REPORT

Development of Greenfield Vadhavan Port

Detailed Project Report - Road Connectivity to proposed Greenfield Vadhavan Port

Client: Jawaharlal Nehru Port Trust

Reference: DI1452-RHD-DP-XX-RP-PM-0001

Status: Draft/P01

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Project related

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Classification
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Table of Contents

Table of Tables

Table of Figures

Appendices

Revision History

Rev	Date	Prepared	Checked	Approved	Modification	Status
R0	13th Jan 2022	Project Team	SK Raina	Sanjay Mittal		
R1	28th Jan 2022	Project Team	SK Raina	Sanjay Mittal	Modified as per Partial Topographic Survey Data	

Acronym/ Abbreviations and Technical Terms

Acronym	Full Form
BIS	Bureau of Indian Standards
CAGR	Compound Annual Growth Rate
CBR	California Bearing Ratio
CVPD	Commercial Vehicle Per Day
CWC	Central Water Commission
DFCCIL	Dedicated Freight Corridor Corporation Ltd.
DPR	Detailed Project Report
FMCG	Fast Moving Consumer Goods
FT	Feet
GOI	Government of India
HFL	High Flood Level
HR	Hour
IMD	India Meteorological Department
IRC	Indian Road Congress
JNPT	Jawaharlal Nehru Port Trust
JV	Joint Venture
LED	Light Emitting Diode
LPG	Liquid Petroleum Gas
MDR	Major District Road
MMB	Mumbai
MMTPA	Million Metric Tonne Per Annum
MORTH	Ministry of Road Transport and Highways
MRVC	Mumbai Rail Vikas Corporation
MSA	Million Standard Axle
MSL	Mean Sea Level
MT	Metric Tonne
NH	National Highway
NHAI	National Highway Authority of India
ODR	Other District Road
PCUs	Passenger Car Unit
POT-PTFE	Pot Polytetrafluoroethylene
PSC	Pre-Stressed Concrete
RCC	Reinforced Cement Concrete
RDSO	Research Designs and Standards Organization

RFID	Radio Frequency Identification
ROB	Road Over Bridge
ROW	Right of Way
RUBs	Road Under Bridges
VDF	Vehicle Damage Factor
VDR	Vadodara
WDFC	Western Dedicated Freight Corridor
WR	Western Railway

Executive Summary

This Report

The Jawaharlal Nehru Port Trust (JNPT) at Navi Mumbai (formerly known as the Nhava Sheva Port) is India's No. 1 container port across all major ports in India. JNPT occupies a prominent place among the most modern ports in India and is ranked 28th among the top 100 container Ports in the world. In last three decades, JNPT systematically evolved its operational efficiency and improved its handling capacity to transform itself into a Port at par with global standards.

JNPT has been assigned the responsibility to develop Vadhavan port as a major port on landlord port development model. Vadhavan port site has natural and strategic advantages to become a mega port and has prospect of achieving throughput of 300 million Tonnes.

Proposed Port Road Route

As per previous JNPT DPR (2018), Seven (7) options of road alignment were evaluated against set of parameters and out of these, 2 alignments were short listed for further detailed evaluation on technical aspect, cost consideration, societal issues and availability of government land etc. The details of final two selected alignment is shown in figure below.

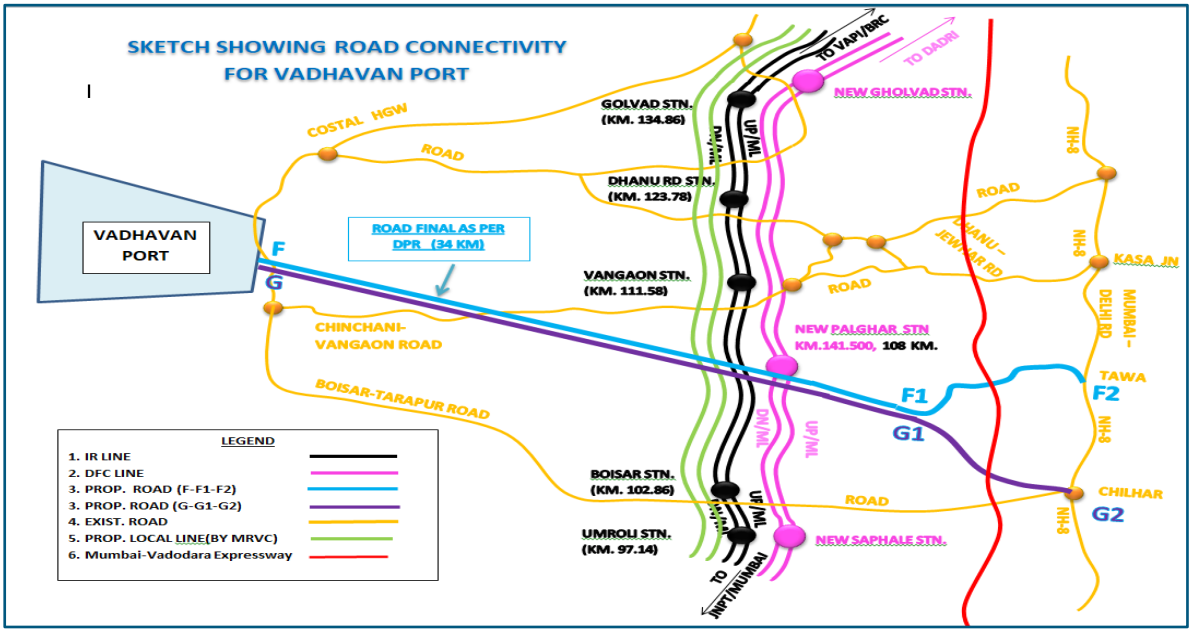


Figure 1-1Road Connectivity for Vadhavan Port

- Option I-F-F1-F2- Varor (Vadhavan port) to NH-08 (Tawa Junction)
- Option-II-G-G1-G2- Varor (Vadhavan port) to NH-08 (Chilhar)

Option I (F-F1-F2) have been finally recommended for further studies. The Detail Project Report for this alignment was prepared by M/s Progen Consultants for JNPT.

The difference between the road alignment as per JNPT DPR -2018 and as per current DPR -2022 i.e. based on partial topographic survey data has been given as an Appendix 1.4- Variation Between Road Alignment As Per DPR 2018 and Current DPR 2022.
Further review and detailed engineering designs, which is the present mandate, is being done for the Option I alignment as per partial survey data received from JNPT Surveyor i.e. from Varor (Vadhavan Port) to NH 8 (near Tawa Junction).

The road alignment starts from Varor (Vadhavan port) and ends at NH-08 (Tawa junction) between coordinates 19°55'10.41"N, 72°40'34.28"E and 19°52'47.68"N, 72°56'40.50"E. The length of the new road is about 32.30 Km. The proposed Port Rail alignment runs along to road alignment for initial 12 Km or so. Road and Rail route map is as shown in figure below:

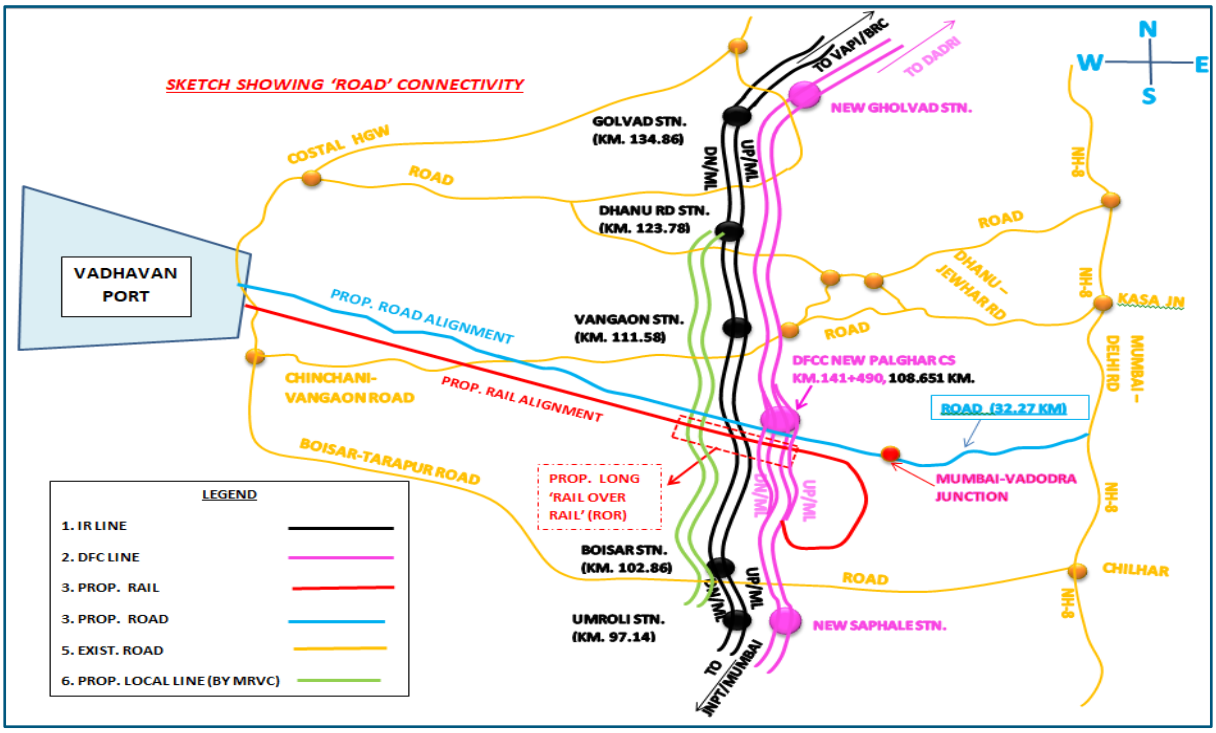


Figure 1-2 Rail and Road Connectivity

Traffic & Engineering Survey & Investigations

Based on the traffic study, as part of DPR up-dation, the traffic projections have been done till year 2050.

The reassessment and up-dation of potential traffic for the new port is being separately studied by the lead consultant of this study *M/s Royal HaskoningDHV.* The study is 'ongoing' and 'Work in Progress (WIP)'. The overall traffic assessment, as of date, is as follows:

Table 1-1 Current & Projected Traffic on Road

S. No.	Commodity	Truck Movements per day		
		2030	*2040*	*2050*
Outgoing				
1.	Fertiliser	86	86	100
2.	Edible Oil	135	162	189
3.	LPG	74	100	124
4.	Chemicals	143	175	206
Total Outgoing Trucks per Day		**437**	**522**	**619**
Incoming				
5.	RO-RO	28	97	130
Total Incoming Trucks per Day		**28**	**97**	**130**

S. No.	Commodity	Truck Movements per day		
		2030	*2040*	*2050*
Incoming /Outgoing				
6.	General Cargo	686	1.314	2,057
7.	Coastal Cargo	486	914	1,429
8.	Containers (EXIM)	11,338	30,818	49,154
Total Incoming/ Outgoing Trucks per Day		**12,509**	**33,046**	**52,640**
Total Trucks to be Handled per Day (incoming and Outgoing)		**13,441**	**34,284**	**54,137**
Total PCUs to be handled per day (Truck 3; Container Trailer 4.5)		**57,329**	**149,079**	**236,142**

[Source: Data received from M/s Royal HaskoningDHV]

Recommended Number of Lanes

Table 1-2 Recommended Number of Lanes for the Project

	Proposed		
Year	2030	2040	2050
Traffic Projections (in PCUs)	**57,329**	**149,079**	**236,142**
No. of Lane Required (considering Peak Hour Flow of 6%)	**4**	**8**	**12**

For the purpose of this Report, an eight lane highway is being considered which can be expanded in future as per the actual growth of traffic. It is suggested that, based on the future traffic growth rate, revised traffic survey needs to be carried out to finalize the additional number of lanes to be developed.

Considering the traffic, number of lanes and speed requirements, the Port Road will be designed to the IRC's (Indian Road Congress) 'Expressway' standards.

Design Standards and Specifications

The road (expressway) is proposed to be 'access controlled' road where entry and exits are planned to be provided at predetermined locations to give access to the National Highway (NH8) and the proposed Mumbai – Vadodara Expressway under construction. A new road is designed based on numerous considerations such as type and volume of traffic, Design Speed, Safety, Capital and Maintenance Costs, Operational Efficiency, Aesthetics and Control & Management of traffic. The primary engineering considerations for geometric designs are appropriate horizontal & vertical alignment design and effective management of surface runoff.

Summary of Design Features of Port Road

Following are the design parameters adopted for proposed port road:

Table 1-3 Summary of the Proposed Road

Parameter	Description	Provision
No. of Lane	Lane	8 Lane
Guidelines & Standards	IRC, NHAI, MoRTH	

<table>
<tr><th>Parameter</th><th>Description</th><th>Provision</th></tr>
<tr><td rowspan="7">Type of Traffic</td><td>Total traffic</td><td>34,284/day (for 2040) 1429/hr</td></tr>
<tr><td>Heavy Vehicle:</td><td></td></tr>
<tr><td>Container</td><td>20/ 40 ft</td></tr>
<tr><td>General Cargo/Coastal Cargo</td><td>10 M.T.</td></tr>
<tr><td>Liquid</td><td>18 M.T.</td></tr>
<tr><td>Dry Bulk</td><td>10 M.T.</td></tr>
<tr><td>IRC Class 70R</td><td>Multi Trailer Vehicle</td></tr>
<tr><td rowspan="2">Wheel Load (Class 70R)</td><td>Single Axle Load</td><td>20 tonne (As per IRC 6-2017: Clause 204.1.3)</td></tr>
<tr><td>Single Wheel Load</td><td>5.1 tonne</td></tr>
<tr><td>Total Truck Load Considered</td><td>100 t = 980665 N</td><td>(As per IRC 6-2014: Clause 204.1.3)</td></tr>
<tr><td rowspan="11">Road Alignment Details</td><td>Design Speed</td><td>120 Kmph (as per IRC SP 99-2013: Clause 2.2.1)</td></tr>
<tr><td>Right of Way</td><td>120 m</td></tr>
<tr><td>Lane width</td><td>3.75 m (as per IRC SP 99-2013: Clause 2.4)</td></tr>
<tr><td>Median</td><td>Adopted 3 m Flush median as per JNPT advice against Recommended= 4.5m as per IRC: SP: 99-2013: Clause 2.5.1</td></tr>
<tr><td>Paved Shoulder
Earthen Shoulder</td><td>Adopted 1.5 m paved shoulder against 3 m provided in IRC: SP 99 clause 2.6.1
Adopted 1.0 m gravel shoulder against 2 m provided in IRC: SP 99 clause 2.6.1</td></tr>
<tr><td>Super elevation</td><td>As per IRC for designed speed of 120 km/hr</td></tr>
<tr><td>Crossfall (Camber)</td><td>2.5% (Unidirectional (IRC SP 99 Clause 2.8)</td></tr>
<tr><td>Radius of Horizontal Curve</td><td>Desirable minimum 1000 mm for 120 Km/hr</td></tr>
<tr><td>Length of Transition Curve</td><td><table><tr><th>Design Speed (Km/h)</th><th>Minimum Length of Transition Curve (m)</th></tr><tr><td>120</td><td>100</td></tr><tr><td>100</td><td>85</td></tr><tr><td>80</td><td>70</td></tr></table>Adopted 100 m for design speed of 120 Kmph (IRC: SP: 99 Clause 2.9.2.4)</td></tr>
<tr><td>Sight Distance (m)</td><td>Desirable minimum sight distance is of 500 m and for Isolated stretches it will be 250 m</td></tr>
<tr><td>Gradient</td><td>Ruling Gradient of 1 in 100 (except 1 in 40 at ROB approaches)</td></tr>
<tr><td></td><td>Pavement Type
Pavement Thickness</td><td>Flexible Pavement
Pavement thickness 625 mm</td></tr>
<tr><td></td><td>Vehicular Underpass -</td><td></td></tr>
</table>

Parameter	Description	Provision
	Vertical Clearance	5.5m
	Vehicular Underpass- Lateral Clearance	12.0m

Port Expressway (Road) Design

For ease of study and design, the road alignment has been split into 3 sections as under:

- From Varor (Vadhavan port) to Western Railway line - Ch. 0.00 to 12.00 Km
- From Western Railway line to Mumbai-Vadodara Expressway Junction - Ch. 12.00 to 21.00 Km
- From Mumbai-Vadodara Expressway Junction to NH-08 junction - Ch. 21.00 to 32.30 Km.

Geometric Features

Curvature

- Total number of curvatures are 24. Out of which 2 curvatures are less than 700.

Gradient

- The 'Ruling' gradient of 1 in 100 has been provided over a length of about 4.50 Km while the remaining length has grade flatter than 1 in 100.

Pavement Design

General

Pavement is the most significant component of a road and therefore its design strength must be adequate to support the projected/ design traffic throughout the service period / life span within acceptable levels of service. Pavement is designed to accommodate design traffic in a safe, durable, and cost-effective manner.
Cost of pavement is one of major component of the total road construction cost.

Pavement design basically aims at determining the total thickness of the pavement structure as well as thickness of the individual structural components. The guidelines IRC: 37 which follow the Mechanistic-Empirical approach for pavement analysis are generally considered. It is proposed to provide a flexible pavement on this port road.

Flexible Pavement Design

Flexible pavement design is done as per IRC: 37.

Assumption of Design CBR (California Bearing Ratio) of Subgrade

- Subgrade CBR value has been considered as 10 % considering that most of the subgrade will be borrowed earth source from identified quarry locations on which good quality control can be achieved.

Pavement Design – Layer thickness

- The pavement structural catalogues presented in the guidelines IRC: 37-2012 has been considered for design traffic levels of 150 msa (Million standard axle). This has been considered to arrive at initial cost estimation. The actual optimal requirement of layer thicknesses shall be evolved based on detailed analysis which will be carried out during detailed design stage when more details in regard to sub grade soil parameter and also type of material which will be utilised for different layers would also be available. Practical considerations and durability of the selected layers would also be kept in mind during the

detailed design stage. Thus, following pavement design thickness has been considered at this stage:

Table 0-1 Pavement Thickness for 150 msa and CBR value of 10%

Bituminous Surface					
CBR Value	**Total Pavement Thickness**	**Bituminous Concrete**	**Dense Bituminous Macadam**	**Granular base**	**Granular Sub base**
	mm	mm	mm	mm	mm
10	625	50	125	250	200

Different methods of currently accepted pavement design guidelines are available, and the approach of the Consultants, during the detailed design stage, will be to work out the requirements by the various methods, compare the results and optimize the recommended solutions based on characteristics of available materials, relevant economics and best engineering judgement.

