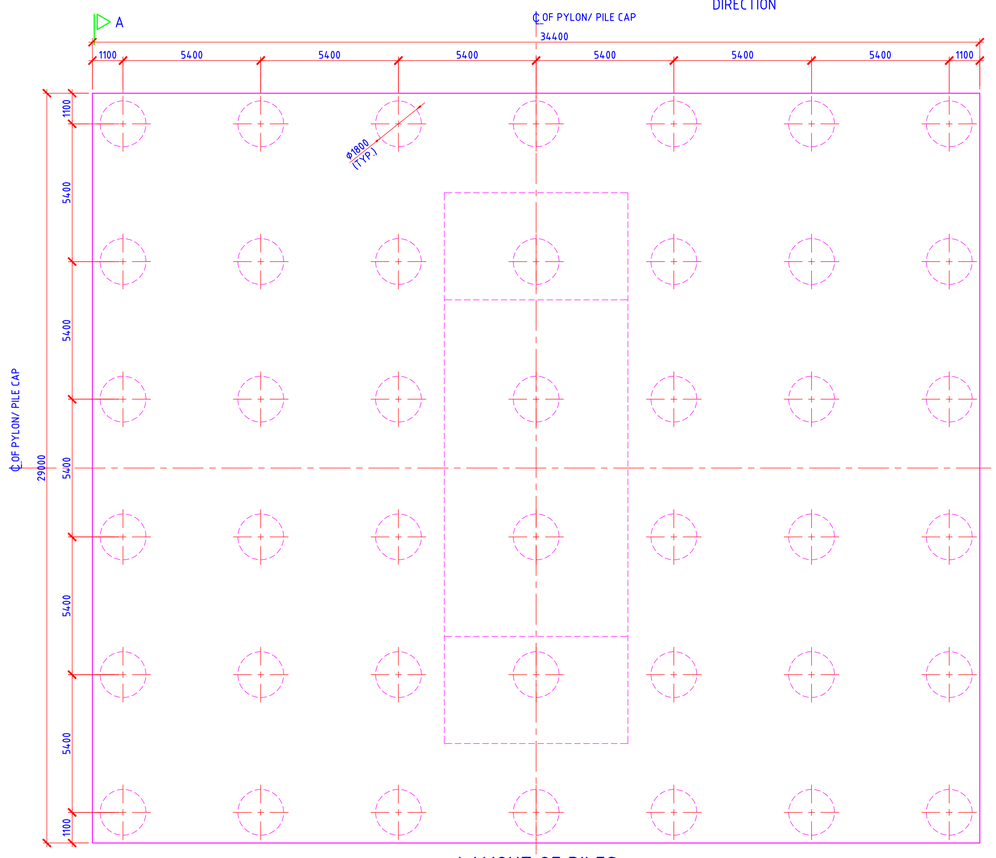


VIEW-A-A
(SCALE 1:100)

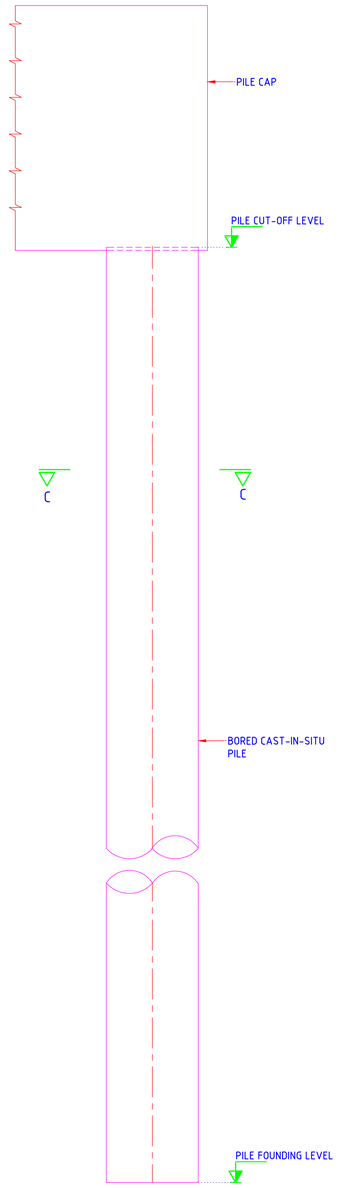


VIEW-B-B
(SCALE 1:100)

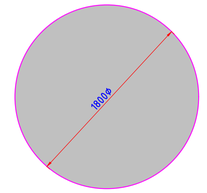
TRAFFIC DIRECTION



LAYOUT OF PILES
(SCALE 1:100)



NUMERATION DETAILS OF PILE
(SCALE 1 : 50)



SECTION C-C
(SCALE 1 : 25)

B

LEGEND:
TYP. - TYPICAL

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES UNLESS OTHERWISE MENTIONED .
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

DRAWING NO.	TITLE
DDI 520	RC DETAILS OF PILE & PILE CAP FOR PYLON
DDI 521	NUMERATION & RC DETAILS OF PYLON

REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	ex:	KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\ ORIGINAL SIZE: A1
C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION DETAILS OF PILE & PILE CAP FOR PYLON (TYP.)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

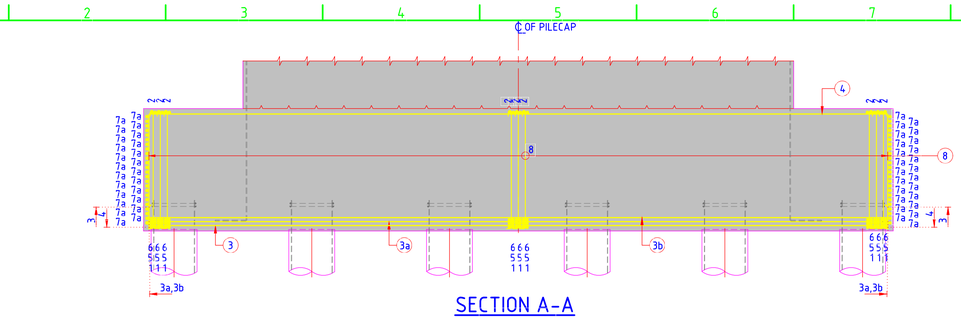
L&T Infrastructure Engineering Ltd.

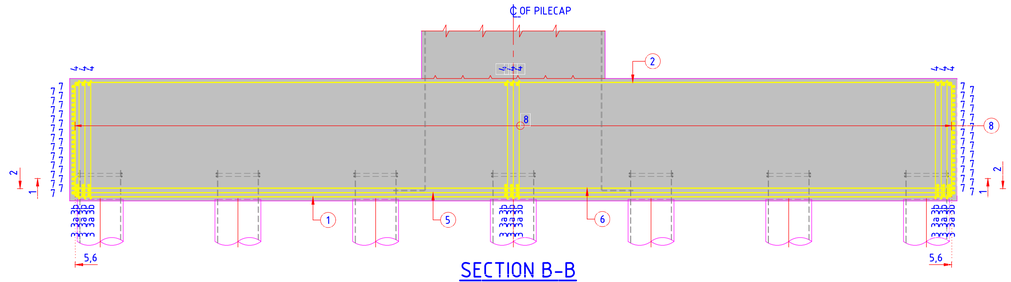
DRAWING NO: DDI 519

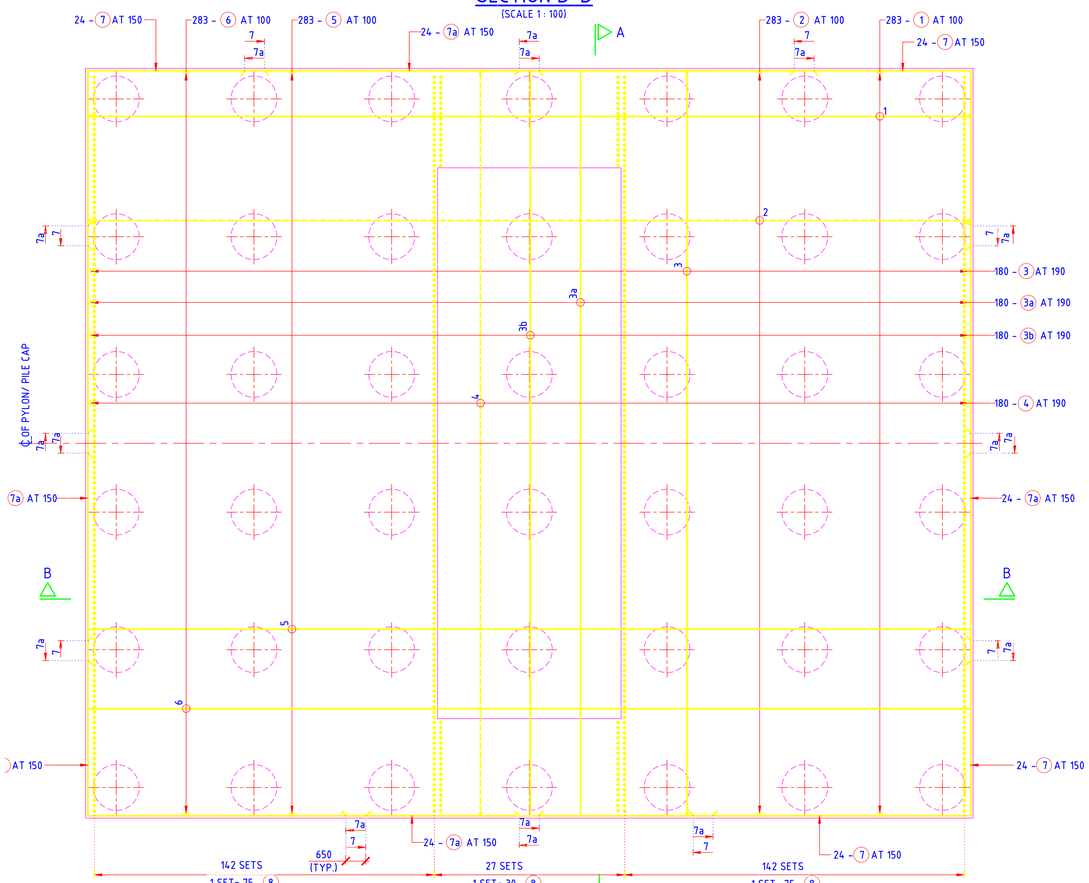
REV: 0

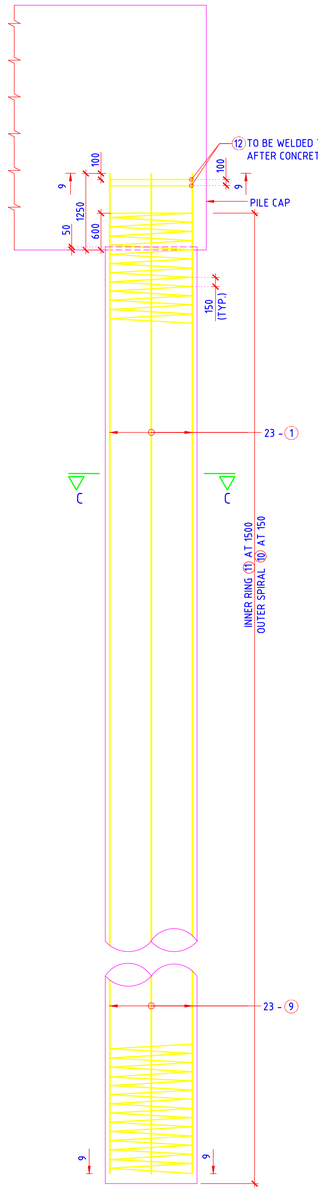
plot scale 50mm

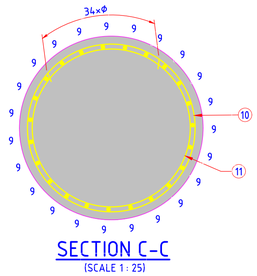
AUTO PATH: I:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRIDGE\WORKING\DRAWINGS\DRAFT CAD\DDI\DDI 519-R0-VNL-NUMERATION DETAILS OF PILE & PILE CAP FOR PYLON.DWG











SCHEDULE OF REINFORCEMENT :

BAR MARK	BAR TYPE/ DIA	BAR SHAPE
1	Y40	
2	Y20	
3	Y25	
3a	Y25	
3b	Y20	
4	Y20	
5	Y40	
6	Y40	
7	Y16	
7a	Y16	
8	Y12	
9	Y25	
10	Y10	
11	Y16	
12	Y20	

LAST BAR MARK USED (12)

LEGEND:

BOTTOM REINFORCEMENT

TOP REINFORCEMENT

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES
2. UNLESS OTHERWISE MENTIONED .
3. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
4. GRADE OF CONCRETE SHALL BE M40.
4. MINIMUM CLEAR COVER FOR OUTERMOST REINFORCEMENT SHALL BE 75mm.
5. GRADE OF REINFORCEMENT SHALL BE Fe500D (CORROSION RESISTANT STEEL), CONFORMING TO IS: 1786 (LATEST).
6. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.
7. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION. LAPS SHALL BE STAGGERED.

DRAWING NO.	TITLE
DDI 519	NUMERATION DETAILS OF PILE & PILE CAP FOR PYLON
DDI 521	NUMERATION & RC DETAILS OF PYLON

REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	ex	KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\Bridges\2019\C193601-DPR - PONNANI CABLE STAYED (ORIGINAL SIZE: A1)

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RC DETAILS OF PILE & PILE CAP FOR PYLON (TYP.)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

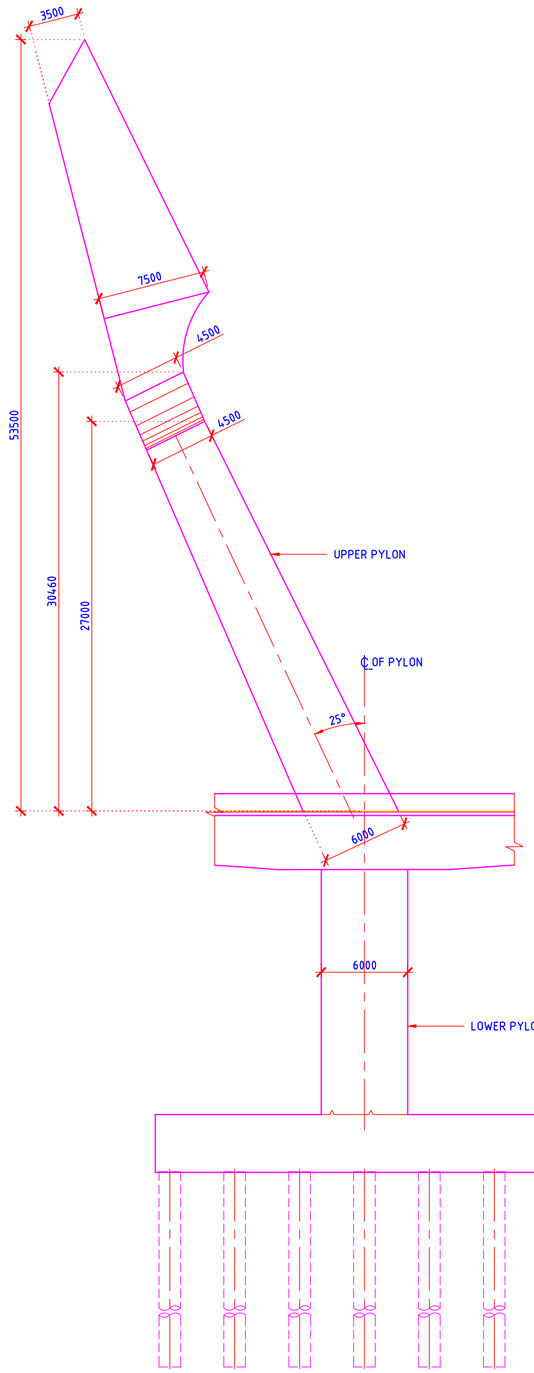
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 520

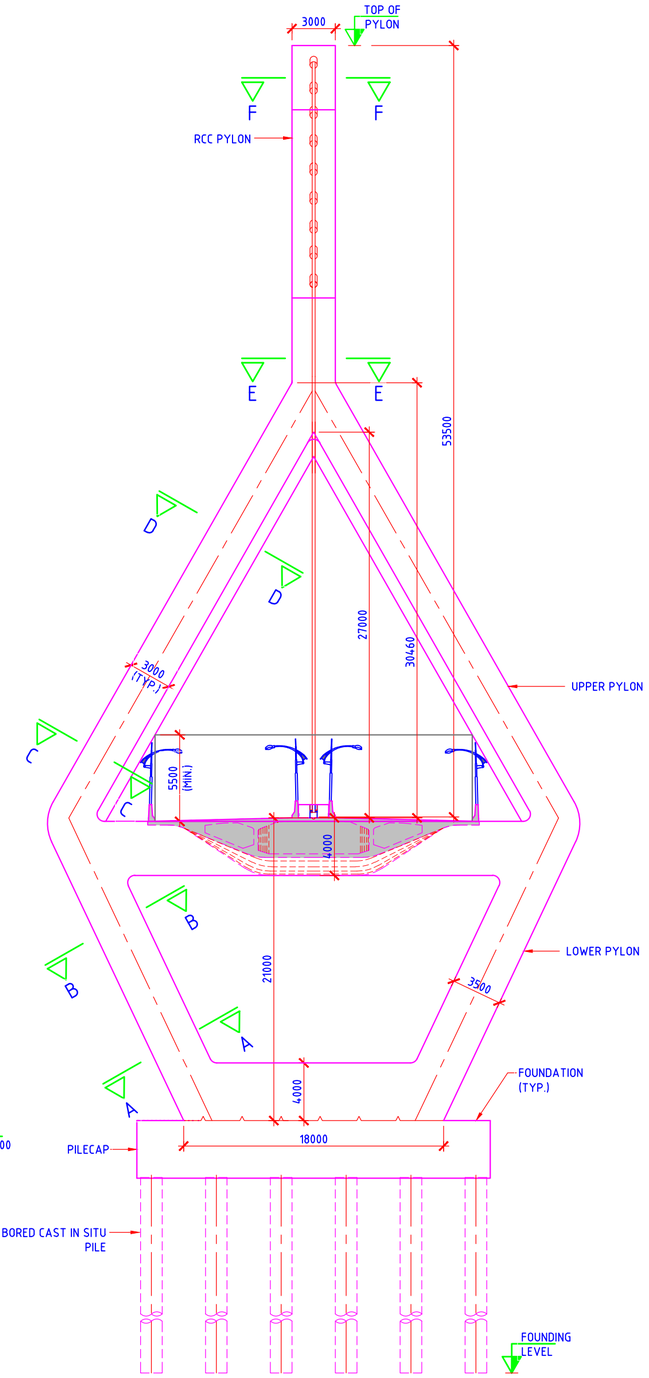
REV: 0

plot scale 50mm

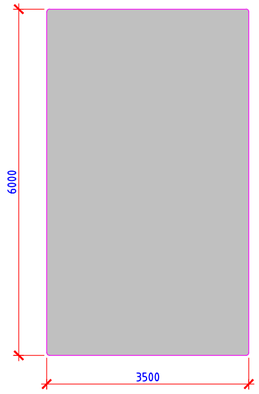
AUTO PATH: J:\BRIDGES\2019\C193601 - DPR-PONNANI CABLE STAYED\BRIDGE\DRAWING\DRAFT\DDI\DDI520 534-ABA-XXX-RC-DE-DETAILS OF PILE & PILE CAP FOR PYLON.DWG



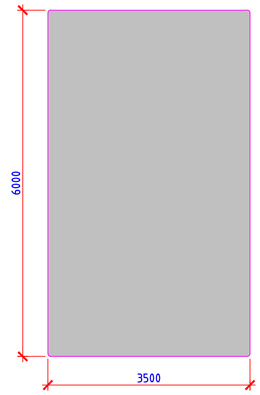
LONGITUDINAL SECTION OF PYLON
(SCALE 1:300)



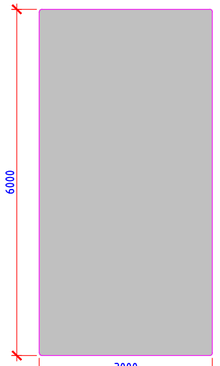
TRANSVERSE SECTION OF PYLON
(SCALE 1:300)



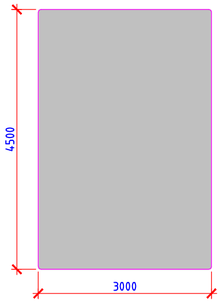
SECTION A-A
(SCALE 1:75)



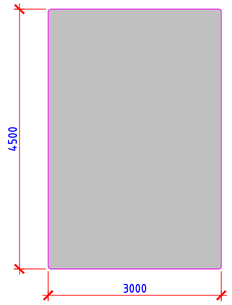
SECTION B-B
(SCALE 1:75)



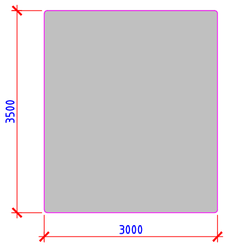
SECTION C-C
(SCALE 1:75)



SECTION D-D
(SCALE 1:75)



SECTION E-E
(SCALE 1:75)



SECTION F-F
(SCALE 1:75)

LEGEND:

℄	- CENTER LINE
(TYP.)	- TYPICAL
B/S	- BOTH SIDES
HTL	- HIGH TIDE LEVEL
LTL	- LOW TIDE LEVEL

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES UNLESS OTHERWISE MENTIONED .
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 538	RC DETAILS OF PYLON

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	VKL	PML	ex:	KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\Bridges\12019\C1193601-DPR-PONNANI CABLE\DRG SIZE A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: NUMERATION DETAILS OF PYLON

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

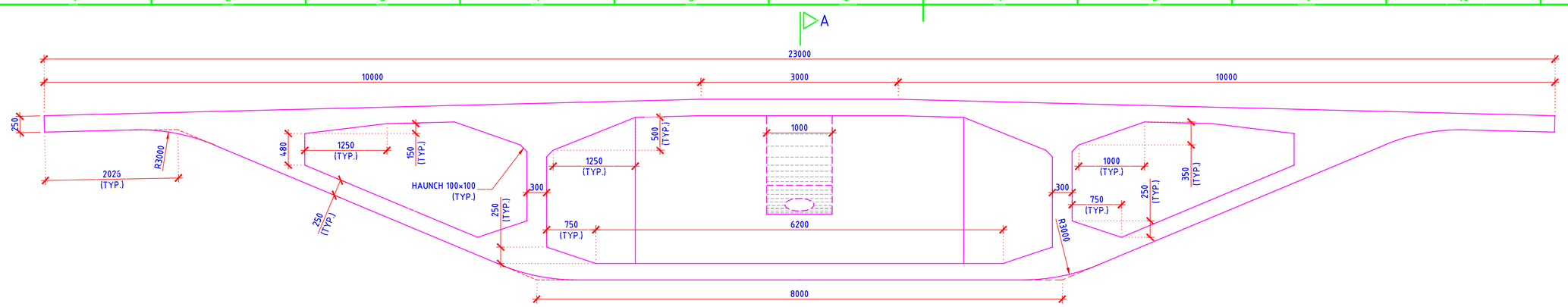
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 521 REV: 0

plot scale 50mm

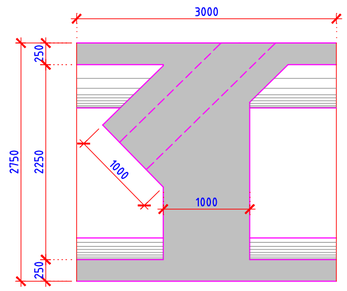
AUTO PATH: J:\BRIDGES\12019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\R0\DDI 521-R0-VKL-NUMERATION & RC DETAILS OF PYLON.DWG

TBNA



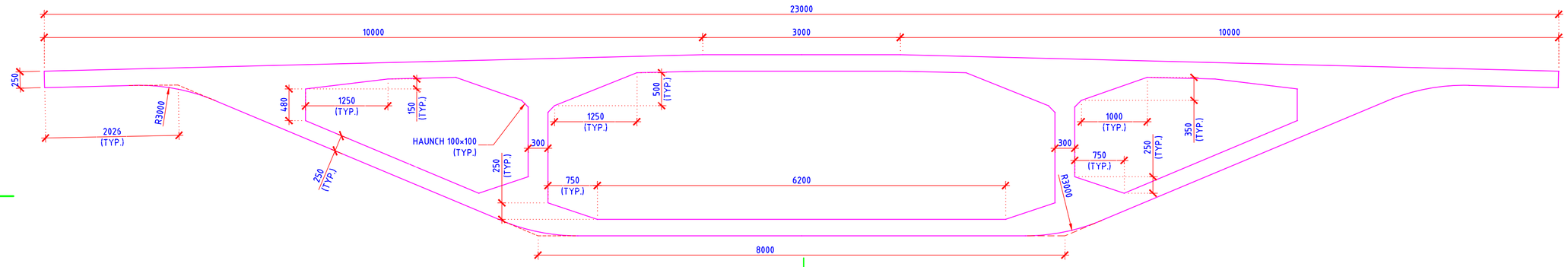
DETAILS OF STAY SEGEMENT

(SCALE 1:50)



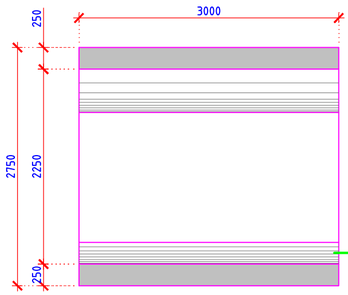
SECTION A-A

(SCALE 1:50)



DETAILS OF RUNNING SEGEMENT

(SCALE 1:50)



SECTION B-B

(SCALE 1:50)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	ANB	VKL	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:J:\BRIDGES\20191\C1193601-DPR -PONNANI CABLE | DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE | PROJECT NO: C1193601