Cross Structures

The details of the bridge structures have been given in Appendix 1.3. The bridge structures have been provided for following –

- Vehicular Underpasses
- Cross Drainage Minor bridges
- Road crossings for Junctions
- Road over bridges (Bridge over Railway)
- Major River crossing

Intersections and Junctions

The road is planned as an entry restricted road connecting with Mumbai Vadodara Expressway and NH-08. Proposed options for connectivity are designed as per MoRTH Guidelines for traffic transfer shown in the figures below:

Connectivity to NH-08: The Junction arrangement plan for connectivity of the port road to NH-08 at Tawa village is as under:

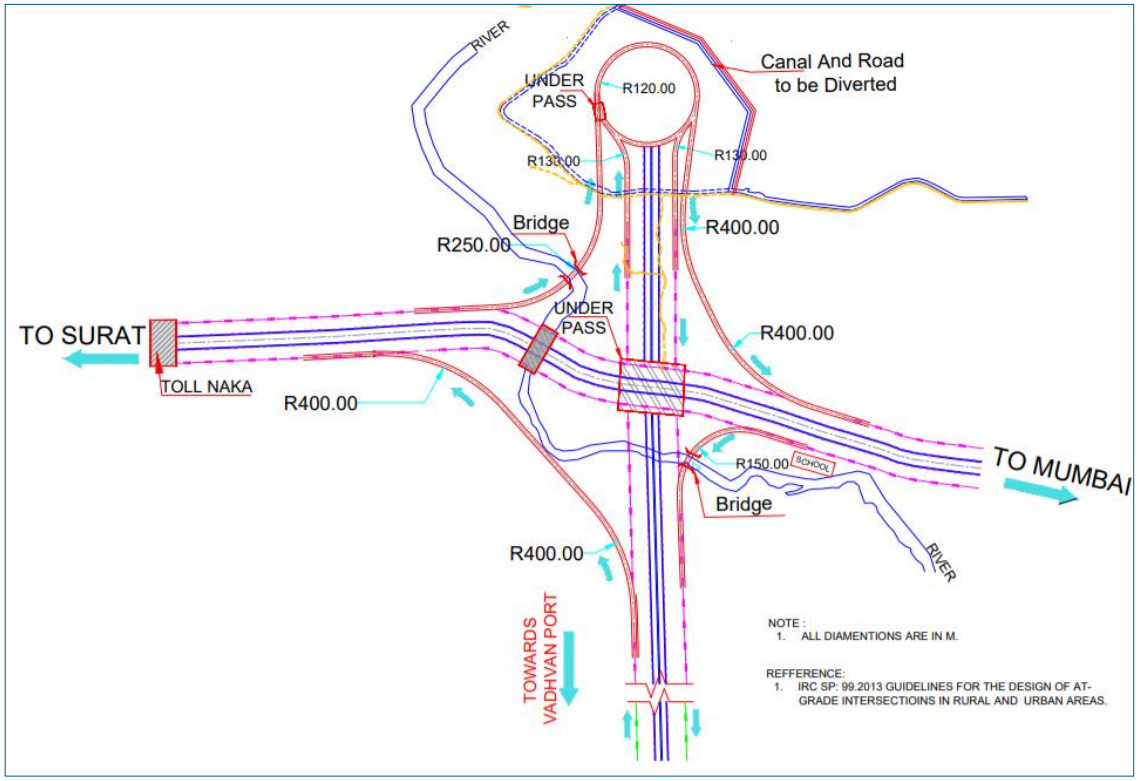


Figure 1-3 Connectivity to NH-08 Option-1 (Recommended Option)

Connectivity to Mumbai-Vadodara Expressway: The junction arrangement plans for connectivity to the proposed Mumbai – Vadodara Expressway is as under:

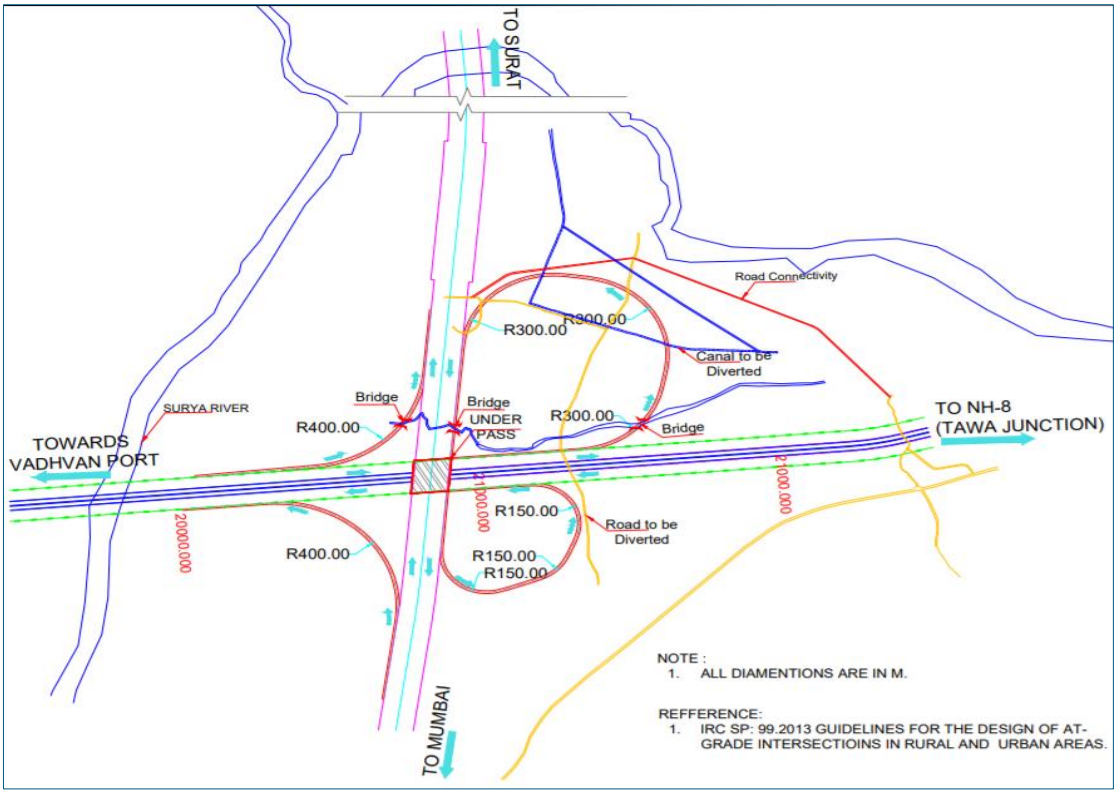


Figure 1-4 Connectivity to Mumbai-Vadodara Expressway Option-2 (Recommended option)

As per the above typical junction arrangement drawing, it will require additional land corridor for road. Detailed topographic survey is required for this land corridor.

Way side Amenities

Based on the road traffic projections there is a need to provide way side facility for the truckers. The wayside amenities are planned as one stop truckers stops with adequate and segregated parking areas, petrol pumps, rest rooms, recreational and shopping areas apart from traffic control & solution centre. This modern amenity hubs are proposed in such a way to serve each and every need for the truck drivers without congestion with systematic monitoring of all truck movements, dedicated parking spaces for different operators, different cargo and will be smart card operated.

Signages

The road signs on expressways are required to provide adequate information on lane driving, advance information to exit, location of facilities for road users and also for emergency need for vehicles. Following IRC standards and MORTH specifications will be followed for providing road signs and road markings:

- Code of Practice for Road Signs (IRC 67:2012)
- Code of Practice for Road Marking (IRC 35 – 2015)
- Guidelines on Traffic Management in Work Zone (IRC 55: 2014)
- MORTH 2013 – Specifications for Roads and Bridge work (Section 800)

Safety Aspects

- Crash Barriers
- Rolling crash barrier

Pavement Markings and reflectors

Pavement markings on the project road have been proposed to be done based on IRC: 35, "Code of Practice for Road Marking" with centre-line, and edge strip.

Lighting

As per IRC: SP:99–2013 Section:15-Lighting Specifications, Minimum level of illumination in the expressway including truck lay-byes, wayside amenities and parking shall be as per the table below.

Table 1-4 Minimum Level of illumination

Category	Average Level	U0	U1	T1
Expressways	25 lux	0.4	0.7	15%

Where:
U0: Overall uniformity
U1: Uniformity along the axis of the road
T1: Maximum glare
Vertical and Horizontal clearances for electrical installations shall confirm to IRC 32.

Kilometre stones

Standard Kilometre, 5th Kilometre and Hectometre stones have been proposed as per provision of IRC 35 and MORTH specifications.

Design Review – Issues

Critical Issues – Design of Road

- **Alignment Finalization**

Compared to the previous JNPT DPR (2018), in the current DPR (2022) the road alignment has been substantially modified based on actual partial topographic survey data provided by JNPT to the Consultant.

The final road alignment will need to be approved by National Highway Authority of India (NHAI). It is understood that NHAI is also doing its own alignment study for Vadhawan Port road connectivity.

- **Curvature**

The DPR (2018) did not provide details of all curves for the entire route. The project sheets also did not provide these details at many locations. Due to changes in the alignment, the alignment has been redesigned. The entire length of the road has a speed potential of 120 Kmph.

- **Road Over Bridge (ROB) over Railway:**

In the DPR (2018), the Railway connectivity to Western Railway and DFC had shown the MRVC (Mumbai Rail Vikas Corporation) Railway lines on elevated section and surface connectivity to connect the Railway line with Western and DFC lines. The details provided for Road Over Bridge crossing at the same location does not show the proposed MRVC (Mumbai Rail Vikas Corporation) line as elevated. If the MRVC lines were elevated the Road over bridge would have to be lifted further and would have passed the railway location at about 18 to 20 m height. Since it has now been clarified during discussions with MRVC and Western Railway that the MRVC lines are not being elevated this mismatch has been dealt with in this Report as well as in the Railway connectivity report.

- **Surya River alignment design**

As per the JNPT DPR (2018), two curvatures were proposed near Surya river. Details of Curvatures were not provided nor included in the project sheets. The missing information required review of land acquisition at this location. Various design alternatives were studied. The alignment at this stretch had to be redesigned. Accordingly, the bridge over Surya river is being provided in curvature of 700 m. Based on discussion with JNPT, the alignment over Surya river was modified to make it straight which reduced the total length of the road. However, the alignment now passes through hilly terrain. The same has now been considered with overburden material being utilized for port land reclamation.

- **Adopting Railway Standard Culvert design in common ROW and on other road section**

In the JNPT DPR (2018), cross drainage culverts of 1.2m diameter pipe were proposed on road portion. The Railway standard is to provide minimum 2 m x 2 m RCC Box culverts. Considering that the Railway bridge has a minimum size of 2 m x 2 m RCC box, similar size box should have been provided in road portion which is also in the common ROW (Right-of-way). Accordingly, same configuration of providing RCC box culverts for road and rail has been proposed in the road alignment along the rail ROW i.e., instead of 1.2m diameter pipe, 2 m x 2 m RCC boxes have been proposed.

- **Pavement design:**

The JNPT DPR (2018), the design for pavement had considered traffic of 30 million standard axles (msa). Considering traffic of only 30 MSA is not commensurate with the level of traffic projected on the road in terms of Commercial Vehicles per day. The Ministry of Road Transport and Highway in their letter number RW/NH – 24036/27/2010 - PPP dated 25.04.2018 on Revision of Normative Cost Norms for the National Highways had recommended adoption of 100 MSA for design traffic for 8 lane highway. Accordingly, based on the updated assumptions a pavement design with traffic of 150 MSA has been considered at this stage which will be further fine-tuned during detailed design stage.

- **Geotechnical Details**

Previously, for road alignment, a total of Seventy (70) bores (of about 15 m depth) were drilled. 25 No. Trail pits were also done.

As per IRC: SP: 84-2019 clause 4.4.2, along the alignment of the road, where unstable strata, soft material or poor subsoil condition is met with at the foundation level, the soil borings shall be at maximum interval of 100 m to a depth of 2 m or more below the existing ground as necessary. Due to change in alignment many more bore holes/trial pits may be required depending on geological

condition, acquisition of new land and actual soil profile and soil nature, type of structure, loading etc. during the phase of detailed engineering & construction,

- **Additional Topographical Survey requirement:**

Additional topographical surveys are required to be done by JNPT for following locations:

- Near Surya river to finalise detailed design of Bridge over Surya River as the design provided during DPR (2018) had not considered proper straight portion over the bridge. Present design has considered straight over the bridge. High flood levels of Surya river has also to be provided.
- Around Railway crossing for Road over bridge over Railway (MRVC, WR and DFC lines) to improve preliminary design so that Road Over Bridge design developed poses least interference to the Railway movement and the design is also acceptable to Railways. The existing rail top levels at every 10-10 m interval along the track needs to be provided.

Variation in Cost Estimates

There are substantial changes in the estimated Project Cost of the previous JNPT DPR (2018) attributable to many reasons such as previous erroneous design criteria, underestimation of quantities and unit rates, and mismatch in various assumptions.

Quantity Assessment

- **Material procurement for embankment and subgrade**

Potential sources of earth for the construction of embankment and sub-grade for new Carriageway will be identified as the excavated materials obtained from borrow area and cut & fill sections.

- **Availability of Bitumen, Steel and Cement**

Table 1-5 Availability of Bitumen, Steel and Cement

Sr. No.	Distance from Proposed Port Road
	Bitumen
1	Available at Mumbai
	Steel
2	Available at Mumbai
	Cement
3	Available at Vadhavan

- **Stone aggregates**

The availability and quality of material of coarse and fine aggregate need to be explored and samples collected from the nearby quarries where large quantities of stone aggregates are available.

Table 1-6 Location of Quarry Material

S. No.	Village	Hillock	Distance from Port in (Km)	Approximate Height in 'm'	Projected Quantity in 'sq. m'	Projected Quantity in 'Brass'
1.	Gargaon	A	17	180	2,54,80,000.00	89,89,344.00
2.	Gargaon	B	17	160	4,57,60,000.00	1,61,44,128.00
3.	Khanivade	C	19	120	3,93,75,000.00	1,38,91,500.00
4.	Khanivade	D	19	124	3,74,00,000.00	1,31,94,720.00
5.	Mahagaon	E	20	127	4,23,00,000.00	1,49,23,440.00

6.	Mahagaon	F	20	110	1,45,00,000.00	51,15,600.00
7.	Nanivali	G	25	380	84,52,60,000.00	29,82,07,728.00
Total					**1,05,00,75,000.00**	**37,04,66,460.00**

Cost Estimates

- **Unit Rates**

The rates of various items of construction work have been analysed as per procedure laid down in the "MORT&H Standard Data Book" and guidelines set therein. Market studies were made to ascertain the rates of various items of construction materials. The rates of earthworks and pavement layers, sand, moorum, gravel & aggregate, etc. have been collected from State Schedule of Rates 2019-2020.

The rates for this project have been adopted from the unit rates as above as well as based on similar projects which have been executed successfully. Detailed analysis of rates has been done for major items. Some of the item rates have been adopted based on 'In-house' database of the Consultant and Market intelligence.

The 7.5% Inflation adjustment has been made in the Total Project Cost to reflect the rates of January, 2022 as the base year.

- **Bill of Quantities**

The major construction items covered in cost estimates are: site clearance; earthwork in new embankment, Subgrade, Pavement in carriageways and shoulders; Culverts; Bridges; Junction improvement; Drainage and Protective works; Access Roads, ROB's, and Miscellaneous items which includes Pavement markings, Signages, etc.

- **Project Cost**

The summary of project cost is as follows:

Table 1-7 Summary of Project Cost for 8 lane flexible pavement

Sr. No.	Description of Work	Unit	%	Total Cost (In Crore)
1	2	3	4	5
Total Length of the Project Expressway = About 32.30 km				
A	**Civil Work**			
i	Site Clearance and Dismantling	Lumpsum		1.00
ii	Earthwork	Cum		397.00
iii	Flexible Pavement			214.00
iv	Underpasses & Road Diversion			327.00
v	Minor Bridges & Culverts			149.00
vi	Major Bridges			225.00
vii	ROB			372.00
viii	Junction (NH-08 & Mumbai-Vadodara Expressway)			110.00
ix	Drainage and Utilities & Fencing			65.00
x	Road Appurtenances (Crash Barrier, Painting etc.)			64.00
xi	Miscellaneous (Retaining Walls, River/Nalla training)	Lumpsum		20.00

Sr. No.	Description of Work	Unit	%	Total Cost (In Crore)
	Total Cost of Civil Work(A)			**1,944.00**
B	**Contingency 3%**		3%	59.00
Total Civil Construction Cost (A+B)				**2,003.00**
C	**Other Charges**			
i	Preliminary & Establishment Cost		3.0%	60.00
ii	Design & Detailed Engineering		1.0%	20.00
iii	Road Safety		0.25%	5.00
iv	Supervision		3.0%	60.00
v	Maintenance after Construction for 3 years		5.0%	100.00
	TOTAL Cost of C			**245.00**
	TOTAL Project Cost (A+B+C)			**2,248.00**
D	**Environmental Mitigation Measures**		1.0%	20.00
E	**Utility Shifting**		0.5%	10.00
	Total Capital Cost of the Project (A+B+C+D+E)			**2,278.00**
	Inflation Adjusted (7.5%) Cost of the Project for Base Year 2022 (values rounded off)			**2,449.00**

Total Project Cost is around Rs. 2450 Cr. for 8 Lane Flexible Pavement.

Note:

1. Land Acquisition Cost is not included in the above estimate.
2. Up to approx. ±15% variation might be there once detailed designs are completed based on detailed field Investigations.
3. The above cost is excluding cost of quarrying of rocks between CH: 17520 to CH: 18990 (approx. 1.5 km) in the hilly portion near Surya river. It is assumed that the material will be procured & utilized for port land reclamation purpose.
4. Way side amenities cost is not included in the above estimate.

1 Introduction and Project Appreciation

1.1 Introduction

The Jawaharlal Nehru Port Trust (JNPT) at Navi Mumbai (formerly known as the Nhava Sheva Port) is India's No. 1 container port across all major ports in India. JNPT occupies a prominent place among the most modern ports in India and is ranked 28th among the top 100 container Ports in the world. In last three decades, JNPT systematically evolved its operational efficiency and improved its handling capacity to transform itself into a Port at par with global standards.

JNPT has been assigned the responsibility to develop Vadhavan port as a major port on landlord port development model. Vadhavan port site has natural and strategic advantages to become a mega port and has prospect of achieving throughput of 300 MT.

Mumbai-Delhi Western Railway Line can be tapped at a distance of 12 Km. NH-8 from Mumbai to Delhi is about 34 Km & Mumbai-Vadodara Expressway is at approx. 18 Km will be linked to the port by dedicated rail and road connectivity.

Vadhavan Port Project Under Sagarmala Programme

As per the studies conducted under the Sagarmala Programme, it is expected that by 2025, cargo traffic at Indian ports will be approximately 2500 MTPA (Million tonne per annum) while the current cargo handling capacity of Indian ports is only 1500 MTPA. A roadmap has been prepared for increasing the Indian port capacity to 3300+ MTPA by 2025 to cater to the growing traffic. This includes port operational efficiency improvement, capacity expansion of existing ports and new port development.

The Government of India has granted in-principal approval for setting up a new Major Port at Vadhavan. Jawaharlal Nehru Port Trust has completed the Detailed Project Report (DPR) for Vadhavan Port in Dahanu Taluka, Palghar District (Maharashtra State) which needs to be updated. JNPT invited reputed consultants for updating DPR and Design & Detailed Engineering for various elements of Marine Structures, Road/Rail connectivity, breakwaters and other infrastructure in connection with development of Vadhavan Port Project in Dahanu taluka of Palghar district of Maharashtra.

JNPT has appointed HaskoningDHV Consulting Private Limited as a Project Consultant for this project. In a pre-bid agreement, HaskoningDHV Consulting Private Limited has associated with M/s M. R. Technofin Consultants Pvt. Ltd. as the 'Expert' Rail and Road Design Sub-Consultant to carry out the studies and detailed designs related to rail/road connectivity to the Vadhavan Port.

The objective of the Consultancy service is for updating previous Detailed Project Report (DPR) in order to bring in line with modifications that have been proposed thereafter and Design & Detailed Engineering for various elements of harbour construction i.e., Breakwaters Marine Structures,

dredging and road/rail connectivity, other infrastructure within and outside the proposed Vadhavan Port limits.

JNPT plans to develop a 120 m wide road corridor for traffic originating from the Port to NH-08 as per Expressway guidelines (SP 99 -2013) of India. The road will be exclusively for catering to traffic 'to and from' the port and having no intersection or proposal of linking this road with existing State Highways or MDR (Major district road)/ODR (Other district road) roads. The road is proposed as a world-class high-efficiency road which will have connectivity with proposed Mumbai - Vadodara Expressway and NH-08 for traffic dispersion. The objectives envisaged under Detail Project Report is to develop basic design & planning for road connectivity from Vadhavan port to NH-08 & proposed Vadodara - Mumbai Expressway. The road is planned as a Greenfield project. It has been envisaged that the proposed road will be developed with "State-of-the-Art Technology" for traffic management & control.

1.2 Scope of Work

The Scope of this study including up-dation of DPR and detailed designs is as follows:

1.2.1 Study/ Review of available earlier Reports

The consultant to examine the following available earlier studies / reports carried out for the project at Vadhavan.

i) Detailed Project Report initially prepared by M/s Progen Pentacle (JV) Consultant and subsequently re-validated and revised by Port Planning Department of JNPT and Advisors appointed by JNPT.
ii) Various Independent technical studies and other reports of Vadhavan collected for and during preparation of DPR available with JNPT.

1.2.2 Updating of Detailed Project Report (DPR) for the Project

- Firm up the commodity-wise Traffic Estimates for 30 years, (2020-2050)
- Phase-wise execution of the project starting from the year 2020 to 2050,
- Other project components including Road and Rail connectivity

1.2.3 Detailed Design & Engineering of Road Connectivity

Review & updating DPR and Detailed Engineering of Road connectivity as under:

- Modal Split of cargo through road mode
- No. of road lanes
- To establish adequate transport linkage from Vadhavan
- Evacuation plans for cargo
- Detailed studies and design of road links
- Co-ordination of Road Authorities and integration of this plans/design with Vadhavan Port Planning

1.3 Objective

The main objective of the overall project study is:

- To update Detailed Project Report (DPR) for the development of Vadhavan Port in line with the in-principle accorded by the GOI (Government of India) and modifications with more details. DPR will be a standalone base document for planning the project, taking investment decision, getting approvals and for execution/implementation of the project

- Design & Detailed Engineering for all Marine Structures including break water, reclamation of land, road, rail linkages, rail yard for exchange of cargo/container rakes, truck/trailer parking / waiting area, flyover over rail lines and road bridge over Surya river and all other related infrastructure of Vadhavan Port.