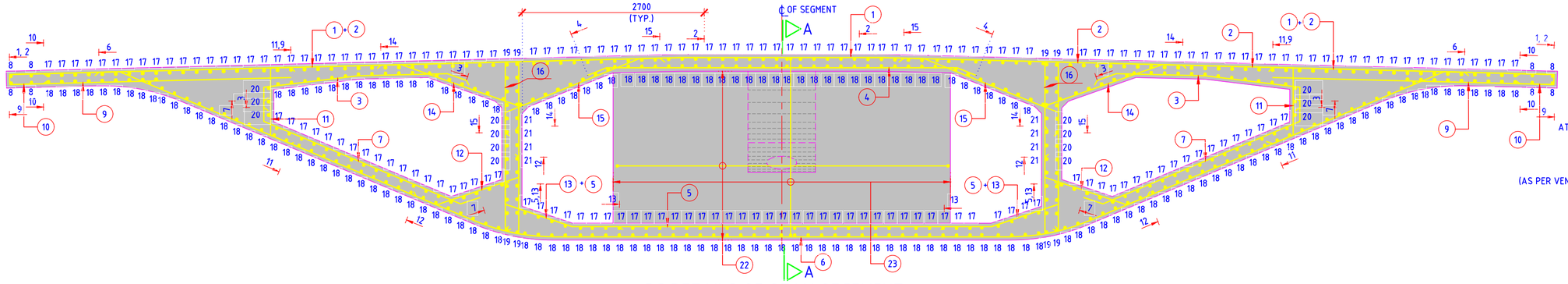
TITLE: NUMERATION DETAILS OF RUNNING & STAY SEGMENTS | COP: IRC | SCALE: AS SHOWN

L&T Infra Engineering | L&T Infrastructure Engineering Ltd. | DRAWING NO: DD1 522 | REV: 0

plot scale 50mm

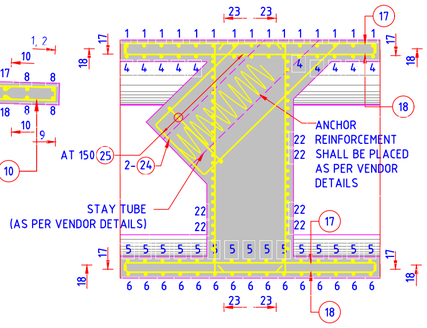
AUTO PATH: J:\BRIDGES\20191\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\01\DD1 522-R0-VKL-NUMERATION DETAILS OF RUNNING & STAY SEGMENTS.DWG

TBNA



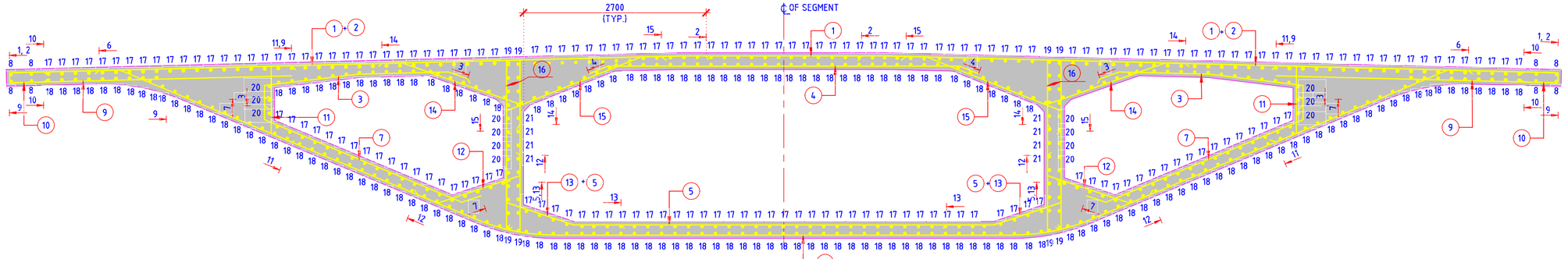
RC DETAILS OF STAY SEGEMENT

(APPLICABLE FOR S12 , S14 S16, S18, S20, S22, S24, S26, S28)
(SCALE 1:50)



SECTION A-A

(SCALE 1:50)



RC DETAILS OF RUNNING SEGEMENT

(APPLICABLE FOR S13 , S15, S17, S19, S21, S23, S25, S27, S29, S30)
(SCALE 1:50)

SCHEDULE OF REINFORCEMENT:

BAR NO.	BAR DIA	SHAPE
1	Y16 AT 200	9950 1500 9950
2	Y12 AT 200	9950 350
3	Y12 AT 200	300 1400 1325 300
4	Y16 AT 200	300 5200 300
5	Y16 AT 200	300 1050 6220 1050 300
6	Y12 AT 200	300 5730 6800 5730 300
7	Y12 AT 200	300 3165 300
8	4-Y16	150 2900 150
9	Y12 AT 200	4170
10	Y10 AT 200	150 500
11	Y12 AT 200	1000 300 300
12	Y12 AT 200	300 1285 300
13	Y16 AT 200	300 1050 700
14	Y12 AT 100	300 1850 300
15	Y12 AT 100	300 2150 300
16	Y16 AT 200 + Y20 AT 200	200 VARIES
17	Y12 AT 200	150 2900
18	Y12 AT 200	150 2900
19	4-Y16	150 2900
20	Y12 AT 200	150 2900
21	Y12 AT 200	150 2900
22	Y25 AT 90	750 4900
23	Y25 AT 90	750 2610
24	2-Y20	1330 900 2150
25	Y16 AT 150	900 900

LAST BAR MARK USED (25)

LEGEND:

BOTTOM REINFORCEMENT

TOP REINFORCEMENT

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE IS M60.
4. MINIMUM CLEAR COVER TO THE REINFORCEMENT SHALL BE 45mm.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	ANB	CKT	PML	ex	KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\Bridges\2019\C1193601-DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\DD01533-R0-VKL-RC DETAILS OF RUNNING & STAY SEGMENTS.DWG

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE — PROJECT NO: C1193601

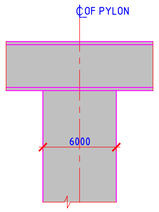
TITLE: RC DETAILS OF RUNNING & STAY SEGMENTS — COP: IRC — SCALE: AS SHOWN

L&T Infra Engineering — L&T Infrastructure Engineering Ltd. — DRAWING NO: DD1 523 — REV: 0

plot scale 50mm

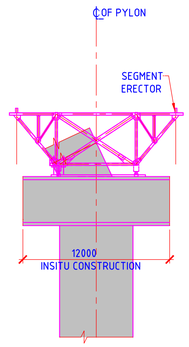
TBNA

1. CAST THE LOWER PYLON UPTO BOTTOM OF PIER TABLE.



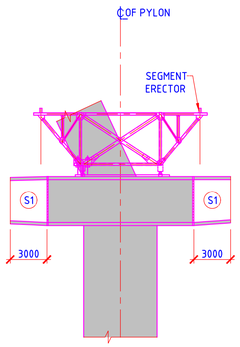
CONSTRUCTION STAGE -0
(SCALE 1:250)

1. CAST THE SUPERSTRUCTURE IN SITU PORTION ON STAGING FROM PILE CAP/PIER.
2. DO THE PRESTRESSING AS PER THE DESIGN.
3. ASSEMBLE SEGMENT ERECTOR AS PER RELEVANT DRAWINGS.
4. CASTING OF UPPER PYLON SHALL BE CARRIED OUT SIMULTANEOUSLY WITH SEGMENT ERRECTION.



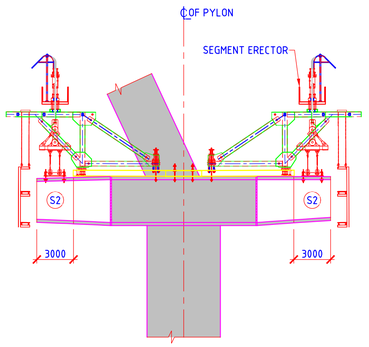
CONSTRUCTION STAGE -1
(SCALE 1:250)

1. ERECT THE SEGMENT (S1) ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
2. ALIGN THE SEGMENT AND DO THE STITCH CONCRETE.
3. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
4. DO THE PRESTRESSING AS PER THE DESIGN.
5. CASTING OF UPPER PYLON SHALL BE CARRIED OUT SIMULTANEOUSLY WITH SEGMENT ERRECTION.



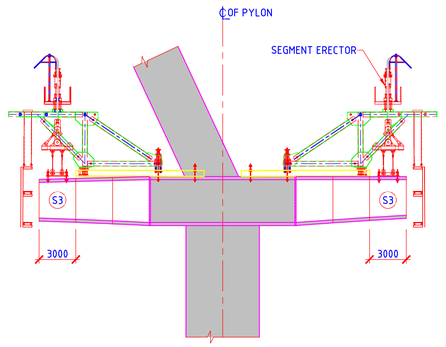
CONSTRUCTION STAGE -2
(SCALE 1:250)

1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ERECT THE SEGMENT (S2) ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
3. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
4. DO THE PRESTRESSING AS PER THE DESIGN.
5. CASTING OF UPPER PYLON SHALL BE CARRIED OUT SIMULTANEOUSLY WITH SEGMENT ERRECTION.



CONSTRUCTION STAGE -3
(SCALE 1:250)

1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ERECT THE SEGMENT (S3) ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
3. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
4. DO THE PRESTRESSING AS PER THE DESIGN.
5. CASTING OF UPPER PYLON SHALL BE CARRIED OUT SIMULTANEOUSLY WITH SEGMENT ERRECTION.



CONSTRUCTION STAGE -4
(SCALE 1:250)

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

THE CONSTRUCTION ARRANGEMENT SHOWN IS TENTATIVE AND MAY CHANGE IN DETAILED DESIGN STAGE.

LEGEND:

(Sn) - SEGMENT NUMBER

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	ex	KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\[ORIGINAL SIZE: A1]
C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 1 OF 6)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

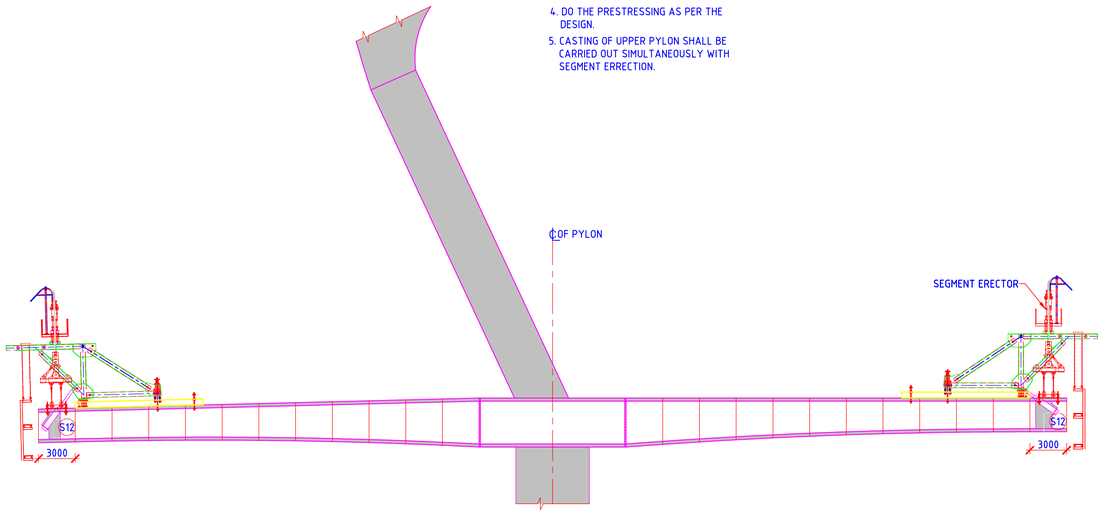
DRAWING NO: DDI 524

REV: 0

plot scale: 50mm

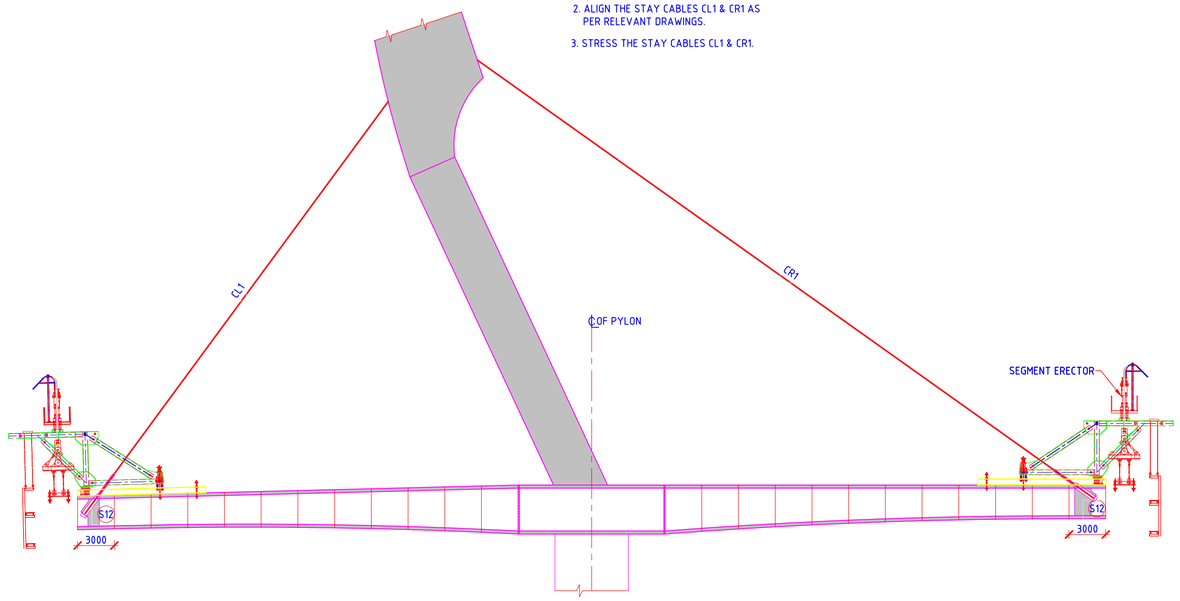
AUTO PATH: I:\BRIDGE\C1193601\TRIBAL - DPR-PONNANI CABLE STAYED BRIDGE\WORKING\DRAWINGS\DRAFT CAD\DRG\DDI 524 TO DDI 529-R0-IMG_CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE SHEET 1 TO 6.DWG

1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ERECT THE SEGMENT S12 ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
3. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
4. DO THE PRESTRESSING AS PER THE DESIGN.
5. CASTING OF UPPER PYLON SHALL BE CARRIED OUT SIMULTANEOUSLY WITH SEGMENT ERRECTION.