- Financial structuring of the Project.

1.4 Purpose of this Report

The Detailed Project Report is the culmination of the project activities related to road connectivity and reporting to date and includes sections on Traffic & Engineering Survey, Design Standards and Specifications, Design, Issues and Concerns, Land Requirement, Cost Estimates and Preliminary Drawings.
All the above has been done as required for the 'Detailed Study' as per the project's 'Terms of Reference'.

1.5 Structure of this Report

This document is the Detailed Project Report for the and presents the findings and conclusions of the work done per the Consultant's work plan.
The remainder of this Report is organized as follows:

→ Executive Summary
→ Section 1 – Introduction and Project Appreciation
→
→ Section 2 – **Error! Reference source not found.**
→ Section 3 –**Error! Reference source not found.**
→ Section 4 - **Error! Reference source not found.**
→ Section 5 -
→
→ Section 6 - **Error! Reference source not found.**
→ Section 7 - **Error! Reference source not found.**
→ Section 8 - **Error! Reference source not found.**
→ Appendix 1 - Data
→ Appendix 2 – Drawings

1.6 Port Master Plan

The road alignment and its connectivity with port premises plays a key role in deciding the final orientation, layout and sizing of the port. Based on the road and railway connectivity and other requirements of the port, the final Master Plan layout drawing of Vadhavan port as given below:

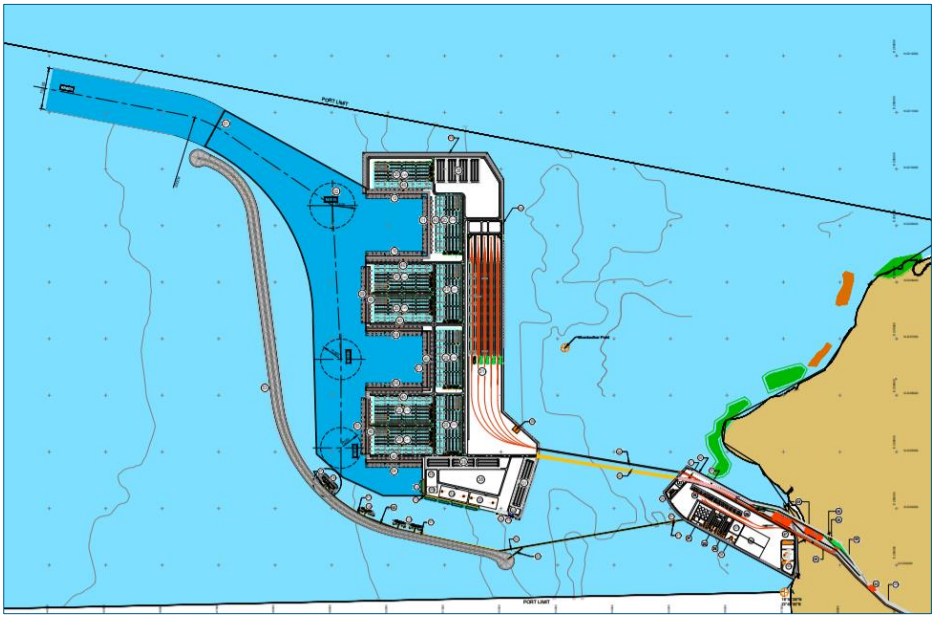


Figure 1-1 Port Master Plan

1.7 Metrological Data of Project Location

Metrological data of the project area in regard to Rainfall, Temperature, Relative humidity, Visibility, Cyclone and Site Seismicity is detailed as under.

- **Rainfall:** The average annual rainfall is 1163 mm with the total number of rainy days per year being 51days. June to August are the wettest months of the year with an average rainfall in excess of 274 mm per month, with a maximum of 451 mm in July 2005 during the southwest monsoon period. February and March are dry months with average rainfall below 1 mm per month.
- **Temperature:** The mean daily maximum temperature is 31°C and with 34°C the highest occurring in April. Mean daily minimum temperature is 24°C and with 18°C the lowest occurring in December.
- **Relative Humidity:** Relative humidity is generally high, and rises to about 85% during the monsoons in the month of August.
- **Visibility:** The visibility throughout the year is good, as the region has zero fog days. However, during rains and squalls, the visibility deteriorates.
- **Cyclone:** In general, the west coast of India is less prone to cyclonic storms compared to the east coast. From the information reported by India Meteorological Department (IMD) it is observed from the tracks of the cyclones in the Arabian Sea from 1877 to 2012 that only 10 storms endangering the Mumbai coast have occurred in the above said period i.e., at a frequency of once in 12 years.
- **Site Seismicity:** Vadhavan Port site is in Zone III of Indian Map of Seismic zones (IS-1893 Part-1 2002) which is a moderate risk seismic intensity zone. However, considering the Palghar earthquake sequence, whose largest magnitude was 4.5 till now and considering the project of national importance and vital installations, it was advised by CSIR - National Geophysical Research Institute to consider the seismic zone IV in design parameters.

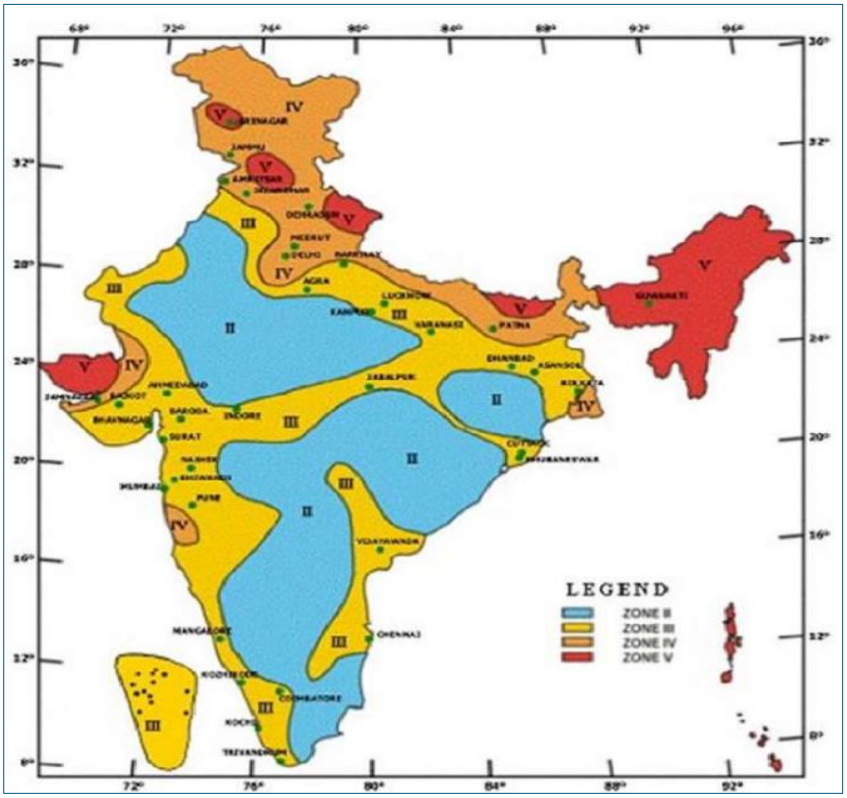


Figure 1-2 Seismic Zone of India

1.8 Previous Road Study

As per previous JNPT DPR (2018), Seven (7) options of road alignment were evaluated against set of parameters and out of these, 2 alignments were short listed for further detailed evaluation on technical aspect, cost consideration, societal issues and availability of government land etc. The details of final two selected alignment is shown in figure below.

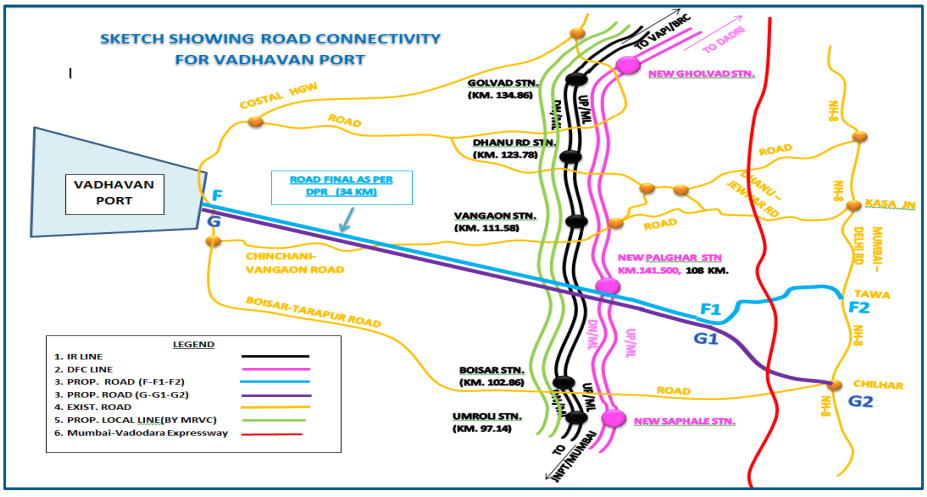


Figure 1-3 Road Connectivity for Vadhavan Port

- Option I-F-F1-F2- Varor (Vadhavan port) to NH-08 (Tawa Junction)
- Option-II-G-G1-G2- Varor (Vadhavan port) to NH-08 (Chilhar)

Option I (F-F1-F2) have been finally recommended for further studies. The Detail Project Report for this alignment was prepared by M/s Progen Consultants for JNPT.
The difference between the road alignment as per DPR 2018 and as per current DPR 2022 i.e. based on partial topographic survey data has been given as an Appendix 1.4- Variation Between Road Alignment As Per DPR 2018 and Current DPR 2022.

Further review and detailed engineering designs, which is the present mandate, is being done for the Option I alignment based on partial topographic survey data i.e., from Varor (Vadhavan Port) to NH-08 (near Tawa Junction).

NHAI note:
The road alignment will be finalized and updated as per National Highway Authority of India (NHAI) decision. NHAI also doing is own alignment study for Vadhawan Port road connectivity.

1.9 Proposed Port Road Route

The road alignment starts from Varor (Vadhavan port) and ends at NH-08 (Tawa junction) between coordinates 19°55'10.41"N, 72°40'34.28"E and 19°52'47.68"N, 72°56'40.50"E. The length of the new road is about 32.30 Km. The proposed Rail alignment runs along to road alignment for initial 12 Km or so. Road route map is as shown in figure below:

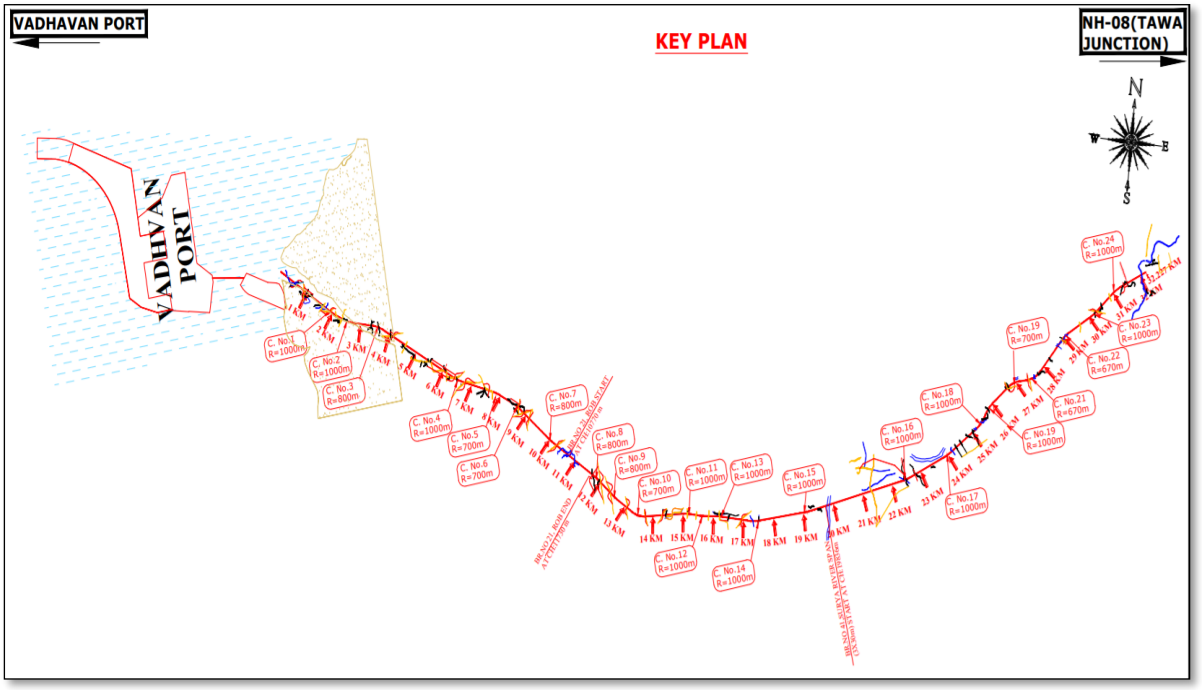


Figure 1-4 Road Connectivity

1.10 Existing Road and Railway Details along the Proposed Road alignment

The proposed road is in the vicinity of/ crosses the following existing roads:

1. Chinchani – Vangaon Road- the proposed road alignment crosses Chinchani - Vangaon road at CH: 8910.
2. Boisar - Tarapur Road (SH-74) – this road is about 6.00 Km away from proposed road.
3. Boisar Road- this road is about 7.00 Km away from proposed road
4. Dahanu - Jawhar Road (SH-30) - this road is about 3.50 Km from the end of proposed road at NH-08.
5. The proposed road crosses Western Railway (WR) Mumbai – Delhi main line and the Western Dedicated Freight Corridor (WDFC). Two new railway lines for suburban traffic are being constructed on the West side of the Mumbai- Delhi main line. Thus, the proposed road will cross eight railway lines viz. two under construction Suburban line of WR (being constructed by MRVC), two WR Mumbai-Delhi Mainline and two main lines of WDFC & two loop lines of WDFC.
6. The proposed Mumbai-Vadodara expressway alignment crosses the project road at chainage at about 20.880 Km.

The details of existing transport infrastructure in the vicinity of the proposed road are indicated in the figure below:

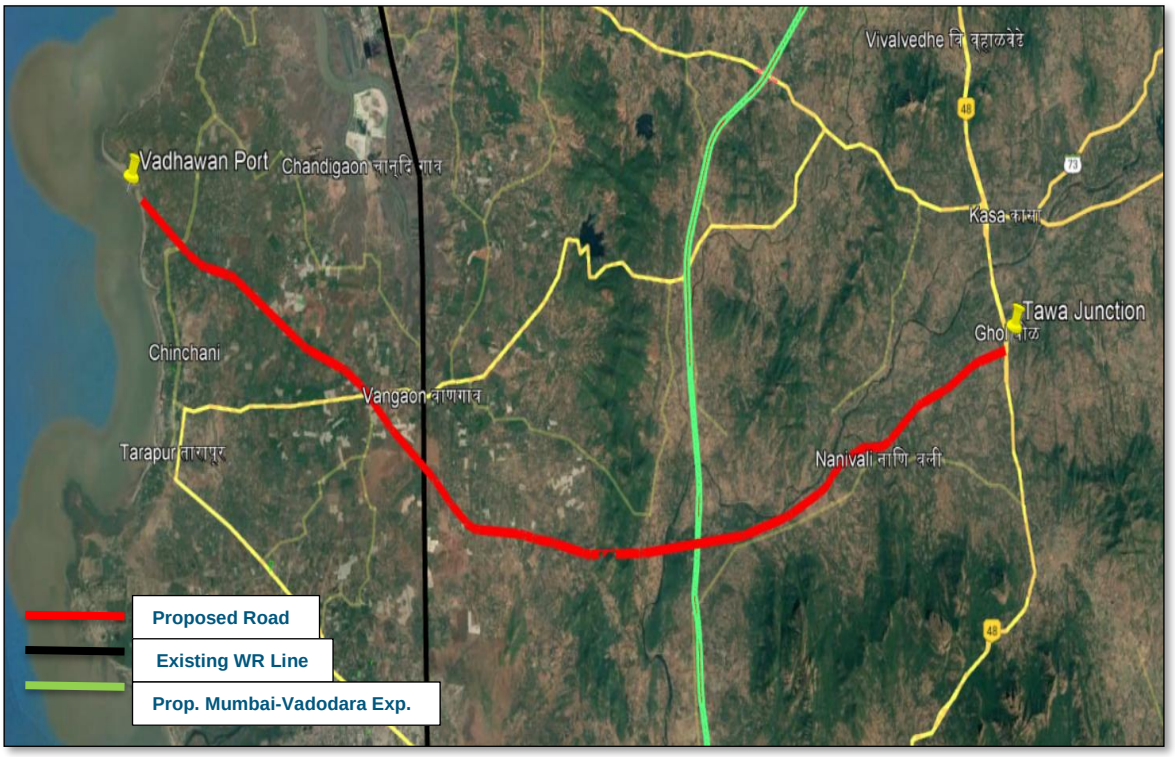


Figure 1-5 Existing Road Details

2 Traffic

2.1 Traffic Data for Port

The 'Port Road' for Vadhavan port is planned as an entry restricted expressway with connecting/ traffic dispersal at National Highway NH-8 and the proposed Mumbai –Vadodara Expressway. The 120 m wide road corridor will cater to truck & trailer traffic to and from the port. Traffic for the corridor is solely from/to a single origin/destination i.e., Vadhavan Port. The reassessment and up-dation of potential traffic for the new port is being separately studied by the lead consultant of this study *M/s Royal HaskoningDHV.* The study is 'ongoing' and 'Work in Progress (WIP)'. The overall traffic assessment, as of date, is as follows:

Table 2-1 Traffic Projection of Port

Cargo	I/E	2025	2030	2035	2040	2050
Containers						
Containers (EXIM)	**I/E**	0.93	6.51	14.10	23.22	39.40
TS	**TS**	-	-	-	-	-
Total (TEU)		0.93	6.51	14.10	23.22	39.40
Total (MTPA)		11.16	78.1	169.20	278.64	472.80
RO-RO Vehicles '000		20.90	49.50	76.80	169.00	227.10
Liquid Bulk						
Edible Oil	**I**	0.40	1.00	1.10	1.20	1.40
LPG	**I**	2.70	3.10	3.80	4.20	5.20
Chemicals	**I**	0.60	0.90	1.00	1.10	1.30
LNG	**I**	-	2.30	4.50	4.50	4.50
Fertiliser	**I**	0.90	1.00	1.20	1.20	1.40
Other cargo						
General Cargo	**I/E**	1.50	2.40	3.50	4.60	7.20
Coastal Cargo	**I/E**	1.00	1.70	2.40	3.20	5.00
		18.26	**90.52**	**186.70**	**298.64**	**498.80**

Source: Data received from M/s Royal HaskoningDHV.

The road design considers these traffic projections till 2050 for deciding the number of lanes and consequent alignment design criteria as well as design of pavement. The design criteria cater to the requirements of desired design speeds to ensure adequate traffic capacity of port road. Consideration for other requirements such as road safety and way side facilities for the high traffic volume of cargo loads, primary movements of loaded containers, have also been taken into account.

2.2 Road Traffic

Forecast for the port road traffic based on updated traffic study is summarised in the table below. For PCU conversion Trucks taken as 3 and for Container Trailer taken as 4.5:

Table 2-2 Current & Projected Traffic on Road

S. No.	Commodity	Truck Movements per day		
		2030	*2040*	*2050*
Outgoing				
1.	Fertiliser	86	86	100
2.	Edible Oil	135	162	189
3.	LPG	74	100	124
4.	Chemicals	143	175	206
	Total Outgoing Trucks per Day	**437**	**522**	**619**
Incoming				
5.	RO-RO	28	97	130
	Total Incoming Trucks per Day	**28**	**97**	**130**
Incoming /Outgoing				
6.	General Cargo	686	1,314	2,057
7.	Coastal Cargo	486	914	1,429
8.	Containers (EXIM)	11,338	30,818	49,154
	Total Incoming/ Outgoing Trucks per Day	**12,509**	**33,046**	**52,640**
Total Trucks to be Handled per Day (incoming and Outgoing)		**13,441**	**34,284**	**54,137**
Total PCUs to be handled per day (Truck 3; Container Trailer 4.5)		**57,329**	**149,079**	**236,142**

[Source: Data received from M/s Royal HaskoningDHV]

Note: The traffic assessment data is 'Work In Progress' (WIP) and is likely to be modified as the overall Study moves further.

2.3 Number of Lanes

2.3.1 Conversion of Road Data into Passenger Car Units (PCU)

Passenger Car Road Traffic in terms of Passenger Car Unit (PCU): PCU is a term which converts actual Road Traffic Projections into PCUs. The factors to be used for conversion into PCUs is given following IRC guidelines:

1. **IRC: 106-1990- Guidelines-for-capacity-of-urban-roads-in-plain-areas; and IRC - 108-1996-Guidelines for traffic prediction on Rural highways**

Factors given IRC:106-1990 are as under:

TABLE 1. RECOMMENDED PCU FACTORS FOR VARIOUS TYPES OF VEHICLES ON URBAN ROADS

Vehicle Type	Equivalent PCU Factors — Percentage composition of Vehicle type in traffic stream	
	5%	10% and above
Fast Vehicles		
1. Two wheelers Motor cycle or scooter etc.	0.5	0.75
2. Passenger car, pick-up van	1.0	1.0
3. Auto-rickshaw	1.2	2.0
4. Light commercial vehicle	1.4	2.0
5. Truck or Bus	2.2	3.7
6. Agricultural Tractor Trailer	4.0	5.0
Slow Vehicles		
7. Cycle	0.4	0.5
8. Cycle rickshaw	1.5	2.0
9. Tonga (Horse drawn vehicle)	1.5	2.0
10. Hand cart	2.0	3.0

Figure 2-1Recommended PCU Factors as per IRC:106-1990

2. Rural roads as per IRC: 108-1996-Guidelines for traffic prediction on Rural highways

Following factors have been provided:

Table 1 : Recommended PCU Factors for various types of Vehicles on Rural Roads

S.No.	Vehicle Type	Equivalency Factor
	Fast Vehicles	
1.	Motor Cycle or Scooter	0.50
2.	Passenger Car, Pick up Van or Autorickshaw	1.00
3.	Agricultural Tractor, Light Commercial Vehicle	1.50
4.	Truck or Bus	3.00
5.	Truck-trailer, Agricultural Tractor-trailer	4.50
	Slow Vehicles	
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

* For smaller bullock carts, a value of 6 would be appropriate.

Figure 2-2 Recommended PCU Factors as per IRC: 108-1996

2.3.2 Capacity

2.3.2.1 Level of Service (LOS)

As per IRC: 106- 1990, LOS is defined as a qualitative measure, describing operational conditions within a traffic stream and their perception by drivers/passengers. LOS definition generally describes these conditions in terms of factors such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety. Six levels of service are recognized and these are designated from A to F, with LOS A

representing the best operating condition ie free flow and the LOS F, the worst ie forced of breakdown flow or saturated flow. These six Los are briefly defined as under:

- LOS A : (Free Flow) Represents a condition of free flow with average travel speeds usually about 90 percent of the free flow speed. Individual users are virtually unaffected by the presence of others in the traffic stream
- LOS B : Reasonably Free Flow
- LOS C : Stable Flow
- LOS D : Approaching Unstable Flow
- LOS E : Unstable Flow

2.3.2.2 Design Service Volume as per Provisions in Indian Road Congress Specifications and Manuals

Working of Number of Lanes based on PCUs and LOS as provided in IRC Guidelines and Manuals are discussed briefly as under:

The Indian Road Congress has issued several Guidelines and Manual of Standards and Specification which also lays down the Design Service Volume to be considered during planning stage and during expansion of roads. These are briefly discussed as under:

- **IRC : 106-1990 Guidelines for Capacity of Urban Roads in Plain Areas**

Design Service Volume: Para 8.3 (Table 2) provides the recommended design service volume for Urban Roads. IRC :106-1990 has recommended the Level of Service (LOS) 'C' should be adopted for design of urban roads.. As per level 'C', design service volume of traffic is around 0.7 times the capacity for the purpose of adopting design values. For various types of 4 Lane divided, 6 Lane divided and 8 lane divided Arterial road it recommends design service volume as under:

Table 2-3Recommended Design service Volume as per IRC:106-1990

Sr. No.	Type of Road	Total Design Volume Recommended by IRC: 106-1990 (in PCUs per hour)
1	Four lane Divided Road	3600
2	Six Lane Divided Road	5400
3	Eight Lane Divided Road	7200

- **IRC: 073-2007 – Manual of Standards & Specifications For two Lanning of State Highways on BOT**

The provision in regard to Design Service Volume for two lane Highway in PCUs per day is given in table 2.8 under para 2.16 which given as under:

Table 2-4 Design Service Volume for Two Lane Highway in PCU per Day (IRC: SP: 73:2007)

Nature of Terrain	Design Service Volume in PCUs per day	
	Without paved shoulder	With minimum 1.5m paved shoulder
Plain	15000	18000
Rolling	11000	13000
Mountanious and Steep	7000	9000

- **IRC:SP: 84-2019 – Manual of Specifications and Standards for four laning of Highways**

Design Service Volume for Four Lane Highways in PCUs per day and level of service has been specified in Table 2.9 under para 2.18 and the same is given as under:

Table 2-5 Design Service Volume for Four Lane Highway in PCU per Day (IRC: SP: 84::2019)

Terrain	Design Service Volume in PCUs per day	
	Level of Service 'B'	Level of Service 'C'
Plain and Rolling	40000	60000
Mountainous and Steep	20000	30000

Note : PCU specified here is as provided in IRS:64

It is also specified in para 2.19 that the highway shall be widened to 6-lane when total traffic including the traffic on service roads, if any, reaches the design service volume corresponding to level of service 'C' for four lane

- **IRC:SP:64-1990- Guidelines for Capacity of Roads in Rural Areas**

The Guidelines covers the provision of Design Service Volume for two lane road in Para 10.

The provisions are as under

- 10.1 Recommended design service volume for two lane roads are given in table 4

TABLE 4. RECOMMENDED DESIGN SERVICE VOLUMES FOR TWO LANE ROADS

S.N.	Terrain	Curvature (Degrees per Kilometre)	Design Service Volume in PCU/day
1.	*Plain*	Low (0-50)	15,000

- 10.2 The values recommended above are based on the assumptions that the road has a 7 m wide carriageway and good earthen shoulders are available. The capacity figures relate to peak hour traffic in range of 8- 10 percent and LOS B.
- 10.3 The capacity of two-lane roads can be increased by providing paved and surfaced shoulders of atleast 1.5 metre width on either side. Provision of hard shoulders results in slow moving traffic being able to travel on the shoulder which reduces the interference to fast traffic on the main carriageway. Under these circumstances, 15 per cent increase in capacity can be expected vis-à-vis the value given in Table 4".

The guidelines vide para 11.1 also recommends adopting a Design Service Volume of 35,000 PCUs for four lane divided carriageways located in plain having reasonably good earthen shoulders and a minimum 3 m wide central verge. Vide para 11.2 and 11.3 it also recommends following :

- "Para 11.2 Provision of hard shoulders on dual carriageways can further increase the capacity as explained in para 10.3. In case well designed paved shoulders of 1.5 metre width are provided, the capacity value of four – lane dual roads can be taken up to 40,000 PCUs.
- 11.3 The capacity values mentioned above relate to LOS B. On dual carriageways it will normally not be desirable to adopt LOS C .

- **IRC: SP: 099- 2013 – Manual of Specifications and Standards for Expressways**

The Manual provides as follows :

2.18 Capacity of Expressway

Rural expressways shall be designed for Level of Service-B.

For the purpose of design and future augmentation of the Project Expressway, the design service volume for level of service– B for plain/rolling terrain shall be 1300 PCU/hr/lane. The design service volume can be determined as per MORTH Guidelines for Expressways. The design service volume per day will depend on the peak hour flow and will be as specified in **Table 2.12**.

Table 2.12 Design Service Volume for Expressways in Plain and Rolling Terrain (in PCUs/per day) for LOS B

Design Service Volume in PCUs per day for LOS B		
4-Lane	**6-Lane**	**8- lane**
86,000 for Peak hour flow (6%) 65,000 for Peak hour flow (8%)	1,30,000 for Peak hour flow (6%) 98,000 for Peak hour flow (8%)	1,73,000 for Peak hour flow (6%) 1,30,000 for Peak hour flow (8%)

Figure 2-3 Design Service Volume as per IRC:SP-2013

2.4 Recommendation on Lanes

The Design Service Volume provision in the IRC Guidelines and Manuals as detailed above, is summarised in the table below for plain and rolling terrain :

Table 2-6 Summary of Design Service Volume as per IRC Guidelines and manuals

Sr. No.	IRC Guideline/Manual	Provision of Design Service Volume	Level of service (LOS)
1	IRC 106: 90 Guidelines for Capacity of Urban Roads in Plain Areas	In terms of PCUs per hr Four lane Divided Road - 3600 (86400 PCUs per day) Six Lane Divided Road – 5400 (129600 PCUs/Day) Eight Lane Divided Road 7200 (172000 PCUs/Day)	C
2	IRC: 073: 2007 – Manual of Standards & Specifications For Two Lanning of State Highways on BOT	For Plain section Design Service Volume for two lane Highway in PCUs per day has been provided as 18000	
3	IRC SP 64: 1990 Guidelines for Capacity of Roads in Rural Areas	40000 PCUs/day for four lane divide carriageways	B
4	IRC SP 84: 2019 Manual of Specifications and Standards for Four Lanning of Highways	40000 PCUs per Day for Four Lane divide Carriageway 60000 PCUs per Day for Four Lane divide Carriageway	B C
5	IRC SP 99: 2013 Manual of Specifications and Standards for Expressways	**For Peak Hour flow of 6%**	
		4 Lane – 86,000 PCUs per day 6 Lane – 130,000 PCUs per day 8 Lane – 173,000 PCUs per day	B B B
		For Peak hour Flow of 8%	

Sr. No.	IRC Guideline/Manual	Provision of Design Service Volume	Level of service (LOS)
		4 Lane – 65,000 PCUs per day 6 Lane – 98,000 PCUs per day 8 Lane – 1,30,000 PCUs per day	B B B

From the above summary of provisions in IRC Guidelines and Manuals, only two guidelines provide for design service volume i.e. IRC:SP: 106 -1990 and IRC:SP:99 -2013 for eight lane expressway/highway. IRC: SP: 99 seems to be the most relevant considering the design parameters of the port road planned and the terrain in the project area which can be classified as 'Plain'.
Hence, following are the traffic requirement considering Peak hour flow of 6% and 8% for LOS B.

Table 2-7 Number of Lanes Required based on Traffic projections for a Peak Hour Flow of 6% and 8%

	Proposed		
Year	2030	2040	2050
Traffic Projections (in PCUs)	**57,329**	**149,079**	**236,142**
No. of Lane Required (considering Peak Hour Flow of 6%)	**3**	**7**	**11**
No. of Lane Required (considering Peak Hour Flow of 8%)	**4**	**10**	**15**

Based on the above table, following are the recommended lanes for the project:

Table 2-8 Recommended Number of Lanes for the Project

	Proposed		
Year	2030	2040	2050
Traffic Projections (in PCUs)	**57,329**	**149,079**	**236,142**
No. of Lane Required (considering Peak Hour Flow of 6%)	**4**	**8**	**12**

For the purpose of this Report, an eight lane highway is being considered which can be expanded in future as per the actual growth of traffic. It is suggested that, based on the future traffic growth rate revised traffic survey needs to be carried out to finalize the additional number of lanes to be developed.

3 Engineering Survey

3.1 Topographic Survey

The Consultant understands that detailed topographic survey for 100 m 'road' corridor has previously been done by JNPT.

It is also learnt that further detailed topographic survey is now being carried out by JNPT for a total corridor width of 120 m for the road from the entry point to the port at Vadhavan end to NH-08 at Tawa Junction.

This Report has been prepared based on the partial survey data provided by the JNPT surveyor.

3.2 Geotechnical Investigations

3.2.1 Previous Investigations

Limited Geotechnical investigations were carried out during preparation of previous JNPT DPR (2018) by JNPT.

In all, for road alignment, a total of Seventy (70) bores (of about 15 m depth) were drilled with drill penetration of at least 5m in good quality rock. Clusters of bore hole were done for individual structure at Underpass and Flyover locations.

Further twenty-five (25) trial pits were also made to extract fresh soil sample at 0.5 m to 1 m depth below existing ground level for laboratory analysis.

Previous DPR study in 2018 reported the Geotechnical details in a separate document as **Report 1: Geotechnical Investigation Report for Road and Rail Corridor in Volume 3** and same has been considered.
The Borehole locations on map is as indicated in the figure below as per DPR (2018):

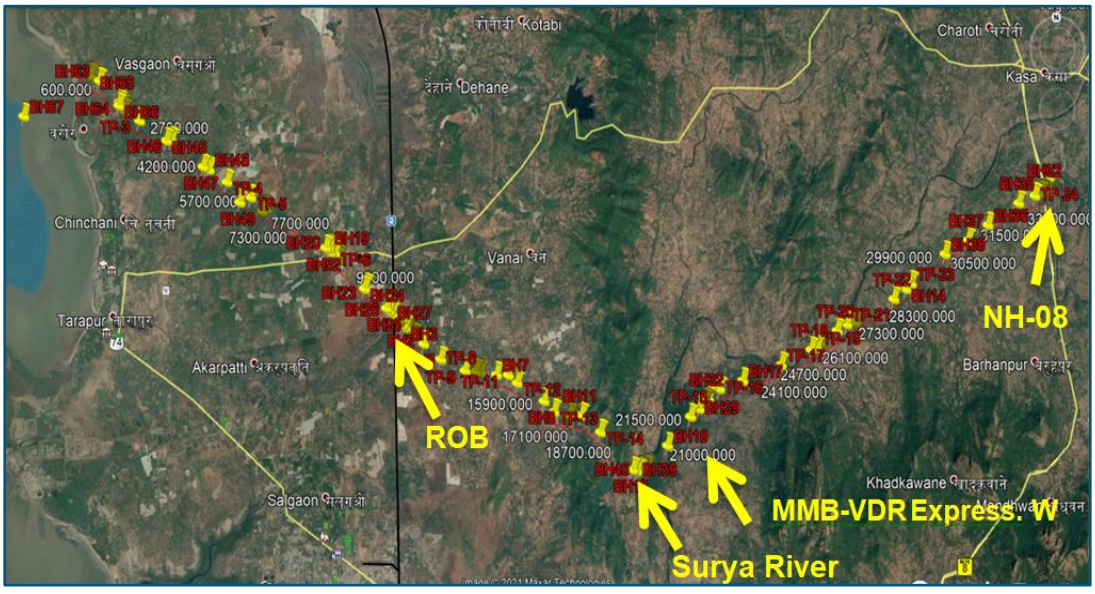


Figure 3-1 Boreholes Layout Plan

3.2.2 Geological Description

The geological conditions in the study area for the road corridor is primarily dominated by basalt, an extrusive rock created by the outpouring of volcanic magma which cools quickly to form small crystals. Basaltic lava flows for great distances before solidifying. Successive eruptions of basalt have formed the Deccan plateau region of south west India.

The area is conspicuously uniform, consisting of series of Deccan Trap flow which are occasionally intruded by a number of basic intrusive. The basalts are mainly capped by lateritic soil. The Deccan trap flows over lie all the earlier formations with profound unconformity covering and filling the uneven pre- trapped topography.

Successive episodes of the lava flow rest in the layered arrangement of the basaltic flow. Since the composition of the volcanic flow differs in each episode, the rock mass possesses layered structures with horizontal continuity but vertical heterogeneity.

In a vertical column of 686m, at least 20 basalt flows varying in thickness from 15 m to 70 m have been recognized along some sections. The flows are of simple to compound pahoehoe type and exhibit variations in colour, grain size and frequency of distribution of phenocrysts. The natural hill slopes produced from this type of rock have a stepped shape, with the steeper portion corresponding to harder layer sand flatter areas to the softer layers. Predominant vertical jointing favours the formation of steep slopes. In both cases, the structure of rock mass is usually of layers of different constitutions, altering weak and strong rocks, with preferential seepage along horizontal discontinuities or weak layers.

3.2.3 Soil Profile

All the borehole taken show the generalized soil profile. The first layer consists of medium stiff to stiff silty clay with mixture of gravels as well. The clay obtained in this layer was observed in yellowish brown/light to dark grey /brown/light grey in colour.

Also, the sand present in this layer was dark grey/ dark greyish brown/dark brown/light grey in colour. The weathered basaltic rock was encountered at below the overburden soil layers. The rock was of amygdaloidal basalt type throughout the depth drilled.

The initial drilled length of the rock was of highly weathered amygdaloidal basalt which was then followed by decreased weathering action along its increasing drilled depth. Also, the values of core recovery (CR) and rock quality designation (RQD) were increasing along the increase in depth. The bores were terminated in the rocky strata upon establishing its continuity. The total depth drilled was 15 m below existing ground level.

3.2.4 Recommendations

Based on geotechnical report recommendations pile foundation has been recommended for major load carrying structures. Pile design, pile diameter, pile capacity can only be finalized during detailed engineering stage. Necessary field tests, pile load tests will need to be carried out to verify pile length, pile capacity, etc.