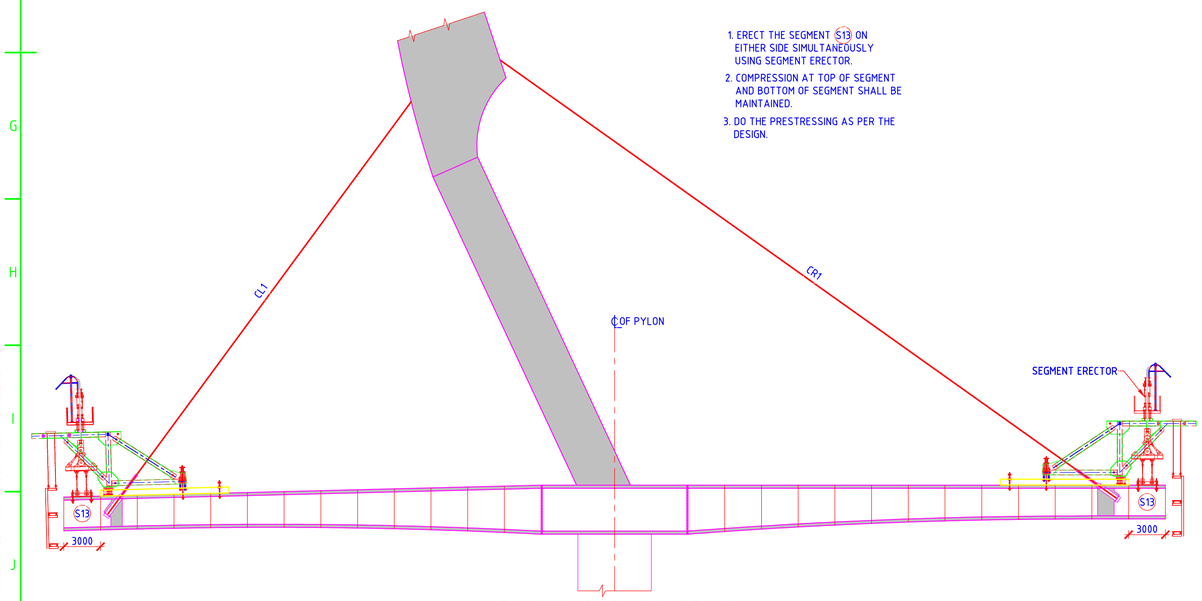
CONSTRUCTION STAGE -13
(SCALE 1:250)

1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ALIGN THE STAY CABLES CL1 & CR1 AS PER RELEVANT DRAWINGS.
3. STRESS THE STAY CABLES CL1 & CR1.



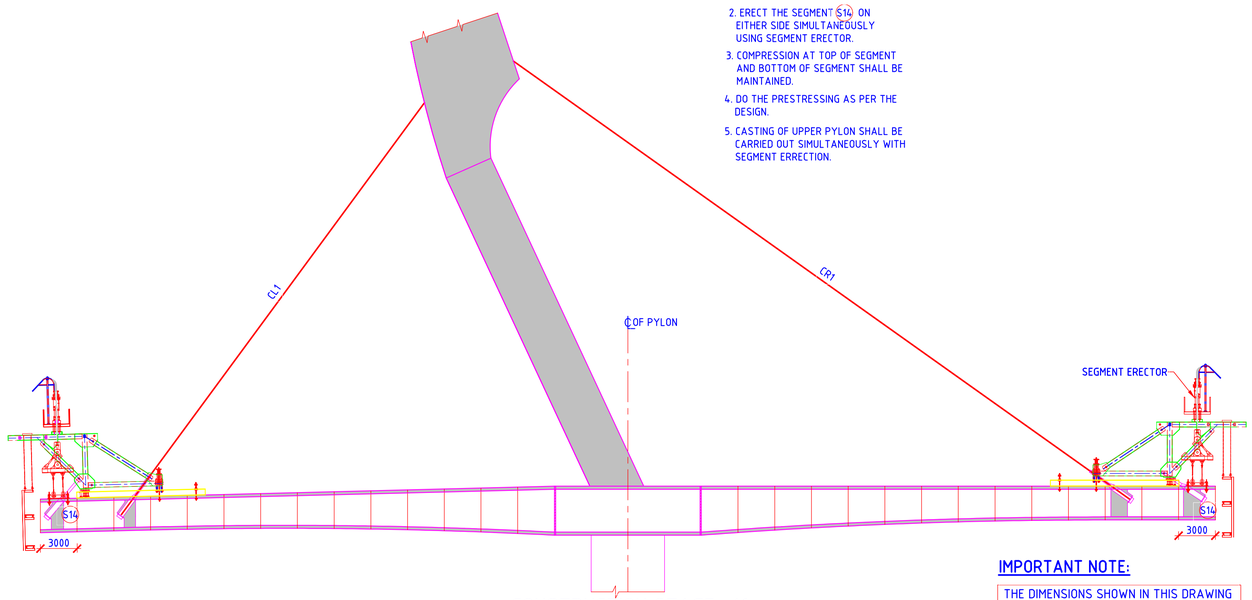
CONSTRUCTION STAGE -14
(SCALE 1:250)

1. ERECT THE SEGMENT S13 ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
2. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
3. DO THE PRESTRESSING AS PER THE DESIGN.



CONSTRUCTION STAGE -15
(SCALE 1:250)

1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ERECT THE SEGMENT S14 ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
3. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
4. DO THE PRESTRESSING AS PER THE DESIGN.
5. CASTING OF UPPER PYLON SHALL BE CARRIED OUT SIMULTANEOUSLY WITH SEGMENT ERRECTION.



CONSTRUCTION STAGE -16
(SCALE 1:250)

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

THE CONSTRUCTION ARRANGEMENT SHOWN IS TENTATIVE AND MAY CHANGE IN DETAILED DESIGN STAGE.

LEGEND:

(Sn) - SEGMENT NUMBER

IMPORTANT NOTE:

CONSTRUCTION SEQUENCE OF SEGEMENTS S4 TO S11 IS REPETITION OF SEGEMENTS S1/S2/S3 AND SHALL BE REFERRED TO THE SAME.

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	2003112	4	FIRST SUBMISSION	NRY	VKL	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\3Bridges\2019\[ORIGINAL SIZE: A1 C1193601-DPR -PONNANI CABLE STAYED BRIDGE\DRAWINGS\DRAFT CAD\DDG 503-504-505 GA, TO DDG 510-511-VKL, CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 1 TO 6).DWG

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 2 OF 6)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

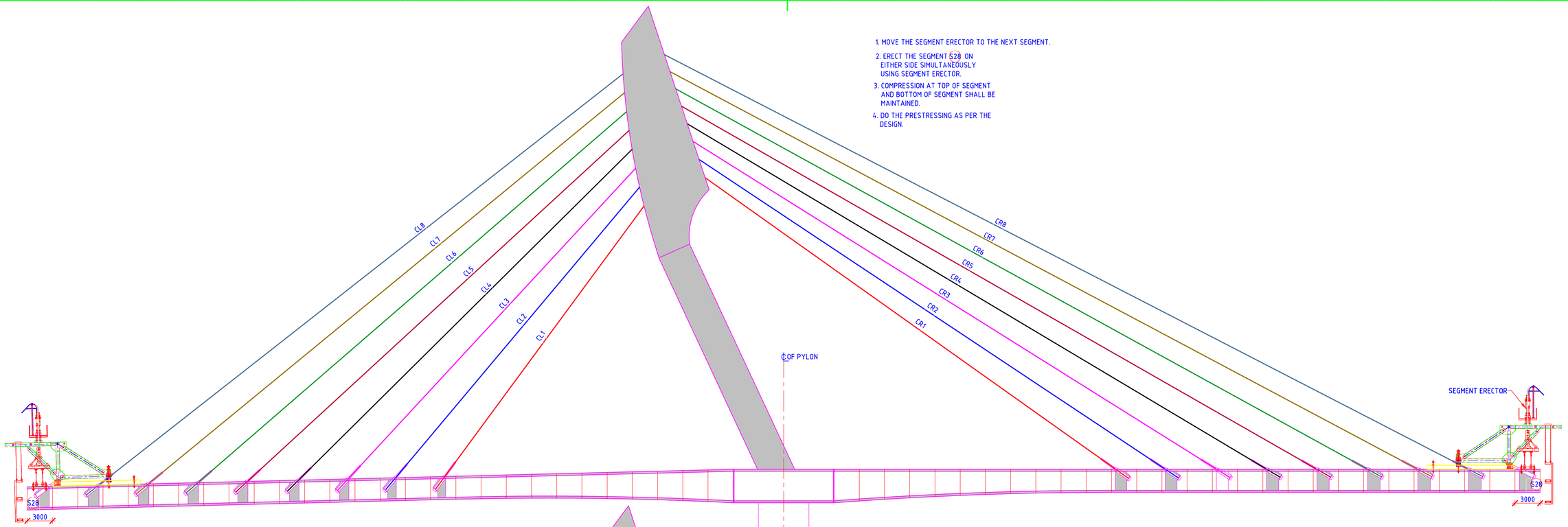
DRAWING NO: DDI 525

REV: 0

plot scale 50mm

TBNA

1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ERECT THE SEGMENT (S28) ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
3. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
4. DO THE PRESTRESSING AS PER THE DESIGN.



CONSTRUCTION STAGE -37
(SCALE 1:250)

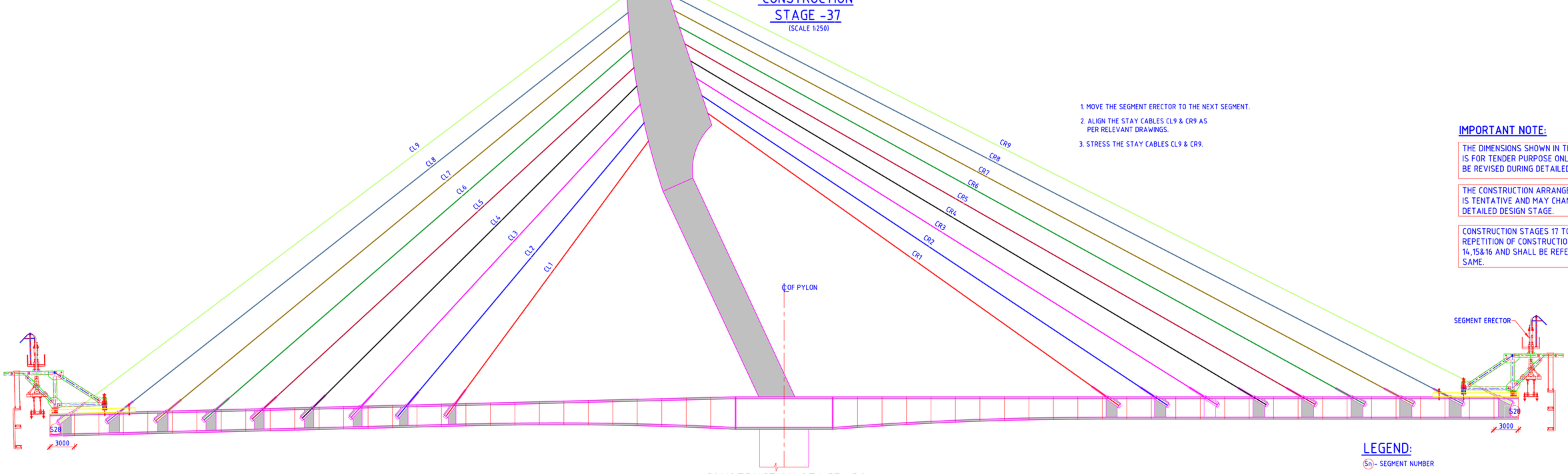
1. MOVE THE SEGMENT ERECTOR TO THE NEXT SEGMENT.
2. ALIGN THE STAY CABLES CL9 & CR9 AS PER RELEVANT DRAWINGS.
3. STRESS THE STAY CABLES CL9 & CR9.

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

THE CONSTRUCTION ARRANGEMENT SHOWN IS TENTATIVE AND MAY CHANGE IN DETAILED DESIGN STAGE.

CONSTRUCTION STAGES 17 TO 36 ARE REPETITION OF CONSTRUCTION STAGES 14,15&16 AND SHALL BE REFERRED TO SAME.