Table 3-1 Location of Seventy Bore holes as per DPR 2018

S. No.	Date	Bore No.	Proposed Structure	Boring Depth	Water Table	Easting	Northing
1.	10-03-2017	BH 1	Rail over Bridge (East)	15	4.5	265795.00 m E	2197342.00 m N

S. No.	Date	Bore No.	Proposed Structure	Boring Depth	Water Table	Easting	Northing
2.	12-03-2017	BH 2	Rail over Bridge (East)	15	4.35	265889.00 m E	2197258.00 m N
3.	19-03-2017	BH 3	Rail Over Bridge (East)	15	4.1	265959.00 m E	2197190.00 m N
4.	23-03-2017	BH 4	Rail Over	15	4.1	266031.00 m E	2197135.00 m N
5.	28-03-2017	BH 5	Cannel Road	15	3.9	266472.00 m E	2196755.00 m N
6.	30-03-2017	BH 6	Village Road	15	3.5	268081.00 m E	2195960.00 m N
7.	04-04-2017	BH 7	Cannel Road	15	4	268547.00 m E	2195883.00 m N
8.	07-04-2017	BH 8	Village Road	15	4.2	269888.00 m E	2195158.00 m N
9.	09-04-2017	BH 9	Village Road	15	4.2	270612.00 m E	2194761.00 m N
10.	16-04-2017	BH 10	Village Road	15	3.9	270645.00 m E	2194751.00 m N
11.	20-04-2017	BH 11	Village Road	15	3.5	270964.00 m E	2194750.00 m N
12.	23-04-2017	BH 12	Village Road	15	3.9	270990.00 m E	2194743.00 m N
13.	26-04-2017	BH 13	Village Road	15	3.9	272377.00 m E	2193330.00 m N
14.	03-05-2017	BH14	Village Road	15	3.9	280542.00 m E	2197335.00 m N
15.	08-05-2017	BH15	Village Road	15	4.5	279039.01m E	2196599.05 m N
16.	12-05-2017	BH16	Village Road	15	5.1	278048.00 m E	2196154.00 m N
17.	19-05-2017	BH17	Near Village	15	5.5	275684.11m E	2195346.73 m N
18.	26-05-2017	BH 18	Village Road	15	5.9	273416.00 m E	2193869.00 m N
19.	13-04-2017	BH 19	Chinchni Vangaon Road	15	6	263850.00 m E	2199265.00 m N
20.	20-04-2017	BH 20	Village Road	15	6.3	263880.00 m E	2199155.00 m N
21.	23-04-2017	BH 21	Village Road	15	6.95	264122.00 m E	2199014.00 m N

S. No.	Date	Bore No.	Proposed Structure	Boring Depth	Water Table	Easting	Northing
22.	27-04-2017	BH 22	Village Road	15	7.1	264089.00 m E	2198946.00 m N
23.	30-04-2017	BH 23	Village Road	15	7	264875.00 m E	2198259.00 m N
24.	04-05-2017	BH 24	Village Road	15	7.3	264830.00 m E	2198196.00 m N
25.	07-05-2017	BH 25	Railover Bridge (West)	15	7.2	265441.00 m E	2197689.00 m N
26.	10-05-2017	BH 26	Railover Bridge (West)	15	9.3	265513.00 m E	2197614.00 m N
27.	14-05-2017	BH 27	Railover Bridge (West)	15	10.5	265594.00 m E	2197533.00 m N
28.	17-05-2017	BH 28	Railover Bridge (West)	15	9.6	265658.00 m E	2197470.00 m N
29.	23-05-2017	BH 29	Vadodara Mumbai Express Way	15	9	274375.00 m E	2194721.00 m N
30.	25-05-2017	BH 30	Vadodara Mumbai Express Way	15	9.5	274436.00 m E	2194790.00 m N
31.	28-05-2017	BH 31	Vadodara Mumbai Express Way	15	9	274571.00 m E	2194899.00 m N
32.	30-05-2017	BH 32	Vadodara Mumbai Express Way	15	9.2	274665.00 m E	2194950.00 m N
33.	19-05-2017	BH 33	River West Bank	15	9	284616.00 m E	2199469.00 m N
34.	21-05-2017	BH 34	River West Bank	15	8.5	284596.00 m E	2199464.00 m N
35.	24-05-2017	BH 35	Village Road	15	9.2	283940.00 m E	2199268.00 m N
36.	26-05-2017	BH 36	Village Road	15	9.2	283016.00 E	2198780.00m N
37.	28-05-2017	BH 37	Village Road	15	8.6	282417.00m E	2198434.00 m N
38.	30-05-2017	BH 38	River East Bank	15	9.5	281728.00 m E	2198136.00 m N
39.	26-05-2017	BH 39	Surya River West Bank	15	8.5	272482.00 m E	2193293.00 m N
40.	21-05-2017	BH 40	Surya River West Bank	15	8.9	272552.00 m E	2193297.00 m N
41.	19-05-2017	BH 41	Surya River West Bank	15	9	272592.00 m E	2193270.00 m N
42.	16-05-2017	BH 42	Surya River West Bank	15	8.9	272587.00 m E	2193300.00 m N
43.	13-05-2017	BH 43	Surya River	15	8.9	272614.00 m E	2193329.00 m N
44.	09-05-2017	BH 44	Surya River West Sank	15	5.5	272561.00 m E	2193306.00 m N
45.	11-04-2017	BH 45	Village Road	15	3.5	259275.65 m E	2202149.40 m N
46.	14-04-2017	BH 46	Village Road	15	4	259425.88 m E	2202167.77 m N
47.	17-04-2017	BH 47	Village Road	15	3 90	260309.00 m E	2201452.00 m N

S. No.	Date	Bore No.	Proposed Structure	Boring Depth	Water Table	Easting	Northing
48.	22-04-2017	BH 48	Village Road	15	3 90	259275.65 m E	2201371.00 m N
49.	26-04-2017	BH 49	Village Road	15	4.1	261326.61 m E	2200519.54 m N
50.	29-04-2017	BH50	Village Road	15	3 80	261975.00 m E	2200265.00 m N
51.	02-05-2017	BH 51	Village Road	15	4.1	262075.00 m E	2200306.00 m N
52.	06-05-2017	BH 52	Chinchni Vangaon Road	15	4.2	263759.00 m E	2199265.00 m N
53.	02-06-2017	BH 53	Surya River East Bank	15	160	272769.00 m E	2193345.00 m N
54.	02-06-2017	BH 54	Surya River East Sank	15	190	272804.00 m E	2193314.00 m N
55.	02-06-2017	BH 55	Surya River East Bank	15	190	272771.00 m E	2193251.00 m N
56.	02-06-2017	BH 56	Surya River East Bank	15	1.8	272765.00 m E	2193313.00 m N
57.	16-05-2017	BH 57	NH-08 East Side	15	13.5	254825.00 m E	2199551.00 m N
58.	13-05-2017	BH 58	NH-08 East Side	15	13.8	284870.00 m E	2199519.00 m N
59.	09-05-2017	BH 59	NH-08 East Side	15	13.9	284842.00 m E	2199459.00 m N
60.	05-05-2017	BH 60	NH-08 West Side	15	14.5	284751.00 m E	2199454.00 m N
61.	02-05-2017	BH 61	NH-08 West Side	15	14.6	284764.00 m E	2199499.00 m N
62.	29-04-2017	BH 62	NH-08 West Side	15	14 00	284765.00 m E	2199546.00 m N
63.	04-04-2017	BH 63	Varor Vadhvan Road	15	3.4	257409.00 m E	2203730.00 m N
64.	04-04-2017	BH 64	Varor Vadhvan Road	15	2.9	257959.00 m E	2203169.00 m N
65.	07-04-2017	BH 65	Tarapur Varor Costal Roao	15	3.6	257959.48 m E	2203169.32 m N
66.	07-04-2017	BH 66	Tarapur Varor Costal Road	15	3.8	257940.49 m E	2203090.25 m N
67.	09-04-2017	BH 67	Village Road	15	3.5	255166.29 m E	2202979.55 m N
68.	09-04-2017	BH 68	Village Road	15	3.55	258097.55 m E	2202945.05 m N
69.	23-04-2017	BH69	River East Bank	15	12.5	284691.00 m E	2199455.00 m N
70.	17-04-2017	BH70	River East Bank	15	12.5	284657.00 m E	2199477.00 m N

Table 3-2 Location of Twenty-Five Trial Pits

S. No	Trial Pit No.	Date	Proposed Structure	Easting	Northing
1.	TP 01	30-05-2017	Nala	257166.00 m E	2203857.00 m N
2.	TP 02	30-05-2017	Nala	258068.00 m E	2203065.00 m N
3.	TP 03	30-05-2017	Village Road	258525.00 m E	2202682.00 m N
4.	TP 04	30-05-2017	Village Road	260984.00 m E	2201040.00 m N

S. No	Trial Pit No.	Date	Proposed Structure	Easting	Northing
5.	TP 05	30-05-2017	Village Road	261661.00 m E	2200622.00 m N
6.	TP 06	30-05-2017	Nala	264018.00 m E	2199123.00 m N
7.	TP 07	30-05-2017	Village Road	266212.00 m E	2196964.00 m N
8.	TP 08	31-05-2017	Canal road	266945.00 m E	2196346.00 m N
9.	TP 09	31-05-2017	Nala	267641.00 m E	2196029.00 m N
10.	TP 10	31-05-2017	Nala	267947.00 m E	2195992.00 m N
11.	TP 11	31-05-2017	Village Road	268885.00 m E	2195852.00 m N
12.	TP 12	31/05/2017	Village Road	269133.00 m E	2195646.00 m N
13.	TP 13	31/05/2017	Village Road	270169.00 m E	2194878.00 m N
14.	TP 14	31/05/2017	Road	271483.00 m E	2194306.00 m N
15.	TP S	31/05/2017	Village Road	274121.00 m E	2194548.00 m N
16.	TP 16	01-06-2017	Village Road	275000.00 m E	2195180.00 m N
17.	TP 17	01-06-2017	Nala	276822.00 m E	2195671.00 m N
18.	TP 18	01-06-2017	Nala	277710.00 m E	2195997.00 m N
19.	TP 19	01-06-2017	Village Road	277882.00 m E	2196033.00 m N
20.	TP 20	01-06-2017	Nala	278489.00 m E	2196420.00 m N
21.	TP 21	01-06-2017	Nala	278783.00 m E	2196565.00 m N
22.	TP 22	01-06-2017	Village Road	280181.00 m E	2197110.00 m N
23.	TP 23	01-06-2017	Nala	280708.00 m E	2197463.00 m N
24.	TP 24	01-06-2017	Village Road	284418.00 m E	2199428.00 m N
25.	TP 25	01-06-2017	NH-08 -Highway Junction	284817.00 m E	2199518.00 m N

4 Port Road Design

4.1 Road Alignment

For ease of study and design, the road alignment has been split into Three sections as under:

- From Varor (Vadhavan port) to Western Railway line - Ch. 0.00 to 12.00 km
- From Western Railway line to Mumbai-Vadodara Expressway Junction - Ch. 12.00 to 21.00 km
- From Mumbai-Vadodara Expressway Junction to NH-08 junction - Ch. 21.00 to 32.30 km.

4.1.1 From Varor (Vadhavan port) to Western Railway line- Ch. 0.00 to 12.00 Km

- The proposed road starts from Varor (Vadhavan port).
- It crosses two (2) village roads near Varor and moves toward southeast.
- Again, it crosses ten (10) village roads and crosses Chinchani - Vangaon road at CH: 8910.
- It crosses Suburban lines of WR (under construction by MRVC); Western Railway Mumbai – Delhi Main line, & Western Dedicated Freight Corridor Lines under construction at CH: 11370. ROB with approach roads will be provide at this location.
- The route length of proposed road for this section is 12.00 km.
- The Vangaon Western railway station is 2.50 km from proposed road.
- The proposed road is. about 0.50 Km away from DFCC-New Palghar crossing station.

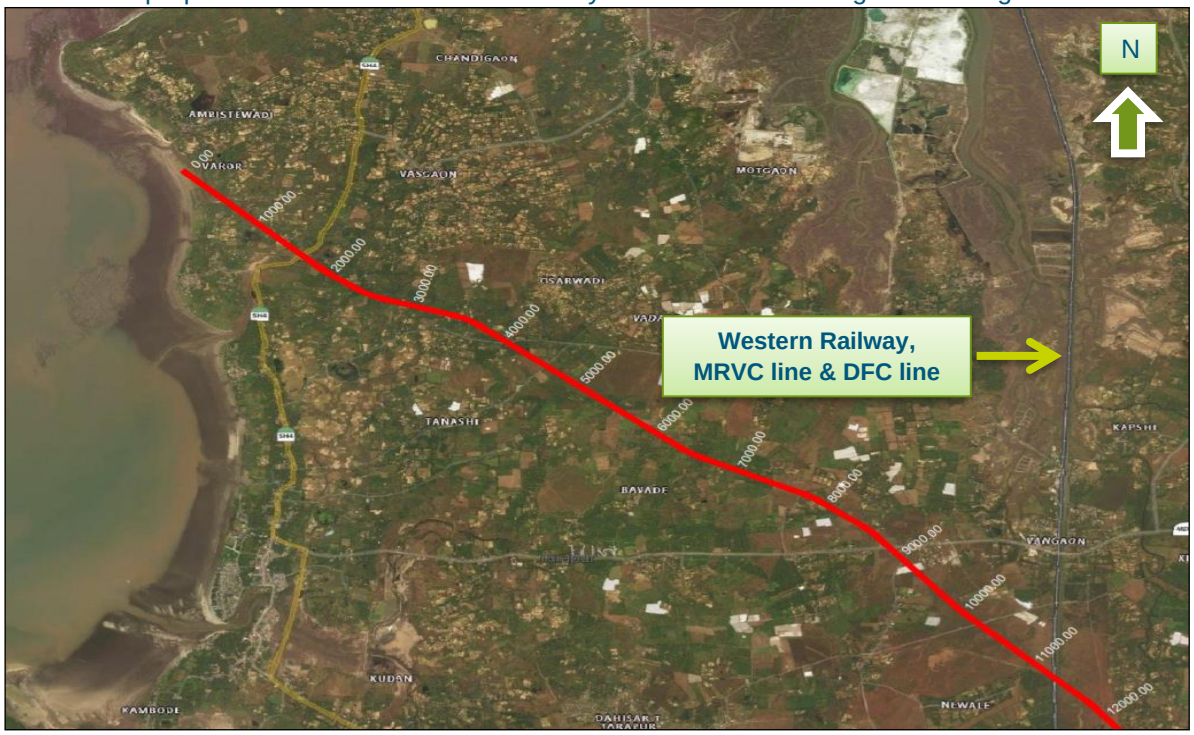


Figure 4-1 Varor (Vadhavan port) to Western Railway line- Ch. 0.00 to 12.00 Km

4.1.2 From Western Railway line to Surya River- Ch. 12.00 to 21.00 km

- After crossing the Railway lines, alignment moves southeast.
- Certain stretches of the terrain in this portion are hilly. The road alignment has been designed to cut the hilly areas (as shown in figure below) in which it is assumed that the quarrying of rocks from CH:17520 to CH: 18990 (approx.1.5 km),material will be procured & utilized for port land reclamation purpose..
- It crosses Vanai - Shigaon road at CH: 17520.

- It crosses Surya River of approx. 90 m with 400 m approach.
- It crosses Mumbai-Vadodara expressway at CH: 20880 which is 8 lane Greenfield Project.
- The route length of the road for this section is 9.00 Km.

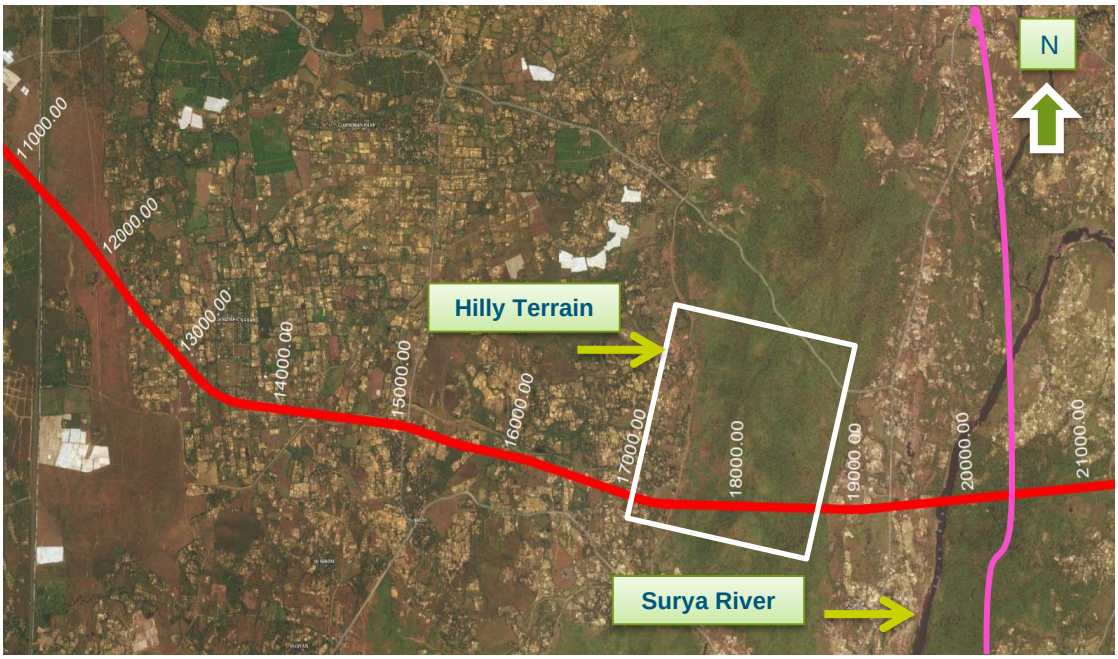


Figure 4-2 Western Railway line to Surya River- Ch. 12.00 to 21.00 Km

Hiily Portion Near Surya River

As per DPR 2018, the road alignment near Surya river was designed in a way to avoid hill cutting. The river width for the purpose of bridging was 610 m including approaches.
In the revised alignment, the quarrying of rocks between CH: 17520 to CH: 18990 (approx. 1.5 km) in the hilly portion near Surya river is envisaged. As per the discussion & meeting with JNPT, it has assumed that the material will be procured & utilized for port land reclamation purpose.
The maximum depth of cutting in this portion is about 100 m. However, for this portion the ground levels have been considered an average 2 m below the proposed formation level for quantity estimation excluding hill cutting.

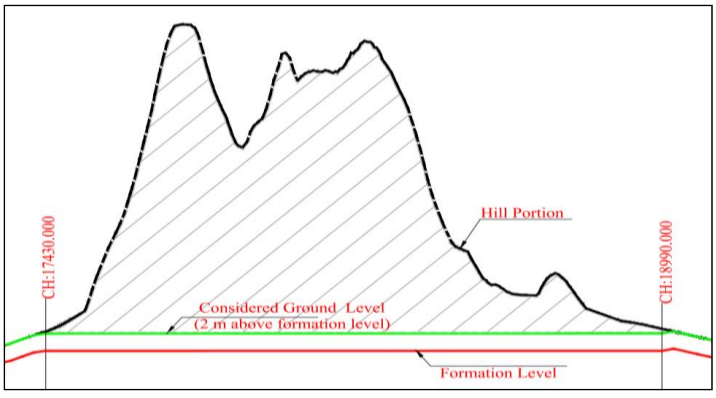


Figure 4-3 Hilly Portion Near Surya River

4.1.3 From Surya River to NH-08 (Tawa junction)- Ch. 21.00 to 32.30 Km.

- After crossing Surya River alignment moves toward North.

- It crosses stream of Surya river at CH: 28700 of approx.
- The proposed road alignment ends at NH-08 junction near Tawa.
- The route length of the road for this section is 11.30 km.
- The total length of the road/ expressway is about 32.30 km.

Figure 4-4 Surya River to NH-08 junction- Ch. 21.00 to 32.30 Km

4.2 Geometric Features

4.2.1 Curvature

Summary of curvatures on the proposed road/ expressway is given below:

Table 4-1Summary of Curvature of proposed road alignment

SN	Radius of Curvature	No. of Curves
1	670	2
2	700	4
3	800	3
4	1000	14
5	1200	1

The detailed curvature list is attached as an Appendix 1.1.

4.2.2 Gradient

Following are the gradients on the proposed route. It will be observed that 'Ruling' gradient of 1 in 100 has been provided over a length of about 4.50 Km while the remaining length has grade flatter than 1 in 100.

Summary of Gradient is given below:

Table 4-2 Summary of Gradient of proposed road alignment

S. No.	Gradient	Total Length (m)
1.	Level	4800
2.	1 in 40	780
3.	1 in 100	4580
4.	1 in 110	1110
5.	1 in 112	840
6.	1 in 115	780
7.	1 in 120	510
8.	1 in 125	330
9.	1 in 130	780
10.	1 in 150	2820
11.	1 in 175	1230
12.	1 in 200	1440
13.	1 in 234	630
14.	1 in 250	420
15.	1 in 290	1080
16.	1 in 300	2790
17.	1 in 350	2220
18.	1 in 500	780
19.	1 in 600	960
20.	1 in 650	1620
21.	1 in 700	1020
22.	1 in 2500	780
Total Length (m)		**32,300**

The detailed gradient list is attached as an Appendix 1.2.

4.3 Pavement Design

4.3.1 General

Pavement is the most significant component of a road and therefore its design strength must be adequate to support the projected/ design traffic throughout the service period / life span within acceptable levels of service. Pavement is designed to service the design traffic in a safe, durable, and cost-effective manner.
Cost of pavement is one of major component of the total road construction cost.

Pavement design basically aims at determining the total thickness of the pavement structure as well as thickness of the individual structural components. The guidelines IRC:37 which follows the Mechanistic-Empirical approach for pavement analysis is generally considered.

It is proposed to provide a flexible pavement on this port road.

4.3.2 Flexible Pavement Design

4.3.2.1 Design Procedure

Thicknesses of individual pavement layers are computed as per IRC 37. The prime factors are:

- Design traffic in terms of cumulative number of standard axles (in Million Standard Axles (MSA)
- CBR value of sub grade over which the pavement is proposed.

4.3.2.2 Design Traffic

The design methodology considers traffic in terms of the cumulative number of Standard Axles (8160 kg) during the design life. This requires the following information:

- Initial traffic (two-way) on the road in terms of Commercial Vehicle (having the laden weight of 3 tonnes or more) Per Day (CVPD).
- Traffic growth rate during the design life
- Design life in number of years (considered 20 years)
- Vehicle Damage Factor (VDF) to be calculated as per traffic projections
- Distribution of commercial traffic over the carriageway (for 4 lane road it is considered as 40%).
- Traffic growth Rate: The standard traffic growth rates for a classical highway/expressway is generally taken as 7.5 %. However, for this port the traffic projection data is available. This has been utilised to predict the actual traffic growth rate.

As per traffic study the projected traffic on the proposed Port road is as under:

Table 4-3 Current and Projected Traffic on the Proposed Port Road

S. No.	Commodity	Truck Movements per day		
		2030	*2040*	*2050*
Outgoing				
1.	Fertiliser	86	86	100
2.	Edible Oil	135	162	189
3.	LPG	74	100	124
4.	Chemicals	143	175	206
	Total Outgoing Trucks per Day	**437**	**522**	**619**
Incoming				
5.	RO-RO	28	97	130
	Total Incoming Trucks per Day	**28**	**97**	**130**
Incoming /Outgoing				
6.	General Cargo	686	1.314	2,057
7.	Coastal Cargo	486	914	1,429
8.	Containers (EXIM)	11,338	30,818	49,154

S. No.	Commodity	Truck Movements per day		
		2030	*2040*	*2050*
	Total Incoming/ Outgoing Trucks per Day	**12,509**	**33,046**	**52,640**
	Total Trucks to be Handled per Day (incoming and Outgoing)	**13,441**	**34,284**	**54,137**
	Total PCUs to be handled per day (Truck 3; Container Trailer 4.5)	**57,329**	**149,079**	**236,142**

[Source: Data received from M/s Royal HaskoningDHV]

Note: The traffic assessment data is 'Work in Progress' (WIP) and is likely to be modified as the overall Study moves further.

The traffic growth rate has been calculated as per following formula which gives the compounded annual growth rate based on traffic projections:

$$\mathrm{CAGR} = \left(\frac{V_{\mathrm{final}}}{V_{\mathrm{begin}}}\right)^{1/t} - 1$$

Where:
CAGR = Compound annual growth rate
V begin = Beginning value
V final = Final value
T = Time in years
Based on above formula, Compound annual growth rate as per given traffic data for first 10 years is slightly more than 10% while in 20 year period it was calculated as 8.7%. Accordingly, 8.7% was considered.
Traffic Growth Rate over the years (r) - **8.7%**
Design Life Period of the port road (n) - **20 years**

- **Vehicle damage Factor (VDF): VDF is assumed as 5.0.**

Computation of Design Traffic (msa):
As per IRC 37 (clause 4.6.1) the design traffic, in terms of the cumulative number of standard axles is estimated using following equation:

$$N_{Des} = \frac{365\times[(1+r)^n-1]}{r} \times A \times D \times F$$

Where:

- N_{Des} = cumulative number of standard axles to be catered for during the design period of 'n' years
- A = initial traffic (commercial vehicles per day) in the year of completion of construction (directional traffic volume to be considered for divided carriageways where as for other categories of the carriageway, two-way traffic volume may be considered for applying the lateral distribution factors)
- D = lateral distribution factor (as per para 4.5 of IRC: 37-2018)
- F = vehicle damage factor (VDF)

- n = design period, in years
- r = annual growth rate of commercial vehicles in decimal (e.g., for 6 per cent annual growth rate, r = 0.06). Variation of the rate of growth over different periods of the design period, if available, may be considered for estimating the design traffic

The traffic in the year of completion of construction has been estimated using equation:

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

Where:
P = number of commercial vehicles per day as per last count.
x = number of years between the last count and the year of completion of construction.
For arriving at cumulative standard axles following details have been considered:

1. Lane Distribution Factor (D) - Dual Four Lane Carriageway - 45%
2. Traffic Growth Rate (r) - 8.7%
3. Design Life- For Expressway or Urban Roads (n) - 20 Years
4. Vehicle Damage Factor (VDF) - 5.0
5. Initial Traffic - 3638

According to Clause No. - 4 6.1, IRC 37:2018

N = (365[(1+r) ^ n - 1] X A X D X F)/r
= (365[(1+0.087) 20-1] x3638x 0.45 x 5.0)/ 0.087
= 147.80million standard axles
= 150 MSA

The pavement layer thicknesses considered at this stage is 150 million standard axles. This is quite different from the DPR (2018) where the calculated MSA was arrived as 20 MSA and 30 MSA was considered for pavement design.

Assumption of Design CBR of Subgrade

Subgrade CBR value has been considered as 10 % considering that most of the subgrade will be borrowed earth source from identified quarry locations on which good quality control can be achieved.

Pavement Design – Layer thickness

The pavement structural catalogues presented in the guidelines IRC: 37-2012 has been considered for design traffic levels of 150 msa. This has been considered to arrive at initial cost estimation. The actual optimal requirement of layer thicknesses will be evolved based on detailed analysis which will be carried out during detail design stage when more details in regard to sub grade soil parameter and also type of material which will be utilised for different layers would also be available. Practical considerations and durability of the selected layers would also be kept in mind during the detailed design stage. Thus, following pavement design thickness has been considered at this stage:

Table 4-4 Pavement Thickness for 150 msa and CBR value of 10%

Bituminous Surface					
CBR Value	**Total Pavement Thickness**	**Bituminous Concrete**	**Dense Bituminous Macadam**	**Granular base**	**Granular Sub base**
	mm	mm	mm	mm	mm
10	625	50	125	250	200

Different methods of currently accepted pavement design guidelines are available, and the approach of the Consultants, during the detail design stage, will be to work out the requirements by the various methods, compare the results and optimize the recommended solutions based on characteristics of available materials, relevant economics and best engineering judgement.

4.4 Critical Locations for Alignment design

Following are the critical locations where road alignment design required detailed study.

Table 4-5 Critical Locations along proposed Road Alignment

S. No.	Location	Reason	Proposed
1.	Near Vangaon Railway Station	Alignment crossing the Western Railway, MRVC line, DFC line	ROB is proposed.
2.	Near Gargaon	Alignment crossing Hilly Terrain	Stone will be quarried for Port Land reclamation purposes
3.	Near Rawte	Alignment crossing Surya river	Major River bridge of 90 m+ approaches is proposed
4.	Near Chinchare	Alignment crossing Mumbai-Vadodara expressway	Junction is proposed

4.5 Name of The Villages Through Which Road Passes

The proposed road alignment passes through following villages

Table 4-6 List of Nearby villages along proposed alignment

S. No.	Village Name
1.	Varor
2.	Chinchani
3.	Tanashi
4.	Bavade
5.	Vangaon
6.	Kolavali
7.	Newale
8.	Hanuman Nagar
9.	Shigaon
10.	Sumdi
11.	Khanivade
12.	Ravte
13.	Chinchare
14.	Aakoli
15.	Aakegavhan
16.	Naniwali

S. No.	Village Name
17.	Ambhede
18.	Dhamatane
19.	Kolhan
20.	Ghol
21.	Tawa

4.6 Crossing Details of the Road Alignment

The proposed road alignment crosses village roads, major roads, major/minor streams, Surya river, existing railway line, Mumbai-Vadodara expressway, canal etc. Summary of crossing details given below:

Table 4-7 Summary of crossing of proposed Road Alignment

SN	Proposed	Crossing detail	Total No.
1	Underpasses	Road Crossing	40
2	Culvert	Stream (Total bridge length up to 6m)	4
3	Minor Bridges	Stream (Total bridge length 6 < 60 m)	18
4	Major Bridges	Stream (Total bridge length > 60 m)	1
5	ROB	Railway Crossing	1
6	Junction	Road Crossing	2
7	Road to be Diverted	Road Crossing	34
8	Stream/Canal to be diverted	Stream (Total bridge length 6 < 60 m)	6

The detailed crossing list is attached as an Appendix 1.3.

4.7 Bridge Structures- Design

The details of the bridge structures have been given in Appendix 1.3. The bridge structures have been provided for following –

- Vehicular Underpasses
- Cross Drainage Minor bridges
- Road crossings for Junctions
- Road over bridges (Bridge over Railway)
- Major River crossing

The aim of bridge design is to provide typical designs which can be used at multiple locations based on the bearing capacities and overburden heights. Accordingly, a few typical designs have been developed for minor bridge locations, while at other locations site specific designs have been developed.

4.7.1 Vehicular Underpass/Overpass

The vehicular underpass structures have been provided at all the locations where existing road crosses the proposed road alignment. At a few locations, roads have been diverted based on the site conditions so as to reduce the number of such crossings.

For all these structures RCC box design has been considered with width of 12 m and height of 5.5 m thus providing passage for two lanes each of 3.5 m width and 2.5 m pedestrian lane on both sides.

The structure has been designed as an RCC box structure with load coming on four sides of the box walls. The design has been prepared based on IRC: 6 and other IRC/IS codes and specifications. The typical dimensions and design of such RCC boxes is given as under:

- Clear horizontal opening (width) - 12 m
- Clear vertical opening (height) - 5.5 m
- Top Slab thickness - 0.8 m
- Bottom Slab thickness - 0.8 m
- Wall thickness - 0.6 m
- Length of the RCC Box – will depend on the height of embankment at the location where the underpass is being provided

Typical cross section of the underpass is indicated in the figure below:

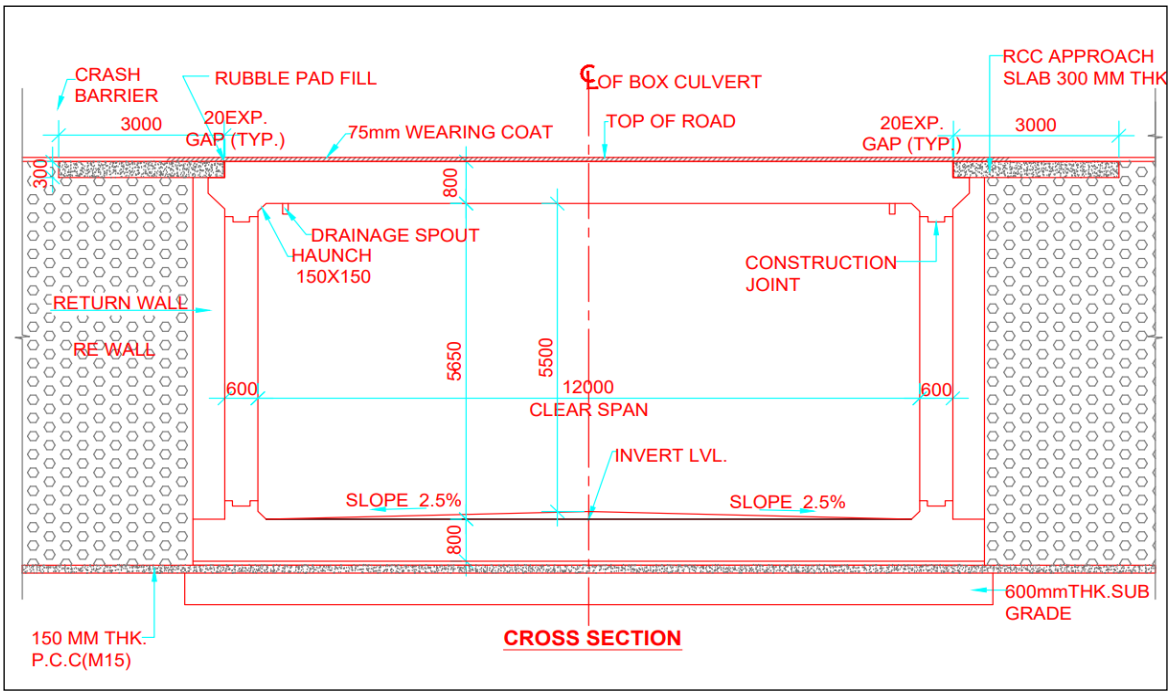


Figure 4-5 Typical Cross Section of Underpass

4.7.2 Culverts

As per IRC: 5-2015, the total length of bridge up to 6 m is classified as Culvert. In all, 4 culverts have been proposed. All these structures have been provided as RCC boxes with varying spans. The opening (size i.e. height and width) of culverts provided on the road have been matched with the minimum size of 2 m X 2 m required to be provided on Railway for along Rail and Road ROW. For the remaining stretch of the road also, the same concept of providing a minimum size of RCC Box as 2 mx2 m has been considered.
A typical cross section of culverts is shown as under:

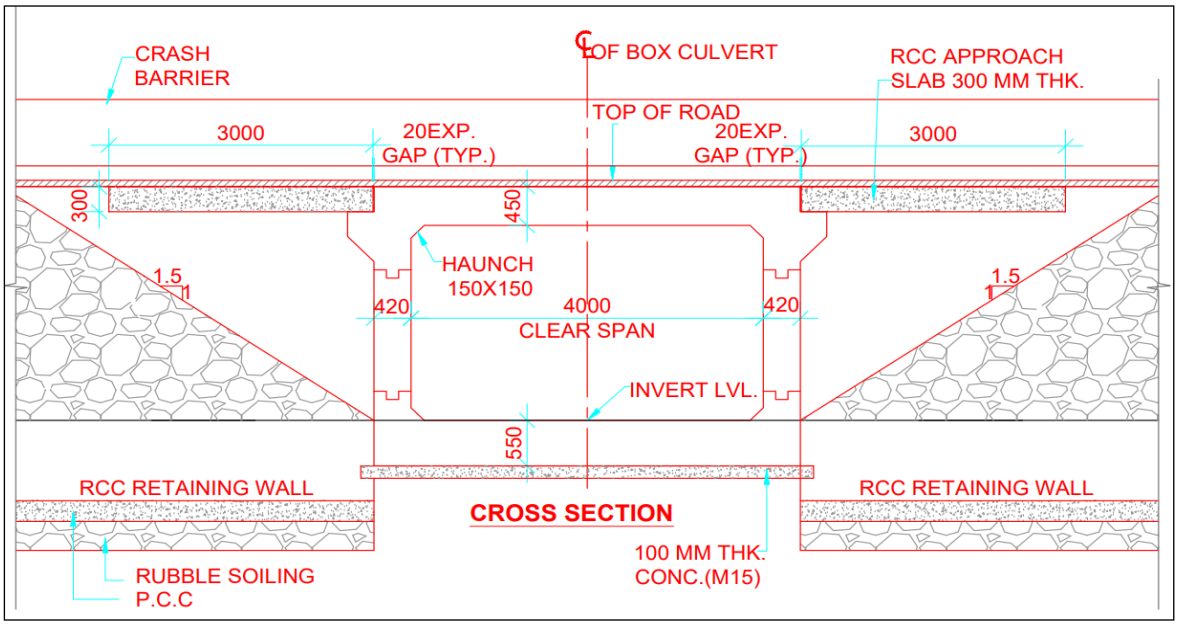


Figure 4-6 Typical Cross Section of Culvert

4.7.3 Minor Bridges

As per IRC: 5-2015, the total length of bridge from 6 m up to 60 m is classified as minor bridge. In all, 18 minor bridges have been proposed.
A typical cross section of minor bridge is shown as under:

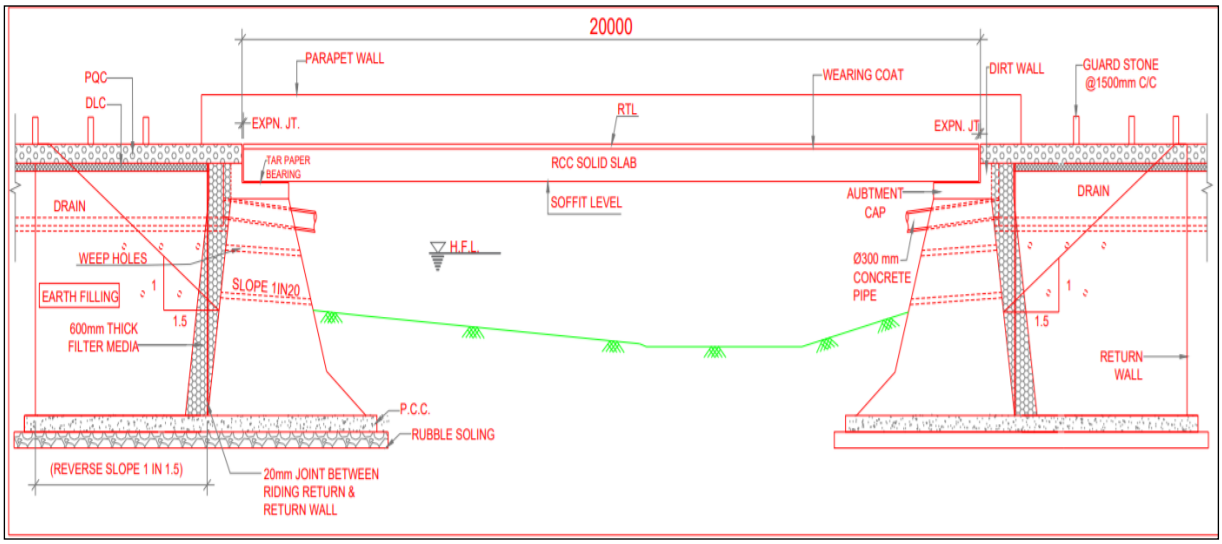


Figure 4-7 Typical Cross Section of minor bridge

4.7.4 Major Bridges

As per IRC:5-2015, bridges having total bridge length greater than 60m are termed as Major Bridge. On this project following two bridges are major bridges. The brief details of these bridges is indicated as under.

Table 4-8 Major Bridges

S. No.	Chainage (M)	Types of Structures	Linear Length of The Bridge (M)	Vertical Clearance (M)	Proposed Span Arrangement

1.	10770-11730	ROB With Approach	960	8.05 from Rail level	Proposed modified railway span 2 x 74m bow string RDSO girder + approaches
2.	19691-19981	Bridge with approach (over Surya river)	290	9.6	Proposed modified span is dual carriageway of (3 x 30m) + approaches

4.7.5 Bridge over Surya River

The bridge over Surya river as per DPR (2018) was provided in straight with two approach curves. The approach curve details were not indicated. In order to have a straight portion with curved approaches the alignment was shifting beyond the planned ROW. After the discussion & meeting with JNPT , the alignment is realign at Surya river and proposed as crossing hilly terrain. The waterway of the bridge has been kept as 90 m as per realign road alignment.

The preliminary design features are as under:

- Three spans of 30 m each
- Overall length of the bridge -90 m + approaches
- Bridge is in straight portion

Superstructure – PSC I section with reinforced concrete deck slab over I sections. Pot PTFE Bearings fixed to Pier Cap

Substructure: it will comprise of wall type rectangular pier of size 3 m long (in transverse direction) and 1.5 m wide with hammerhead pier cap of 14.3m length and pier head width of 2.6m. A cantilever length to 5.65m on each side of the pier cap would make up the pier cap length so as to accommodate the required length for 8 lane expressway and a pier cap depth of 2 m. Thus, the pier cap size would be (14.3m x 2.6m x2m) trapezoidal pier cap.

Foundations The foundation will comprise of pile foundations on 1.2 m dia piles of 9 piles three rows each having three piles. The pile cap size of 8.7 m x 8.7 m x 1.8 m has been considered. The length of piles will vary depending on the geotechnical results and would generally be more than 15 m long which will be well embedded in hard rock.