CONSTRUCTION STAGE -38
(SCALE 1:250)

LEGEND:
(Sn) - SEGMENT NUMBER

NOTES
1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\1Bridges\2019\[ORIGINAL SIZE A1 C1193601-DPR-PONNANI CABLE STAYED

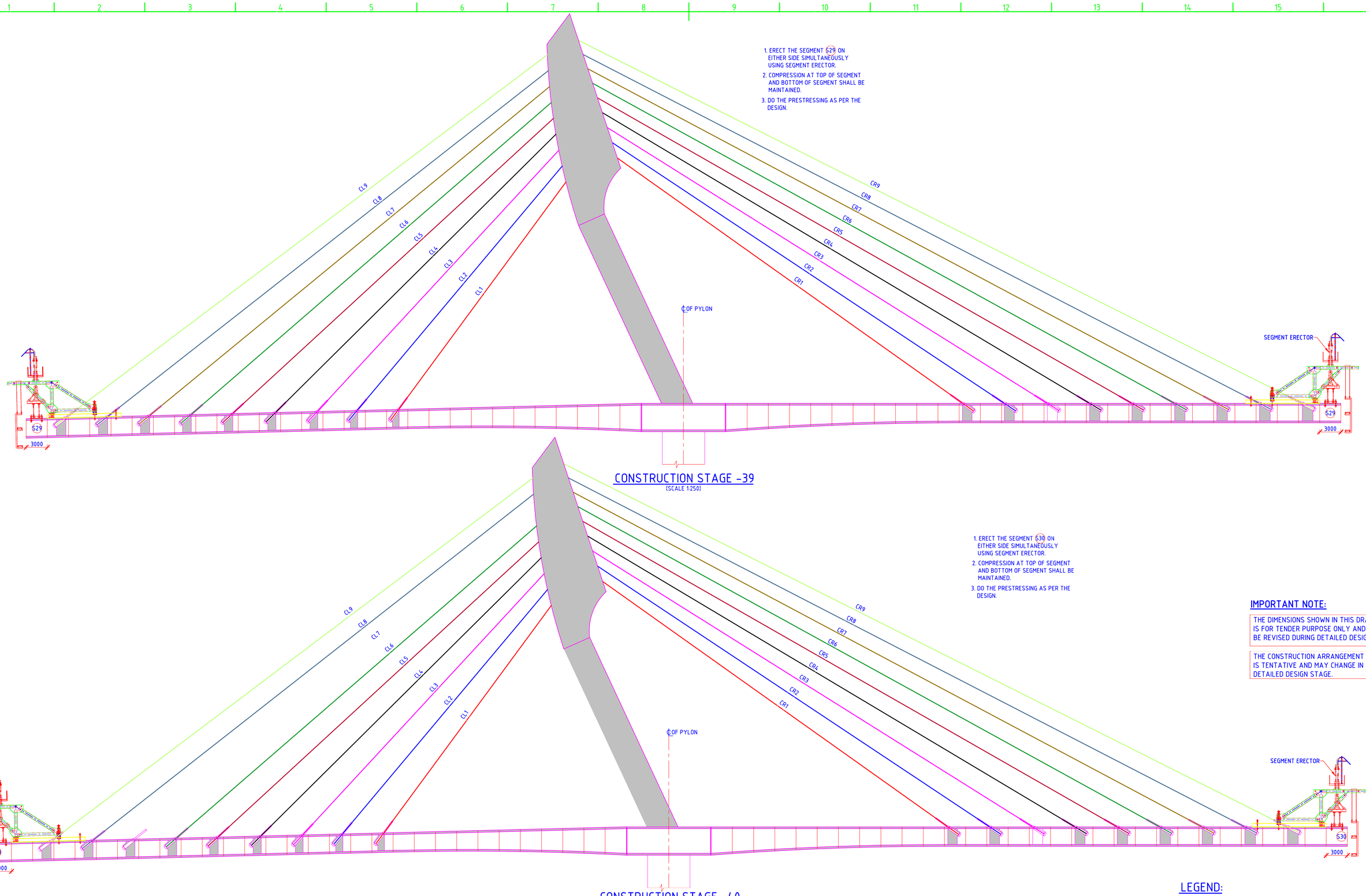
CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE — PROJECT NO: C1193601

TITLE: CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 3 OF 6) — COP: IRC — SCALE: AS SHOWN

L&T Infra Engineering — L&T Infrastructure Engineering Ltd. — DRAWING NO: DDI 526 — REV: 0

plot scale 50mm



IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

THE CONSTRUCTION ARRANGEMENT SHOWN IS TENTATIVE AND MAY CHANGE IN DETAILED DESIGN STAGE.

LEGEND:

(Sn) – SEGMENT NUMBER

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\[ORIGINAL SIZE: A1]
C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 4 OF 6)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

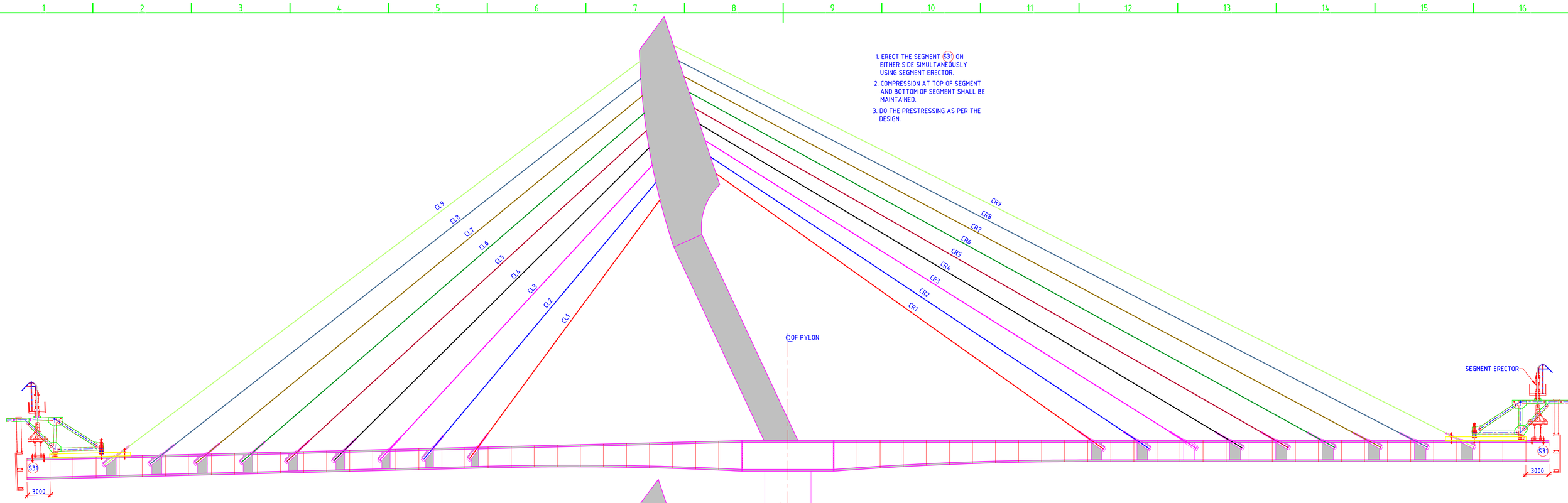
DRAWING NO.: DDI 527

REV.: 0

plot scale 50mm

AUTOPATH: I:\BRIDGE\C1193601\TRIBAL - DPR-PONNANI CABLE STAYED BRIDGE\WORKING\DRAWINGS\DWGF CAD\DDI\DDI 526 TO DDI 529-REV.1\DWG\CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE SHEET 1 TO 6.DWG

1. ERECT THE SEGMENT S31 ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
2. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
3. DO THE PRESTRESSING AS PER THE DESIGN.



CONSTRUCTION STAGE -41
(SCALE 1:250)

1. ERECT THE SEGMENT S32&S33ON EITHER SIDE SIMULTANEOUSLY USING SEGMENT ERECTOR.
2. COMPRESSION AT TOP OF SEGMENT AND BOTTOM OF SEGMENT SHALL BE MAINTAINED.
3. DO THE PRESTRESSING AS PER THE DESIGN.

IMPORTANT NOTE:

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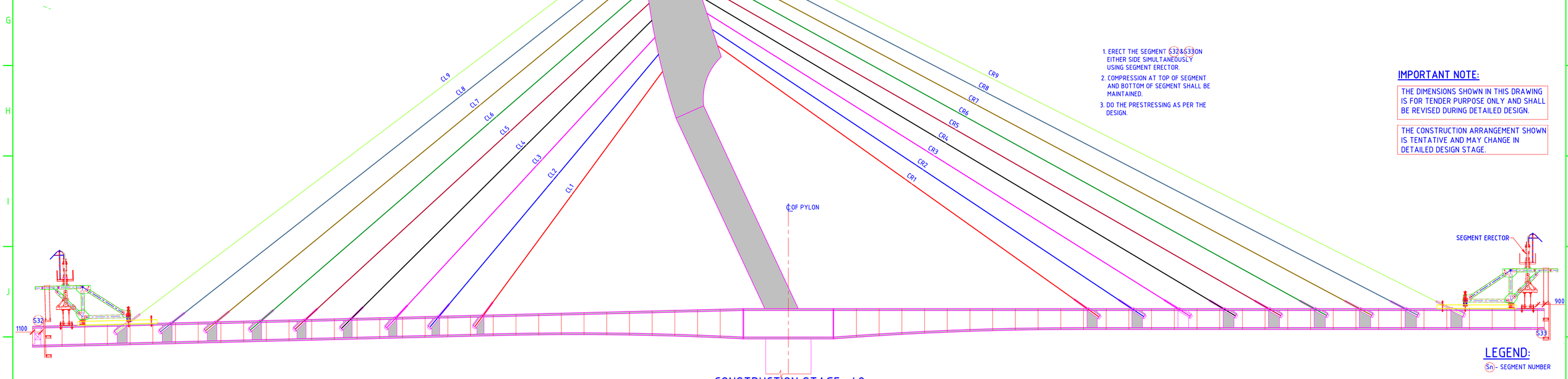
THE CONSTRUCTION ARRANGEMENT SHOWN IS TENTATIVE AND MAY CHANGE IN DETAILED DESIGN STAGE.



CONSTRUCTION STAGE -42
(SCALE 1:250)

LEGEND:

(Sn)- SEGMENT NUMBER

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	VKL	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\[ORIGINAL SIZE: A1]
C1193601-DPR - PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 5 OF 6)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

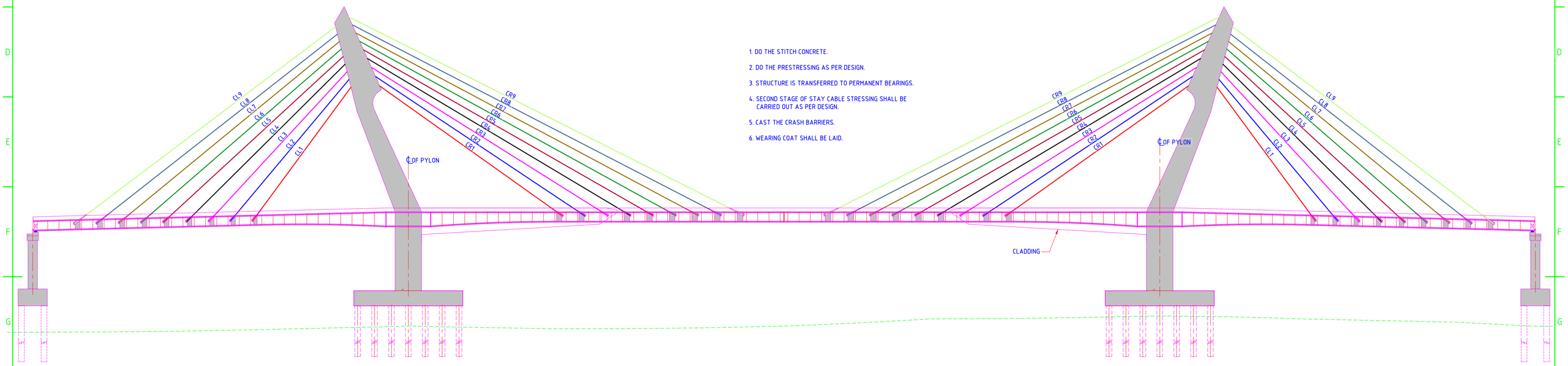
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 528

REV: 0

plot scale 50mm

AUTOPATH: I:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DWGF CAD\DDI\DDI 526 TO DDI 529-R0-WKL CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE SHEET 5 TO 6.DWG



1. DO THE STITCH CONCRETE.
2. DO THE PRESTRESSING AS PER DESIGN.
3. STRUCTURE IS TRANSFERRED TO PERMANENT BEARINGS.
4. SECOND STAGE OF STAY CABLE STRESSING SHALL BE CARRIED OUT AS PER DESIGN.
5. CAST THE CRASH BARRIERS.
6. WEARING COAT SHALL BE LAID.