The preliminary design is indicated in the figures as under

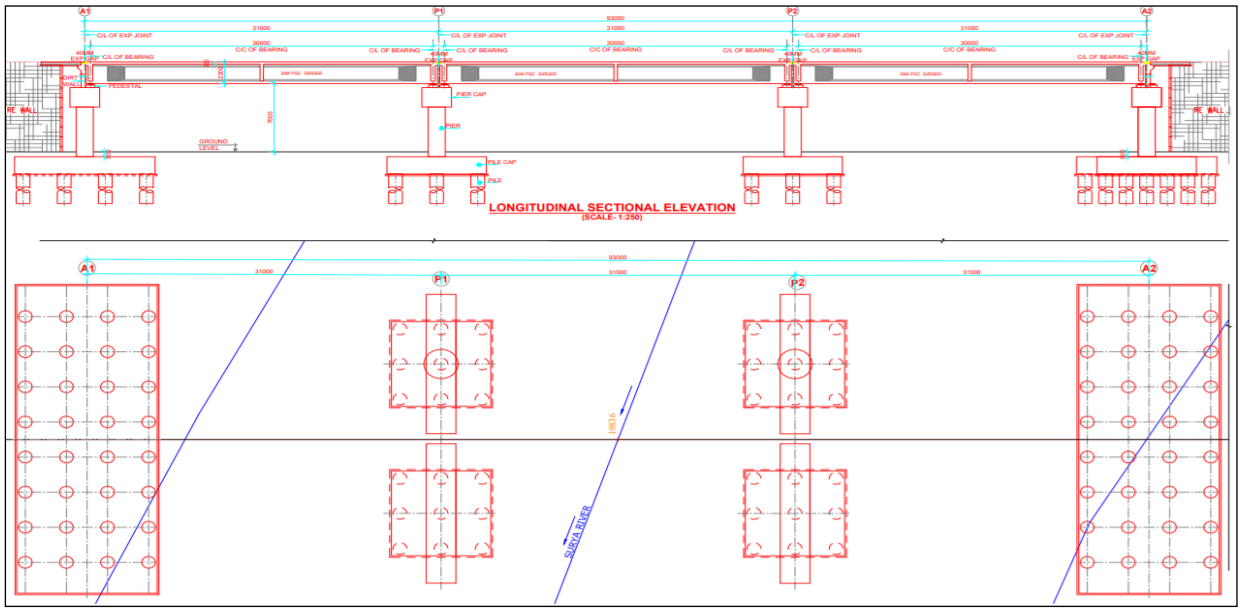


Figure 4-8 Typical Plan & Section of Surya River

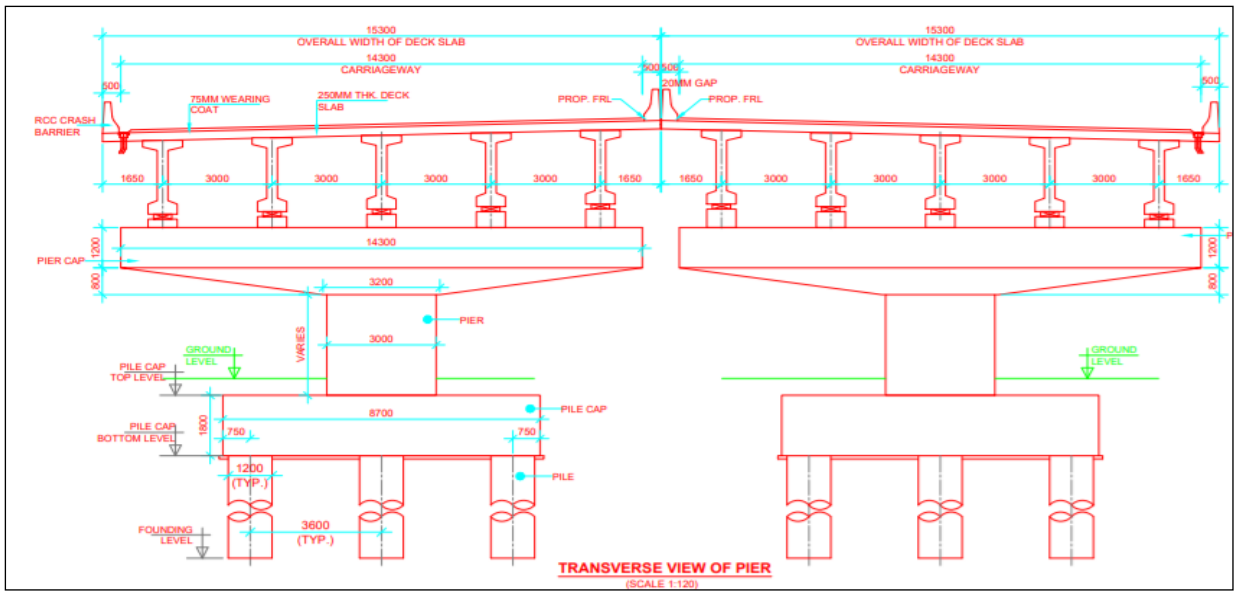


Figure 4-9 Transverse view of Pier

4.7.6 Road Over Bridge (over Railway)

The Port road crosses the Railway at Ch: 11370. The railway at this location, at present has UP and Down mainlines of important Mumbai – Delhi route of Western Railway. At this location Dedicated freight corridor lines are also planned to be constructed. Two more suburban lines are also being constructed by Mumbai Rail Vikas Nigam (MRVC). Thus, the road bridge has to cross over three major Railway systems.

For construction of Road over bridges (RDSO guidelines BS-112 Guidelines for Planning of Road Over Bridges, May, 2014), Railway generally insists that the pier and abutments of proposed ROBs should be kept outside the Railway boundary so as to keep provisions of future needs of the Railway. In very difficult site situations, they may consider provision of one pier/abutment within the railway

area as per their conditions. Considering these limitations, the preliminary design has provided one pier location in the railway area by adopting two long bow string girder design.

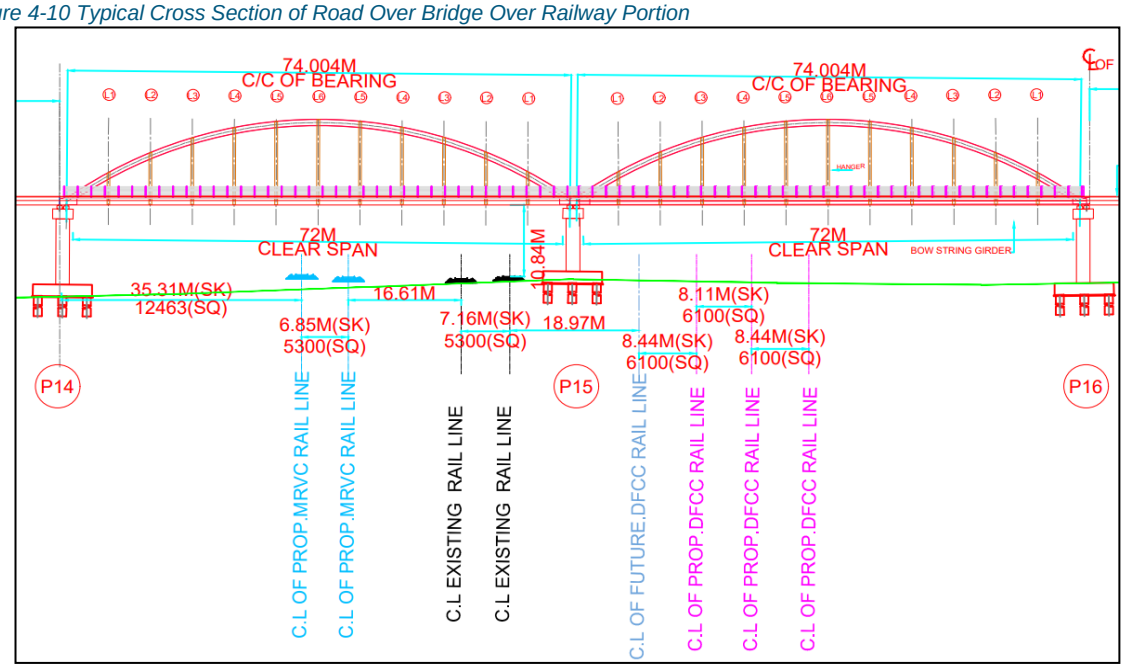
The salient features of the design developed are detailed as under:

- **Superstructure:** Two steel bow string girders of 74 m span as per RDSO's Standard drawings with approach spans comprising of PSC I girders with RCC deck Slab
- **Skew angle:** Bridge is in skew of 41 degree with Railway alignment.
  The bridge crosses Western railway lines, MRVC lines (under construction) and Western Dedicated Freight corridor lines (under construction)
- **Substructure:** will comprise of wall type rectangular pier with trapezoidal pier cap to accommodate the width of the girders.
- **Foundation**: Pile foundations will be provided with 1.2 m dia piles in two rows each row having 5 piles in all 10 piles will be provided. The pile length will vary depending on the geotechnical investigation data for the location where the foundations will be provided. A pile cap of size 5.1 m wide and 15.9 m length having a thickness of 1.8 m will be provided.

For constructing the Pier which falls within the Railway boundary suitable measures to avoid train running restrictions will have to considered.

A typical cross section of the Road Over bridge over railway portion is shown as under

Figure 4-10 Typical Cross Section of Road Over Bridge Over Railway Portion



4.8 Intersections and Junctions

The road is planned as an entry restricted road connecting with Mumbai Vadodara Expressway and NH-08. Proposed options for connectivity are designed as per MoRTH Guidelines for traffic transfer shown in the figures below:

Connectivity to NH-08: Two options of connectivity to NH-08 have been considered. The Junction arrangement plan of the two options are as under:

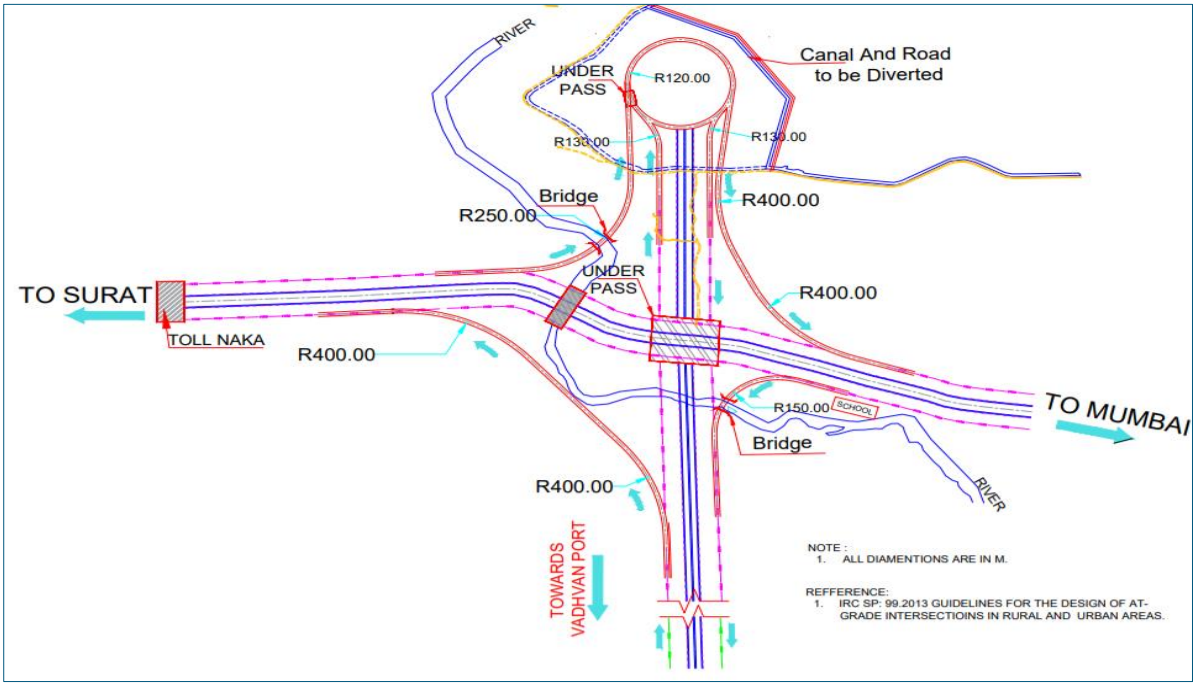


Figure 4-11 Connectivity to NH-08 Option-1 (Recommended Option)

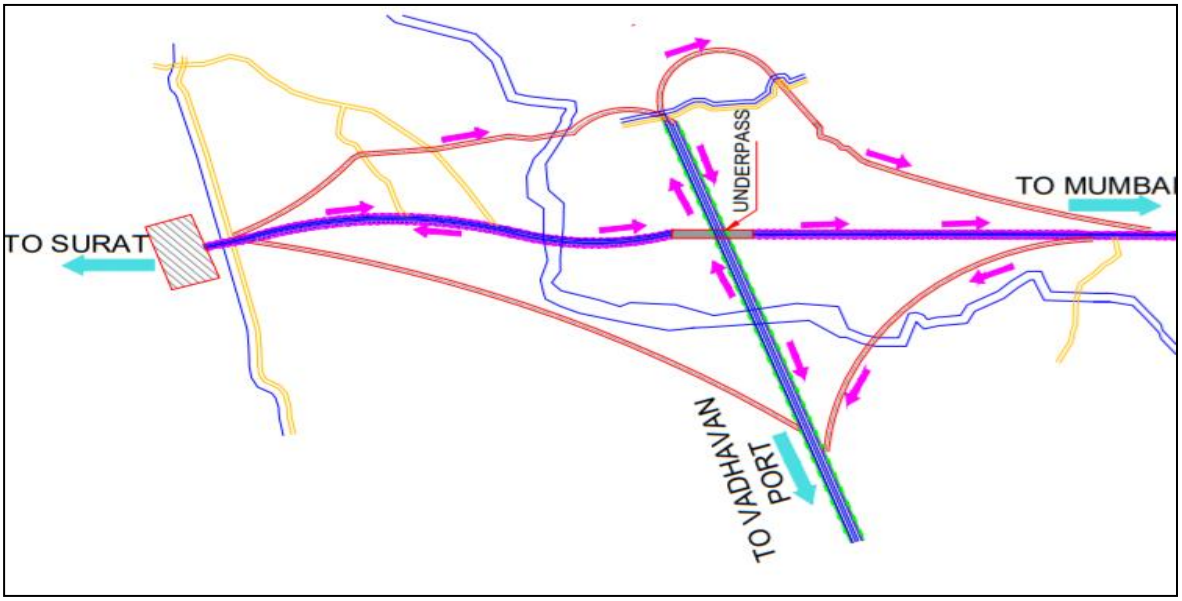


Figure 4-12 Connectivity to NH-08 Option-2

Option-1 is the preferred option for connectivity of the port road to NH-08 at Tawa village.

Connectivity to Mumbai-Vadodara Expressway: Two options of connectivity to Mumbai-Vadodara have been considered. The junction arrangement plan of the two options are as under:

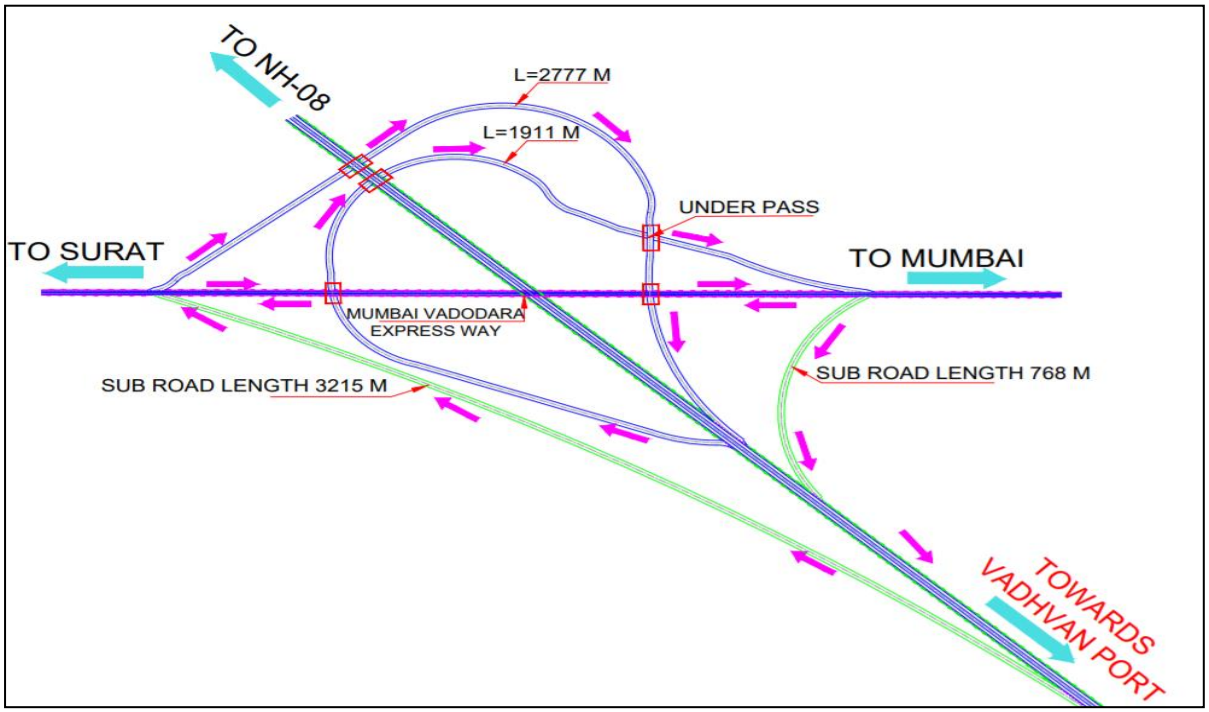


Figure 4-13 Connectivity to Mumbai-Vadodara Expressway Option-1

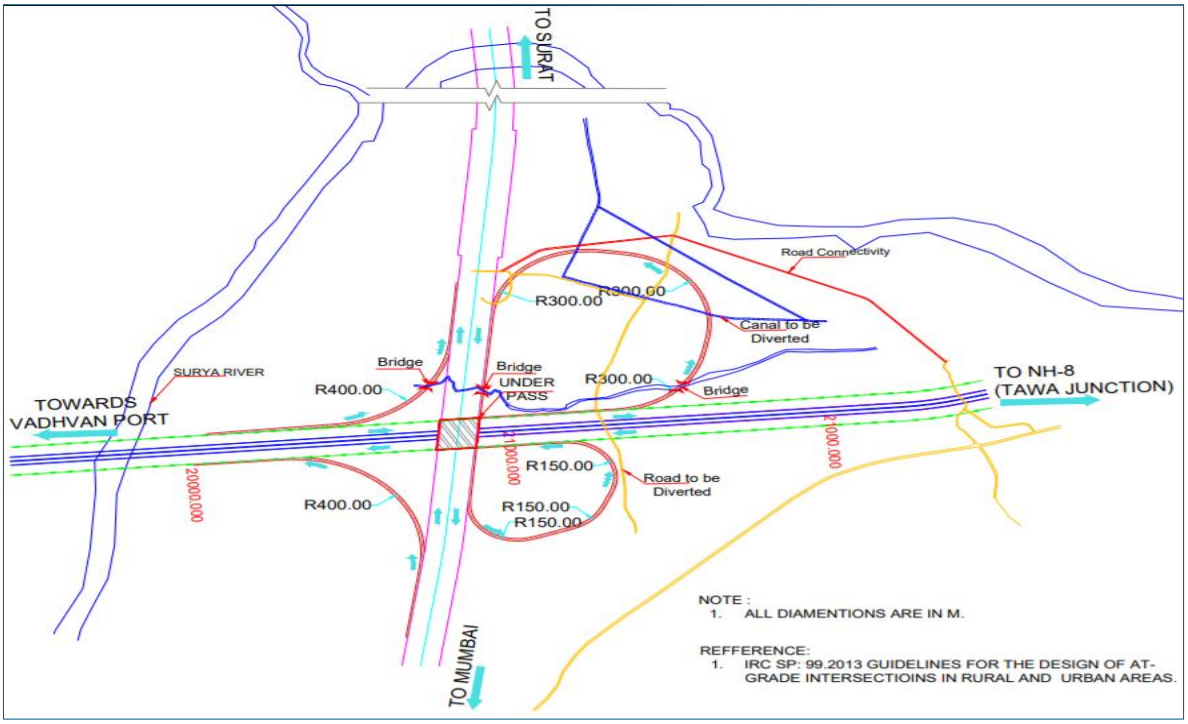


Figure 4-14 Connectivity to Mumbai-Vadodara Expressway Option-2 (Recommended option)

Option-2 is the preferred option. As per the above typical junction arrangement drawing, it will require additional land corridor for road.

4.8.1 Recommendation for Junction Connectivity

Based on above junction drawing options following is recommended:

Connectivity to Mumbai-Vadodara expressway & NH-08: As the traffic towards Mumbai is going to be less compared to northward traffic, Option-1 for NH-08 Connectivity and Option-2 for Mumbai-Vadodara Connectivity is suggested.

Recommended connectivity of Port Road with NH-08, the port road crosses NH-08 via underpass.

- The proposed Port formation level at the point of crossing is 48.608 m, ground level is 49.733 m.

Recommended connectivity of Port Road with Mumbai-Vadodara Expressway, the port road crosses expressway (Mumbai-Vadodara) via underpass.

- The proposed port formation level at the point of crossing is 26.039 m; Average ground level is 24.344 m.
- The proposed level of Mumbai-Vadodara Expressway is 28.989m at chainage 66550 Km, which has to be revised to Average 31.939 m by raising the expressway by 2.95m for attaining the height of underpass for port road.

There is a need for further improvement of the connectivity which can be done after topographical survey. The Land requirement for the connectivity at both the locations will have to be assessed and acquired after finalisation and freezing of connectivity plans.

4.8.2 Way side Amenities

Based on the road traffic projections there is a need to provide way side facility for the truckers. The wayside amenities are planned as truckers stops with adequate and segregated parking areas, petrol pumps, rest rooms, recreational and shopping areas apart from traffic control & solution centre. This modern amenity hubs are proposed in such a way to serve each and every need for the truck drivers without congestion with systematic monitoring of all truck movements, dedicated parking spaces for different operators, different cargo and will be smart card operated. The facilities proposed in the hub are listed below.