CONSTRUCTION STAGE -43

(SCALE 1:500)

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

LEGEND:

(Sn) - SEGMENT NUMBER

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS, LEVELS & CHAINAGE ARE IN METERS UNLESS MENTIONED OTHERWISE.
2. DIMENSIONS ARE NOT TO BE SCALED ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDG 505	GENERAL ARRANGEMENT SECTIONS
DDG 504	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE
DDG 503	GENERAL ARRANGEMENT DRAWING FOR CABLE STAYED BRIDGE

REVISIONS

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH:\\Bridges\2019\C1193601-DPR-PONNANI CABLE STAYED

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 6 OF 6)

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 529

REV: 0

plot scale 50mm

AUTO PLOT BY: SUBHOSES\SUBHOSES - DPR-PONNANI CABLE STAYED BRIDGE\WORKING\DRAWINGS\DRAFT EACH\DDI 529 TO DDI 539 ARE FOR CONSTRUCTION SEQUENCE FOR CABLE STAYED BRIDGE (SHEET 1 TO 11).DWG

BRIDGE CAFE ATTACHED TO PYLON

NOTES:

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

DRAWING NO.	TITLE

REFERENCE DRAWINGS

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PATH: J:\BRIDGES\2019\C1193601-DPR-PONNANI CABLE

DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW - 1

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

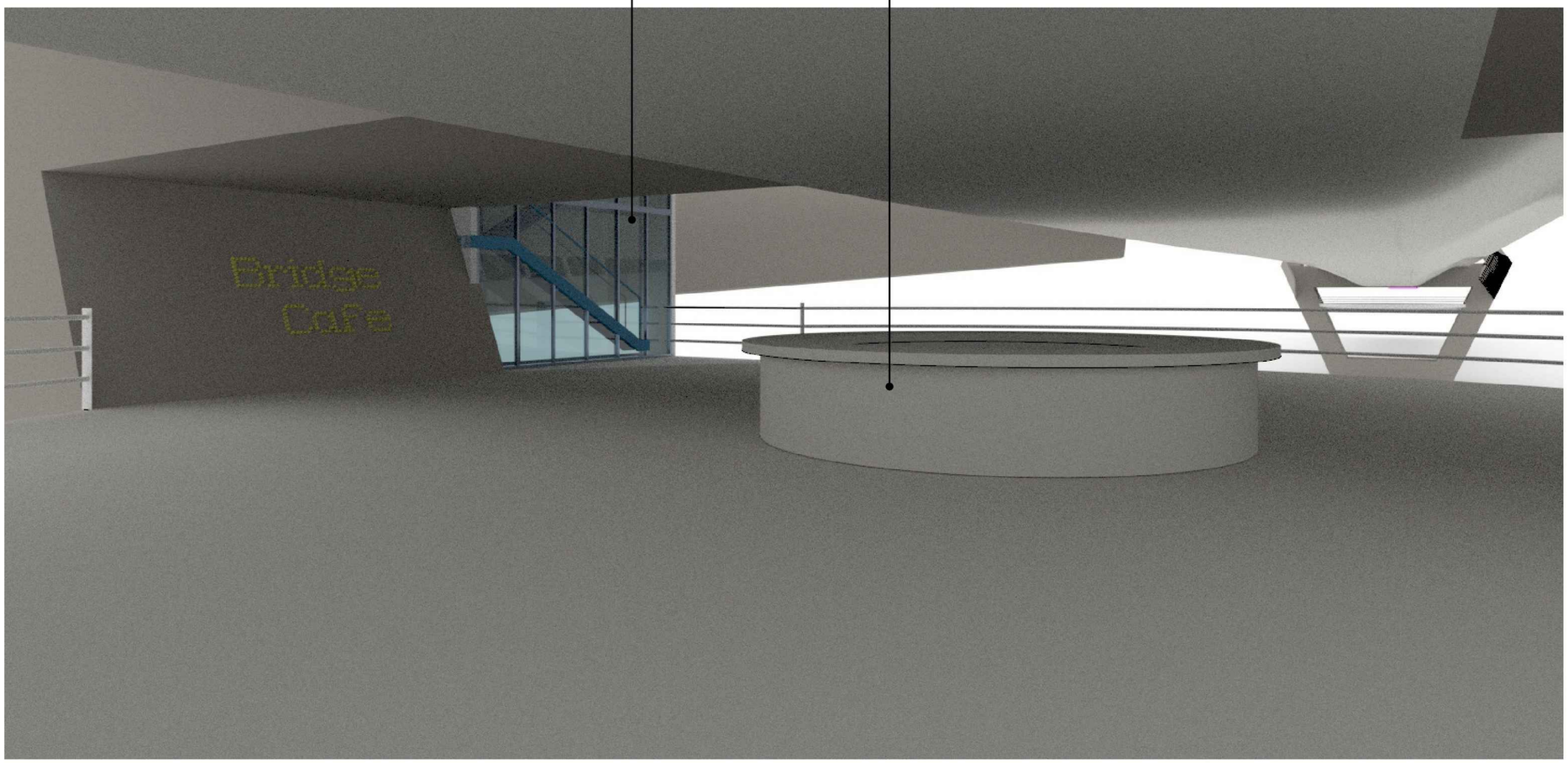
DRAWING NO: DDG 530

REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\R0\DDG 530-RR-VKL-ARCHITECTURAL ISOMETRIC VIEW-1.DWG

TBNA



BRIDGE CAFE INSIDE VIEW

NOTES:

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	INIT. CHECKED	SIGN.	INIT. APPROVED	SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\BridGes\2019\C1193601-DPR -PONNANI CABLE [DRG. SIZE: A2]

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE — PROJECT NO: C1193601

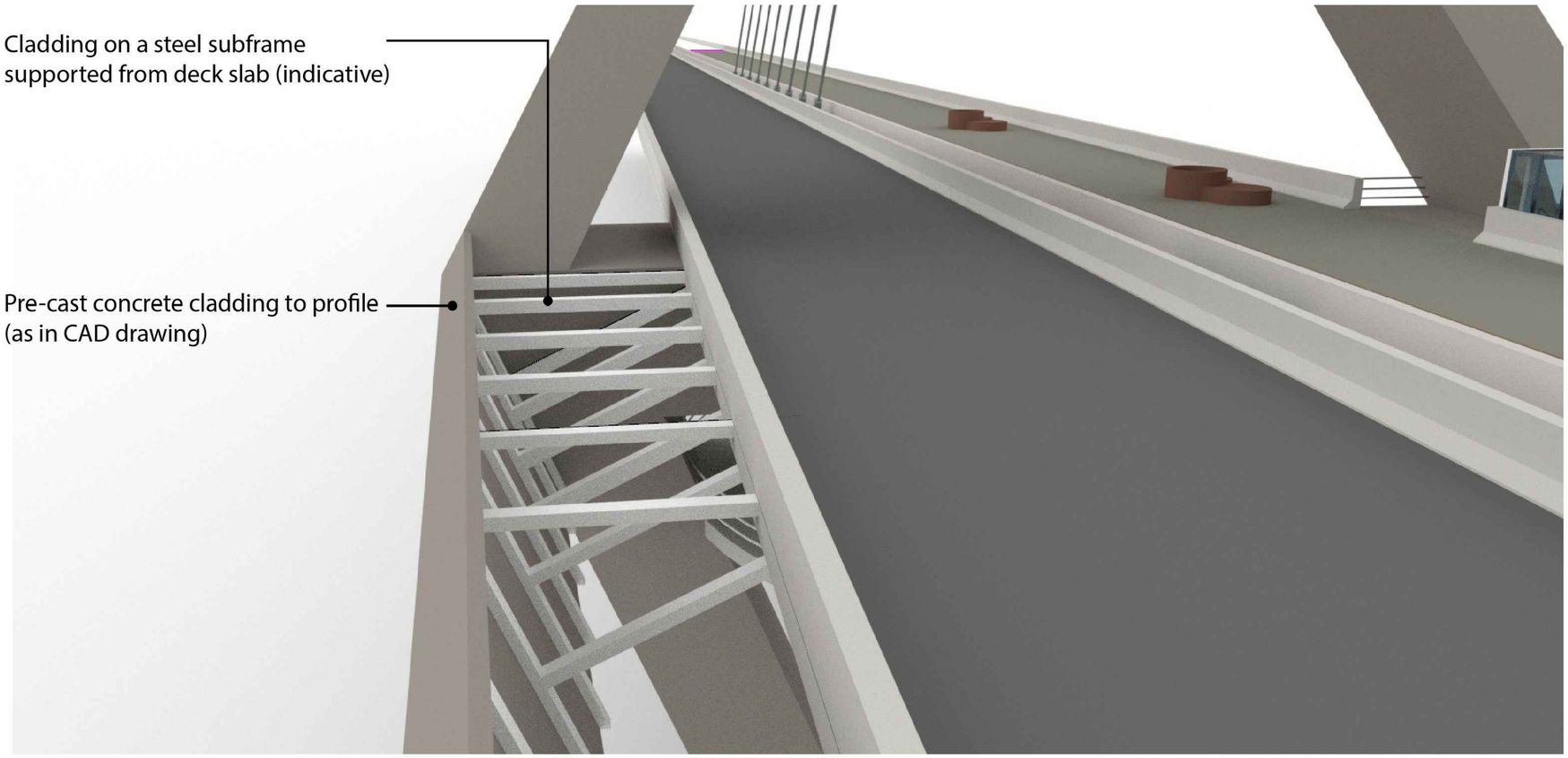
TITLE: ARCHITECTURAL ISOMETRIC VIEW-2 — COP: IRC — SCALE: AS SHOWN

L&T Infra Engineering — L&T Infrastructure Engineering Ltd. — DRAWING NO: DDG 531 — REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R0\DDG 531-R0-VKL-ARCHITECTURAL ISOMETRIC VIEW-2.DWG

TBNA



CLADDING ATTACHED TO BRIDGE

NOTES:

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	ex.	KGN	

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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PATH: J:\Bridges\2019\C1193601-DPR -PONNANI CABLE

DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW-3

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

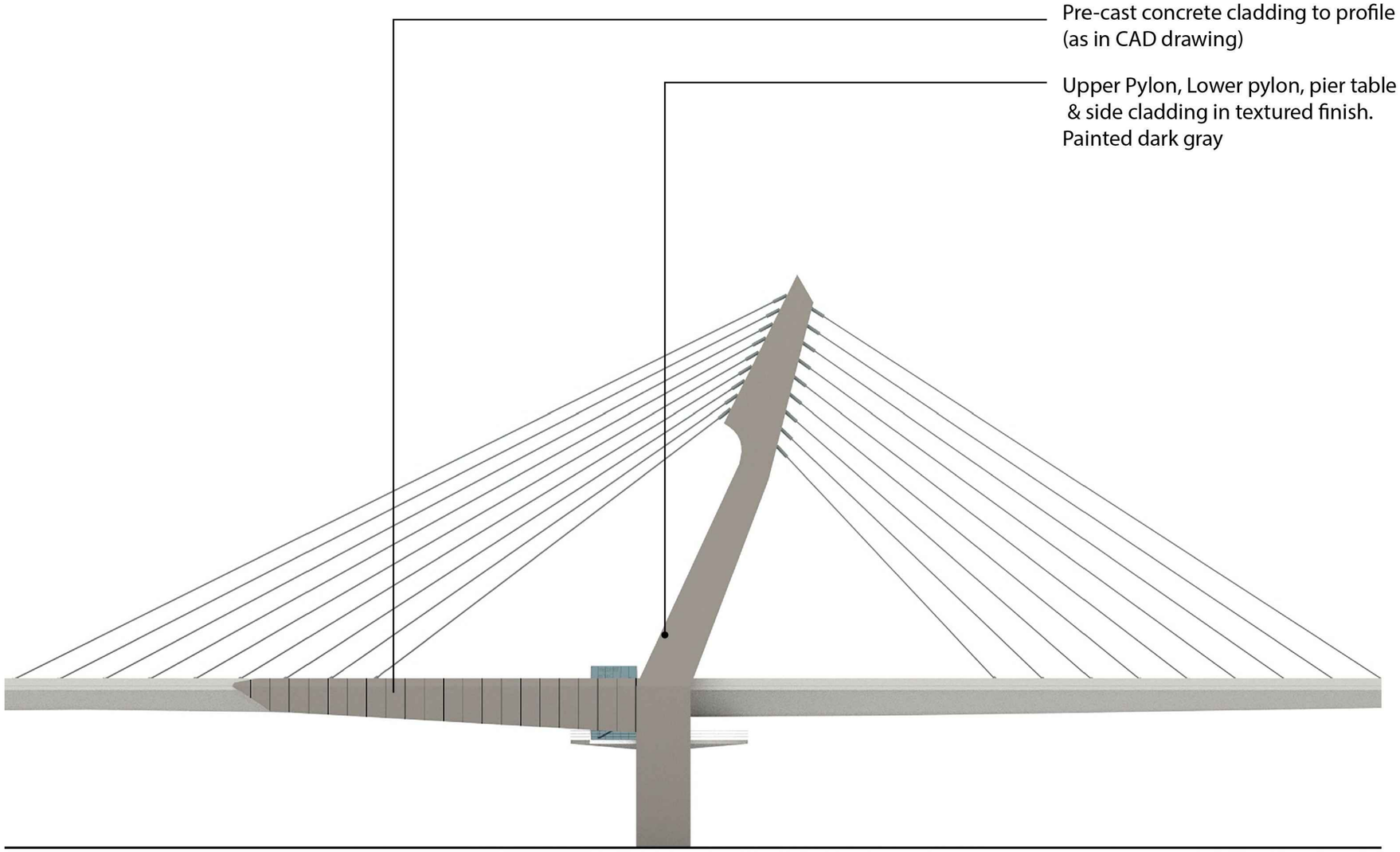
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 532 REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R0\DDG 532-R0-VKL-ARCHITECTURAL ISOMETRIC VIEW-3.DWG

TBNA



ELEVATION

NOTES:

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML ex	KGN

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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PATH: J:\BridgesV2019\C1193601-DPR-PONNANI CABLE

DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW-4

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

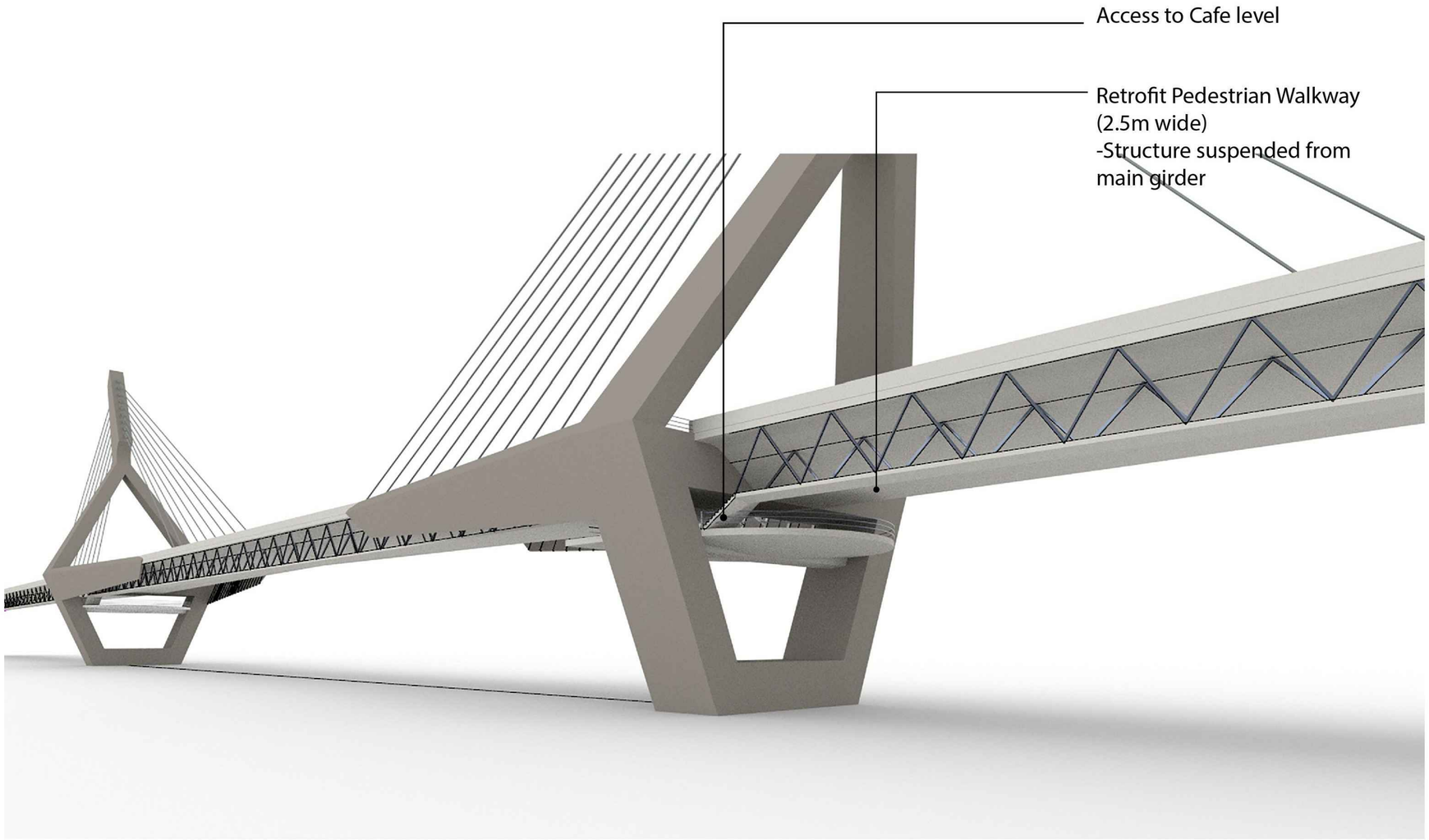
DRAWING NO: DDG 533 REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\REVIDDI 533-R0-VKL-ARCHITECTURAL ISOMETRIC VIEW-4.DWG

TBNA

AFTER CONVERSION TO 4 LANE TRAFFIC



ISOMETRIC VIEW WITH PEDESTRIAL WALK WAY

NOTES:

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML ex	KGN
	YYMMDD					INIT. SIGN.	INIT. SIGN.

DRAWING NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\Bridges\2019\C1193601-DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\DDG 534-RD-VKL-ARCHITECTURAL ISOMETRIC VIEW-5.DWG

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW-5

COP: IRC

SCALE: AS SHOWN

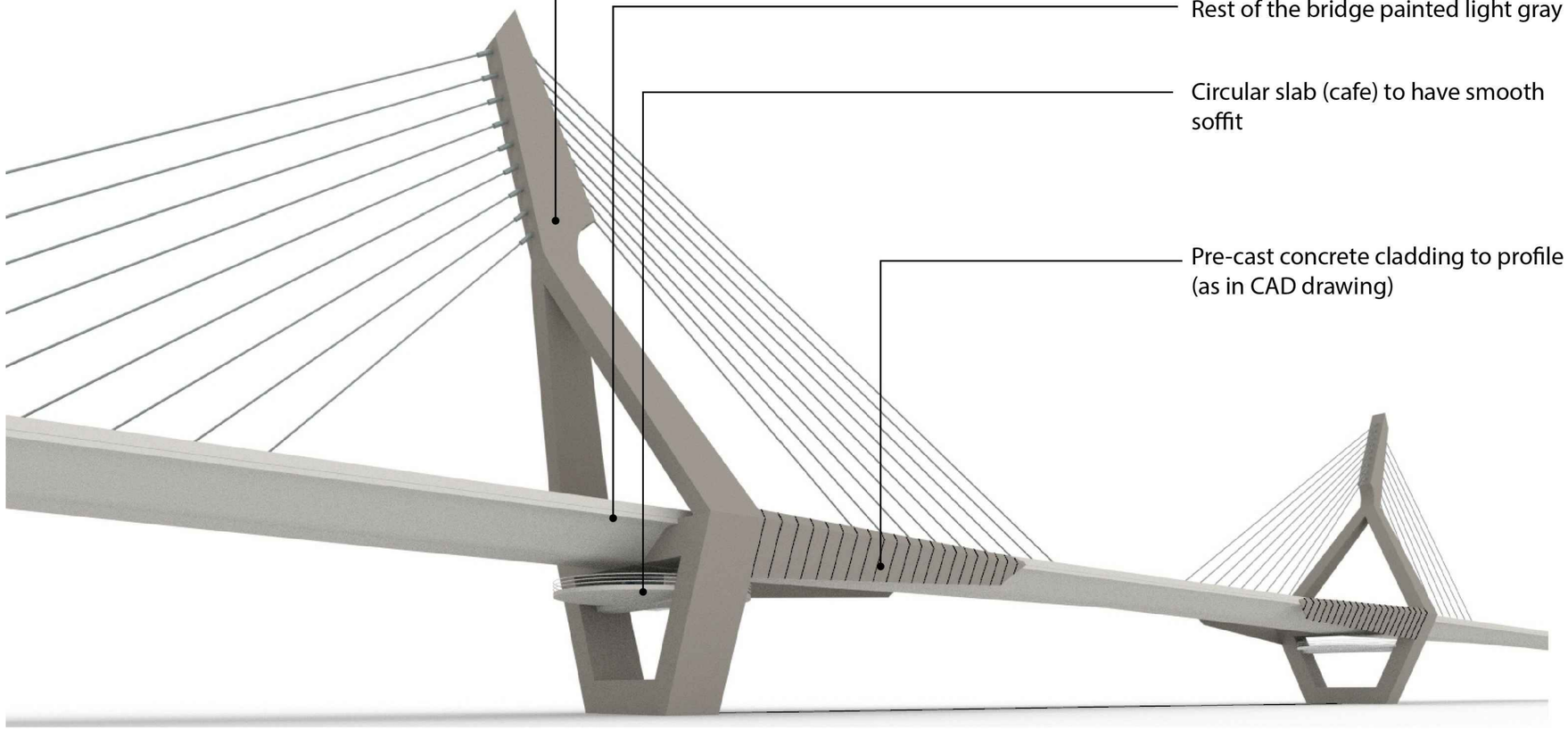
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 534 | REV: 0

plot scale 50mm

TBNA



ISOMETRIC VIEW

NOTES:

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
						INIT. SIGN.	INIT. SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	KGN

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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PATH: J:\Bridges\2019\C1193601-DPR -PONNANI CABLE

DRWG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW-6

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

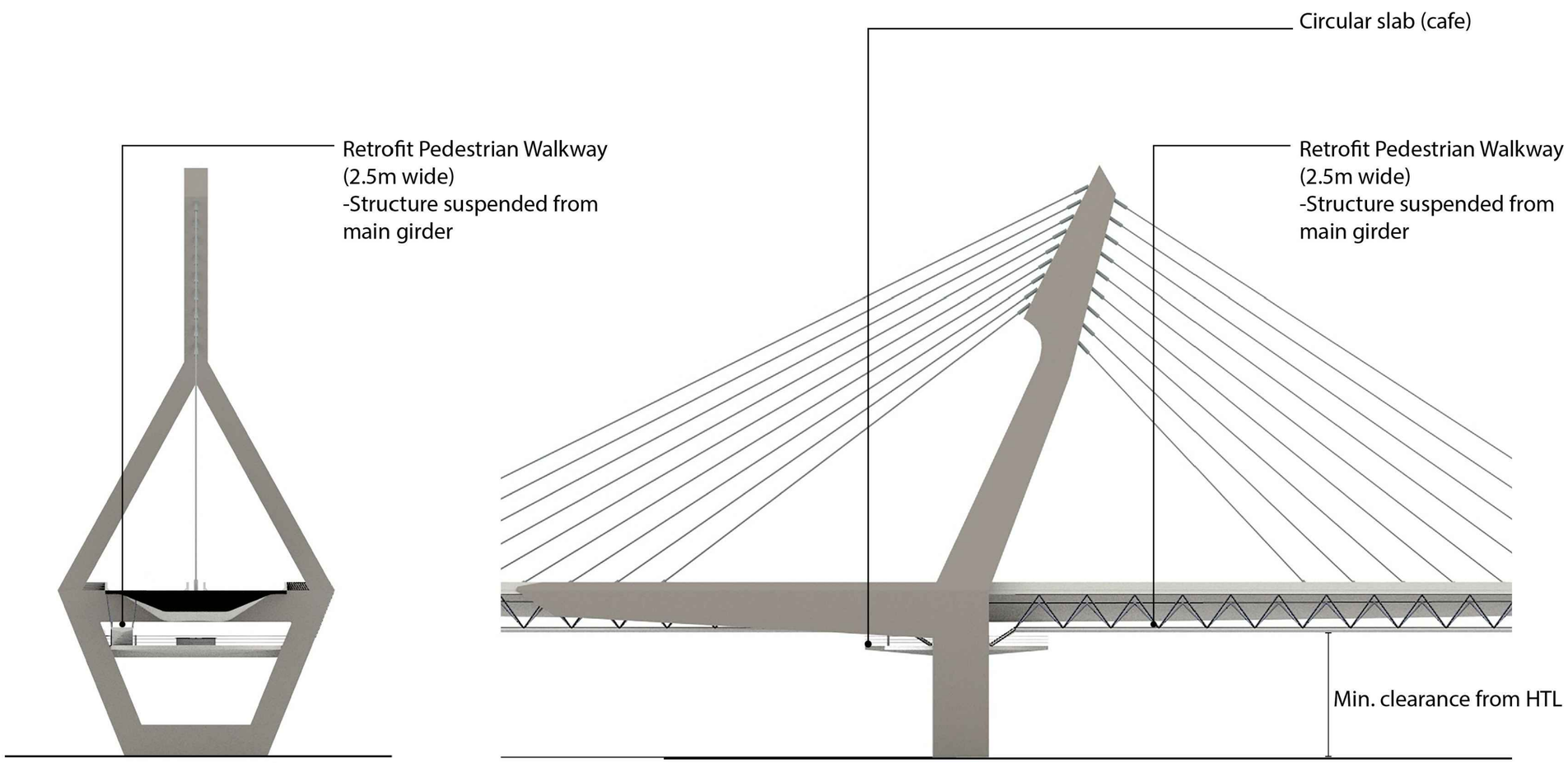
DRAWING NO: DDG 535 REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BR\WORKING\DRAWINGS\DRAFT GAD\R0\DDG 535-R0-VKL-ARCHITECTURAL ISOMETRIC VIEW-6.DWG

TBNA

AFTER CONVERSION TO 4 LANE TRAFFIC



PEDESTRIAN WALKWAY - FUTURE PROPOSAL

NOTES:

REV.	DATE (YYMMDD)	STATUS	DESCRIPTION	DES.	DRN.	CHECKED INIT.	CHECKED SIGN.	APPROVED INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML	ex	KGN	

REVISIONS

DRAWING NO.	TITLE

REFERENCE DRAWINGS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

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PATH: J:\Bridges\2019\C1193601-DPR-PONNANI CABLE | DRG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW-7

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

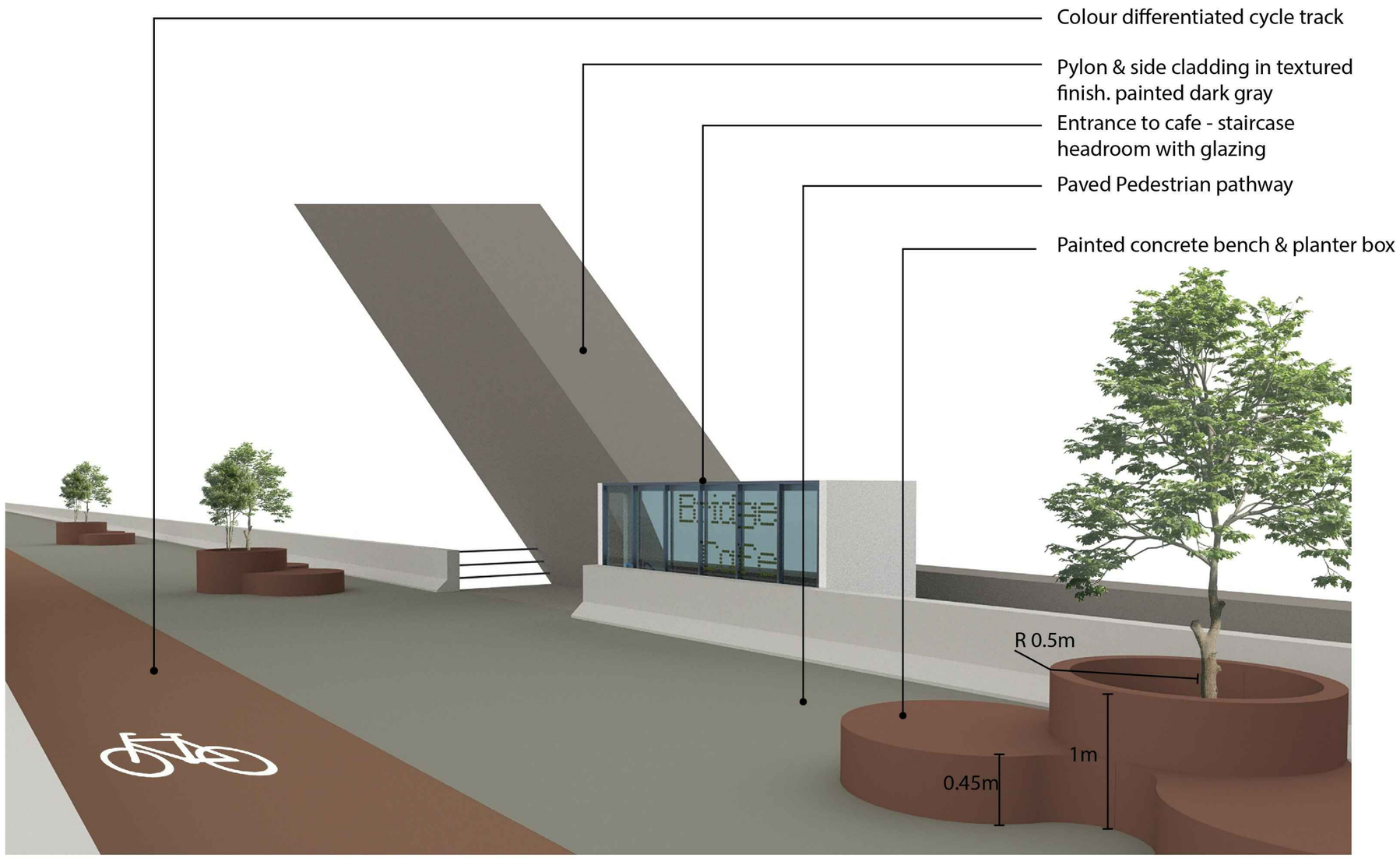
L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 536 | REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\REVISED\ DDG 536-R0-VKL-ARCHITECTURAL ISOMETRIC VIEW-7.DWG

TBNA



REST AREA ON BRIDGE DECK

NOTES:

REV.	DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED	APPROVED
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML ex	KGN

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

DRAWING NO. | TITLE

REFERENCE DRAWINGS

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PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\RIVUDI 531-R6-VKL-ARCHITECTURAL ISOMETRIC VIEW-8.DWG

DRG. SIZE: A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: ARCHITECTURAL ISOMETRIC VIEW-8

COP: IRC

SCALE: AS SHOWN

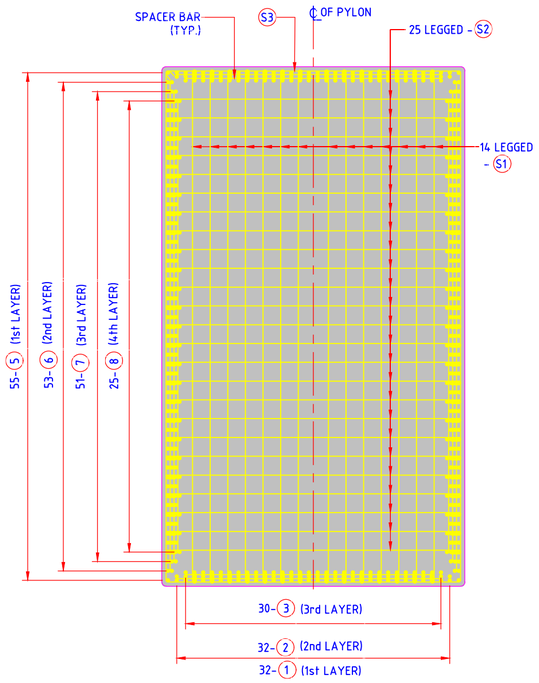
L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDG 537 REV: 0

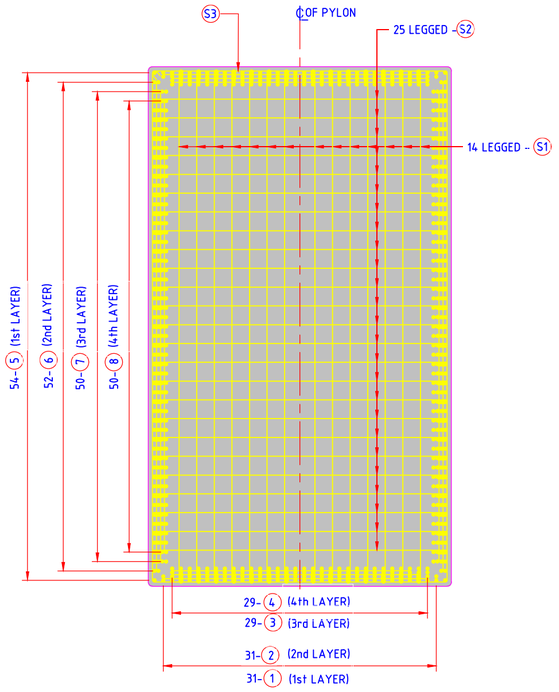
plot scale 50mm

TBNA



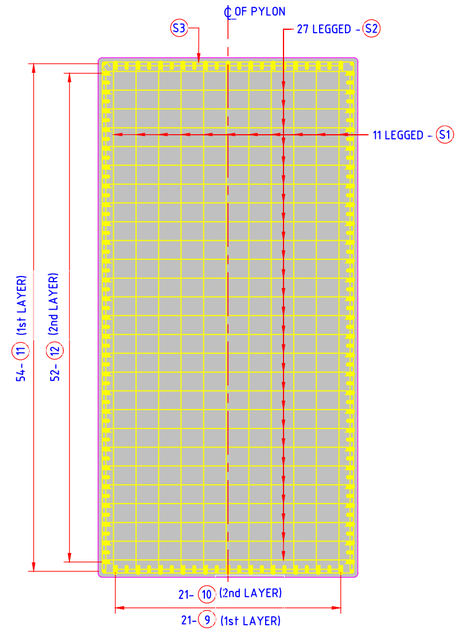
REINFORCEMENT DETAIL OF LOWER PYLON AT PILE CAP TOP

(SCALE 1:50)



REINFORCEMENT DETAIL OF LOWER PYLON BELOW DECK TOP

(SCALE 1:50)



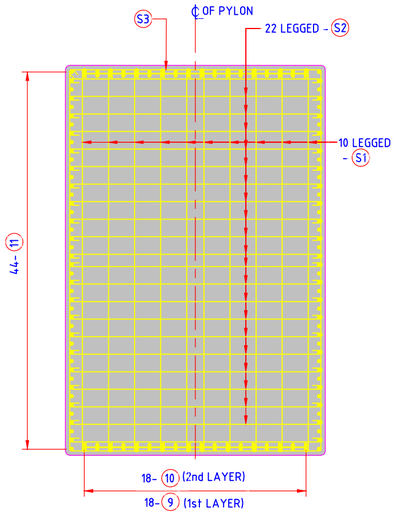
REINFORCEMENT DETAIL OF UPPER PYLON AT DECK TOP

(SCALE 1:50)

SCHEDULE OF REINFORCEMENT:

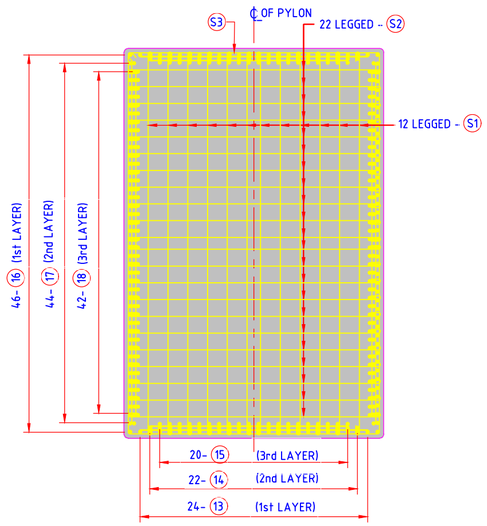
BAR MARK	BAR DESCRIPTION	SHAPE & DIMENSION
1	Y40	
2	Y40	
3	Y40	
4	Y40	
5	Y40	
6	Y40	
7	Y40	
8	Y40	
9	Y40	
10	Y40	
11	Y40	
12	Y40	
13	Y40	
14	Y40	
15	Y40	
16	Y40	
17	Y40	
18	Y40	
S1	Y12	
S2	Y12	
S3	Y12	

LAST BAR MARK USED 18 & S3



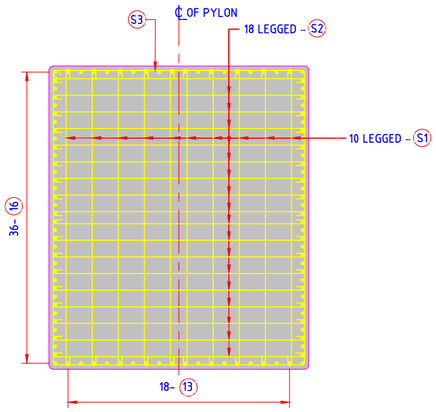
REINFORCEMENT DETAIL OF UPPER PYLON AT PYLON TOP

(SCALE 1:50)



REINFORCEMENT DETAIL OF ANCHORAGE SECTION AT BOTTOM

(SCALE 1:50)



REINFORCEMENT DETAIL OF ANCHORAGE SECTION AT TOP

(SCALE 1:50)

LEGEND:

℄	- CENTER LINE
(TYP.)	- TYPICAL
B/S	- BOTH SIDES
HTL	- HIGH TIDE LEVEL
LTL	- LOW TIDE LEVEL

IMPORTANT NOTE:

THE DIMENSIONS SHOWN IN THIS DRAWING IS FOR TENDER PURPOSE ONLY AND SHALL BE REVISED DURING DETAILED DESIGN.

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES UNLESS OTHERWISE MENTIONED .
2. DIMENSIONS ARE NOT TO BE SCALED, ONLY WRITTEN DIMENSIONS SHALL BE FOLLOWED.
3. GRADE OF CONCRETE SHALL BE M55 FOR UPPER PYLON & M50 FOR LOWER PYLON.
4. MINIMUM CLEAR COVER FOR OUTERMOST REINFORCEMENT SHALL BE 50mm.
5. GRADE OF REINFORCEMENT SHALL BE Fe500D (CORROSION RESISTANT STEEL), CONFORMING TO IS: 1786 (LATEST).
6. FOR ANCHORAGE AND LAP LENGTH REFER IRC 112:2011.
7. NOT MORE THAN 50% OF BARS SHALL BE LAPPED AT A SECTION. LAPS SHALL BE STAGGERED.

REFERENCE DRAWINGS

DRAWING NO.	TITLE
DDI 521	NUMERATION DETAILS OF PYLON

REVISIONS

STATUS CODES 1 : PRELIMINARY 2 : FOR APPROVAL 3 : GOOD FOR CONSTRUCTION 4 : FOR TENDER

REV.	YYMMDD DATE	STATUS	DESCRIPTION	DES.	DRN.	CHECKED PML INIT.	CHECKED SIGN.	APPROVED KGN INIT.	APPROVED SIGN.
0	200312	4	FIRST SUBMISSION	NRY	CKT	PML		KGN	

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PATH: J:\Bridges\2019\C1193601-DPR -PONNANI CABLE STAYED BRIDGE\DRNG. SIZE A2

CLIENT: ROADS AND BRIDGES DEVELOPMENT CORPORATION OF KERALA LTD.

PROJECT: DPR FOR PONNANI CABLE STAYED BRIDGE

PROJECT NO: C1193601

TITLE: RC DETAILS OF PYLON

COP: IRC

SCALE: AS SHOWN

L&T Infra Engineering

L&T Infrastructure Engineering Ltd.

DRAWING NO: DDI 538 REV: 0

plot scale 50mm

AUTO PATH: J:\BRIDGES\2019\C1193601 - DPR-PONNANI CABLE STAYED BRI\WORKING\DRAWINGS\DRAFT GAD\R0\DDI 538-R0-VKL-RC DETAILS OF PYLON.DWG

TBNA