- Parking
- Rest Rooms
- Washrooms
- Medical Centre
- Cooking Space
- Food Court
- Petrol Bunk
- Recreational Spaces (including Multiplex)
- FMCG Stores
- Truckers Daily needed Services like Laundry, Barber shop, Medical Center, Communication centre, Xerox, Lamination, Photo shops, Sweets Shop
- Training Centre
- Truck Control Centre
- Traffic Police Office
- Watch & Ward/Armed Security
- Security Bunker
- Locker
- Huada for bath
- Cloth Drying Stand
- Common Kitchen (Sanjha Chhullah)
- Dormitory
- Signage’s
- Music Accessories/Mobile Repair

Having identified the need of Truckers, further analysis is made for incoming & outgoing traffic, there locations & based on operational need further, Location of Way side Amenities and level of Servicing has been re-assessed. As this needs to be located along Road side, it is pertinent to identify and locate same at government land preferably to avoid land acquisition.

Following Locations could be considered for Way side Amenities on left side of Road for incoming & outgoing traffic based on availability of land, operational requirement, such facilities created on NH-8/MMB-VDR Expressway:

Outgoing Traffic from Port:

- Main way side facilities & Control Station (Location: 2-3 Km away from Port Exit on LHS)
- Intermediate way side facilities & communication Centre (Location: before Mumbai – Vadodara Express way 2-3 Km before on LHS)
- Communication& Emergency Centre (Location: Mumbai – Vadodara Express way & NH-08 Junction on trapped triangular land): For Incoming & Outgoing Traffic.

Incoming Traffic to Port:

- Main way side facilities & Control Station (Location: 2-3 Km away Vadodara–Mumbai Expressway on LHS)
- Intermediate way side facilities & communication Centre (Location: Before Mumbai – Vadodara Exp. way 2-3 Km before on LHS)

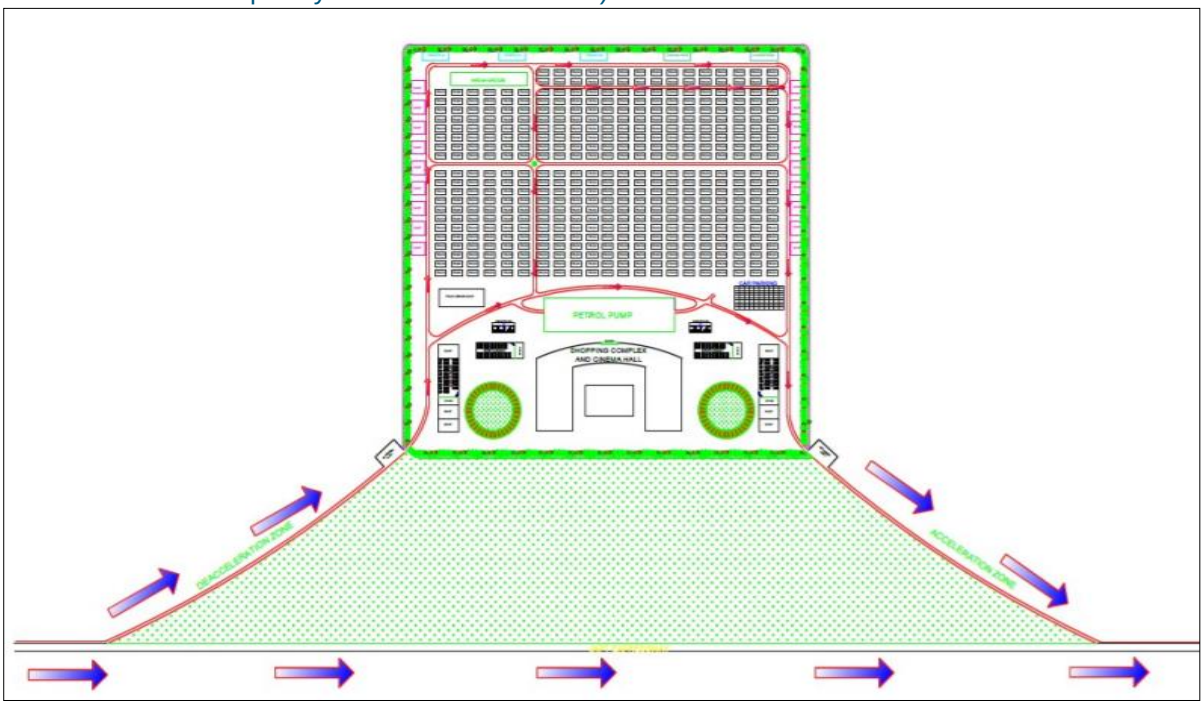


Figure 4-15 Typical Layout of Main way side facilities

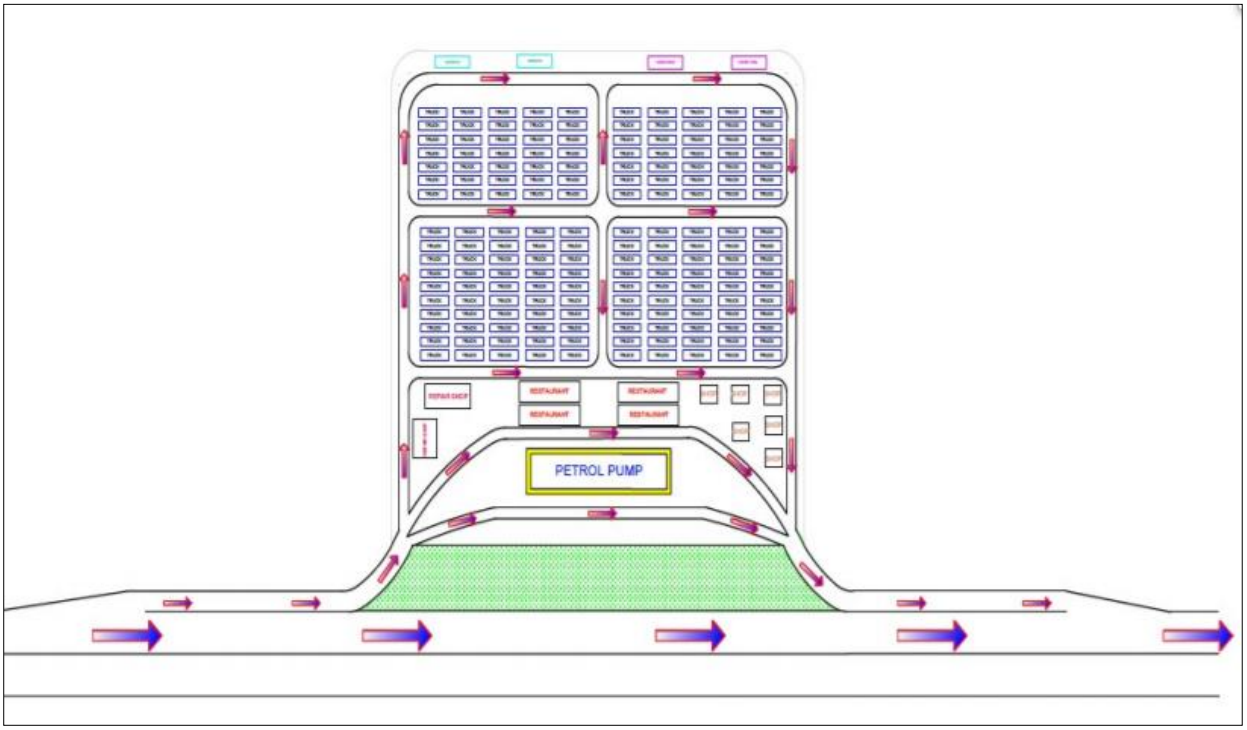


Figure 4-16 Typical Layout of Intermediate way side facilities

4.9 Signages

The road signs on expressways are required to provide adequate information on lane driving, advance information to exit, location of facilities for road users and also for emergency need for vehicles. Following IRC standards and MORTH specifications shall be followed for providing road signs and road markings:

- Code of Practice for Road Signs (IRC 67:2012)
- Code of Practice for Road Marking (IRC 35 – 2015)
- Guidelines on Traffic Management in Work Zone (IRC 55: 2014)
- MORTH 2013 – Specifications for Roads and Bridge work (Section 800)

Clustering and proliferation of road signs shall be avoided for enhancing their effectiveness.

The traffic signs on expressways proposed for distinct functions are described below:

1. Give directions to destinations, or highway routes, or to other Expressway interchanges and toll plazas;
2. Furnish advance notice of the approach to interchanges or toll plaza;
3. Direct road users into appropriate lanes in advance of diverging or merging movements;
4. Identify routes and directions for important destinations on those routes;
5. Show distances to destinations;
6. Indicate access to general motorist services, rest, scenic, and recreational areas; and
7. Provide other information of value to the road user such as weather, maintenance works and occurrence of accidents.

4.9.1 Colour of signs

The Colour of all types of signs except direction information signs will be same as that of Plate-I and Plate-II of IRC: 67. For direction information signs, it will be white lettering, border and arrows on blue background. In case of facility signs, black symbol will be displayed within white Square in blue background. The legend on all signboards will be bilingual-regional/local language and English except

on those sign boards located at entry/exit points. Entry/Exit will have inscriptions in regional/ local language, Hindi and English. The font type will be as per Table below.

Table 4-9 Font type

SN	Language	Font
1	Regional Language	As per regional Practice
2	Hindi	Hindi
3	English	Transport Medium

4.9.2 Sizes of signs

The sizes of various types of signs for design speeds of 80-100 km/hr. and more than 100 km/hr. will be as in Table.

Table 4-10 Sizes of Signs

Sign	Shape	Size for Speeds Above 100 Km/hr (in mm)
Stop Sign	Octagonal	1200
Give Way Sign	Triangle	1200
Prohibitory	Circular	1200
No Parking, No Standing, No Stopping Signs	Circular	1200
Speed Limit and Vehicle Control Signs	Circular	1200
Cautionary Signs	Triangle	1200

4.9.3 Size of letters

Size of letters will be such that these are legible and visible at design speeds. The size of letters for Advance Direction, Flag type direction, reassurance, place identification and Gantry mounted signs for various approach speeds will be as per Table below. For supplementary plates attached with facility signs, regulatory signs or cautionary signs, the letter size will be 100 mm.

Table 4-11 Size of Letters

Advanced Direction Signs (Mounted on Shoulders)			Flag Type Direction Signs, Reassurance Signs, Place Identification Signs		Gantry Mounted Signs	
Design Speed (km/hr)	'x' height lower case (mm)	'x' height upper case (mm)	'x' height lower case (mm)	x' height upper case (mm)	'x' height lower case (mm)	'x' height Upper case (mm)
66-80	150	210	125	175	200	280
81-100	200	280	150	210	250	350
101-110	250	350	200	280	275	385
111-120	300	420	300	420	300	420

4.9.4 Signs on curves

Wherever the Expressway alignment is on a curve, there will be advance cautionary signs for sharp curves (depending on whether it is on left or right) and chevron signs (rectangular in shape with

yellow background and black arrow) at the outer edge of the curve. The size of chevron will be as per IRC: 67.

The curves with radii up to 1200 m will be provided with curves warning sign in advance of hazard and single Chevrons on outer edge of curve. Chevron signs will be always placed on outer edge of the curve and spaced uniformly for the length covering transition length and the straight portion as given in IRC: 67.

The curves with radii 1200 m to 3000 m with deflection angle more than 20 degree will be provided with Chevrons on outer edge of curve at 75 m spacing.

The curves with radii 1200 m to 3000 m with deflection angle less than 20 degree and other curves up to 5000 m radius will be provided with forgiving type delineator posts at 40 m spacing on outer edge of curves.

4.9.5 Overhead signs

The following conditions may be considered while deciding about the locations of overhead signs:

- Traffic volume at or near capacity,
- Restricted sight distance,
- Built up stretches,
- Insufficient space for ground mounted signs,
- Distances of important places and routes at suitable intervals
- Before major intersections with another Expressway or National Highway
- Approaches to Interchanges
- Multi-lane exits
- Entry to Toll Plazas

4.9.6 Safety Aspects

4.9.6.1 Crash Barriers

Metal beam crash barrier, precast concrete or Rolling crash barriers have been proposed to be installed along the roadway edge on either side if road stretch falls under the following category:

- Embankment height > 3m
- Approaches of Underpass / Flyover / ROBs
- On horizontal curve

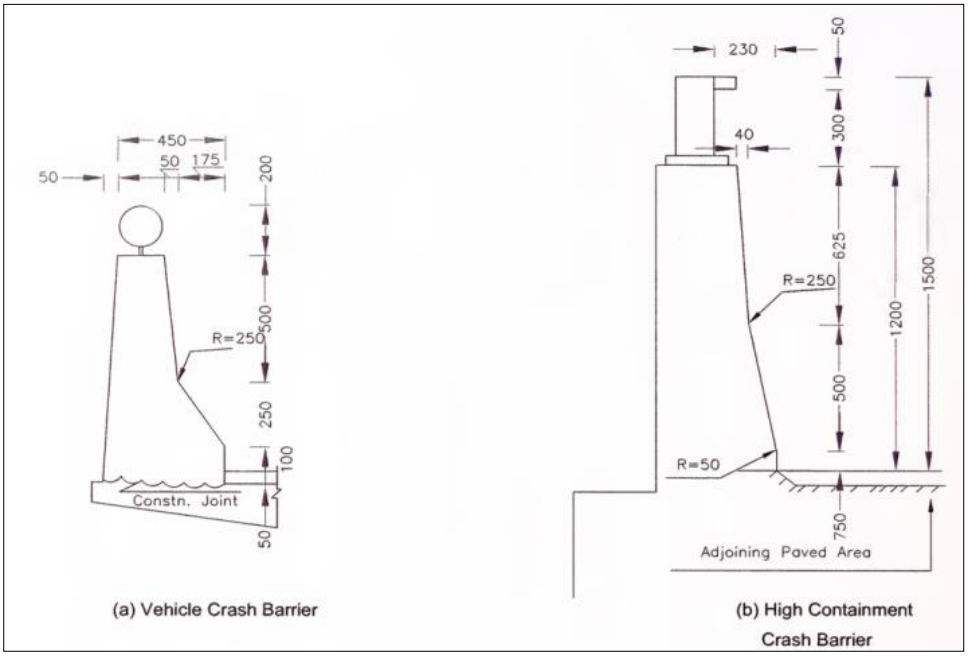


Figure 4-17 Typical Details of Crash Barrier

4.9.6.2 Rolling crash barrier

Features of the Rolling crash barrier as follows:

- LED guide lamp (solar energy).
- Material is eco-friendly.
- It reduces the speed of vehicle.
- Reduces costs in repairing & maintenance due to Roller's resilience.
- Made of special chemical compound like vulcanized rubber.
- Easy to maintain due to separated barrels (recyclable).
- Stopper boards installed on the top and the lower part of the barrels to guide objects back to the road.
- Easy to adjust height, noticeable to drivers due to noticeable coloration and self-luminescence.
- Noticeable to drivers due to noticeable coloration and self-luminescence.

Figure 4-18 Rolling Crash Barrier

4.10 Pavement Markings and reflectors

Markings to guide and assist the road users to negotiate conflict points and to make their manoeuvres in the safest and quickest way that the time they are exposed to risk is minimized. Pavement markings on the project road have been proposed to be done based on IRC: 35, "Code of Practice for Road Marking" with centre-line, and edge strip.

4.11 Lighting

As per IRC: SP: 99 – 2013 Section 15 - Lighting Specifications, Minimum level of illumination in the expressway including truck lay-byes, wayside amenities and parking will be as per the table below.

Table 4-12 Minimum Level of illumination

Category	Average Level	U0	U1	T1
Expressways	25 lux	0.4	0.7	15%

Where:
U0: Overall uniformity
U1: Uniformity along the axis of the road
T1: Maximum glare
Vertical and Horizontal clearances for electrical installations will confirm to IRC 32.

4.11.1 Lighting Standards

Following components shall be taken into consideration

- Average Luminance level
- Overall Uniformity of Luminance
- Glare
- Guidance

4.11.2 Locations for Lighting

- Continues Lighting shall be provided through Expressway
- Interchange Locations
- Bridge Structures and Underpasses
- Special Situations such as tunnels, toll plazas, wayside amenities

4.12 Kilometre stones

Standard Kilometre, 5th Kilometre and Hectometre stones have been proposed as per provision of IRC 35 and MORTH specifications. These are to be made of precast reinforced cement concrete, and lettering/numbering as per the respective IRC codes.

4.13 ITS-Intelligent Transport Systems for Project Road

Road connectivity for the proposed port at Vadhavan is intended to cater to port traffic with high efficiency. Advanced technologies and systems for better traffic management, monitoring and handling of the project road traffic is of prime importance for efficient cargo evacuation from the port. A comprehensive vehicle entry exit management system with minimum halts, efficient data collection, evaluation, transfer and co-ordination with terminal and port logistics is planned for the road traffic through the corridor. Intelligent transport systems and technologies which are planned to be installed on the project road are arrived at considering the following aspects.

- Port Security
- Time Efficiency

- Transit Safety
- Operational Efficiency
- Ease of traffic monitoring and management
- User Friendliness for (truck drivers) etc.

5 Design Standards and Specifications

5.1 Design Standards and Specifications of Roads

5.1.1 General

As stated previously, the road is proposed to be 'access controlled' road where entry and exits are planned to be provided at predetermined locations to give access to the National Highway (NH-08) and the proposed Mumbai – Vadodara Expressway under construction. A new road is designed based on numerous considerations such as type and traffic volume of traffic, Design Speed, Safety, Capital and Maintenance Costs, Operational Efficiency, Aesthetics and Control & Management of traffic.

The primary considerations for geometric designs are appropriate horizontal & vertical alignment design and effective management of surface runoff.

5.1.2 Standards and Specifications

The design standards for this Road project are primarily based on IRC: SP 99 - 2013. However, following are the additional IRC Codes and Specifications used for design of the new roads in India:

Table 5-1 List of Design Standards and Specifications for Roads, Highway

Code	Description
IRC: 5	Standard Specifications and Code of Practice for Road Bridges, Section 1 – General Features of Design
IRC: 6	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses
IRC: 24	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)
IRC: 32	Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
IRC: 37-2018	Guidelines for the Design of Flexible Pavements
IRC: 38	Guidelines for Design of Horizontal Curves for Highways and Design Tables
IRC: 67	Code of Practice for Road Signs
IRC: 73	Geometric Design Standards for Rural (Non-Urban) Highways
IRC: SP: 73-2015	Manual of Specifications & Standards for Two Laning Of Highways with Paved Shoulder
IRC: 75	Guidelines for the Design of High Embankments
IRC: 78	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure
IRC: SP: 13	Guidelines for the Design of Small Bridges and Culverts
IRC: SP: 23	Vertical Curves for Highways
IRC: SP: 42	Guidelines on Road Drainage
IRC: SP: 90	Manual for Grade Separators and Elevated Structures
IRC: SP: 99-2013	Manual of Specification and Standards for Expressways

Code	Description
Other relevant codes	
IRC: 3	Dimensions & Weights of Road Design Vehicles
IRC: 9	Traffic Census on Non-Urban Roads
IRC: 16	Standard Specifications and Code of Practice for Prime and Tack Coat (Second Revision)
IRC: 18	Design Criteria for Pre-stressed Concrete Road Bridges (Post Tensioned Concrete)
IRC: 56	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control
IRC: 83 (Part-I)	Standard Specifications and Code of Practice for Road Bridges, IX-Bearings, Part I: Metallic Bearings
IRC: 83 (Part-II)	Standard Specifications and Code of Practice for Road Bridges, Section IX-Bearings, Part II: Elastomeric Bearings
IRC: 89	Guidelines for Design and Construction of River Training & Control Works for Road Bridges
IRC: 108	Guidelines for Traffic Prediction on Rural Highways
IRC: 112	Code of Practice for Concrete Road Bridges
IRC: SP: 69	Guidelines & Specifications for Expansion Joints (First Revision)
IRC: SP: 80	Guidelines for Corrosion Prevention, Monitoring and Remedial Measures for Concrete Bridge Structures

5.2 Geometric Standards

5.2.1 Terrain Classification

The terrain for a project area is classified based on the following:

Table 5-2 Terrain Classification

Terrain	Cross Slope (%)
Plain	0-10
Rolling	10-25
Mountainous	25-60
Steep	>60

The proposed expressway connecting can be classified as passing through ‘Plain’ terrain.

5.2.2 Design Speed

Rural highways, except freeways, are normally designed for speeds of 80 to 120 km/h depending on terrain and other relevant factors. For express highways the desirable (ruling) design speeds as per IRC: SP: 99 -2013 design standards are 120 km/h for plain/rolling terrain and 80 km/h for mountainous terrains.

Based on terrain classification of the project area, the design speed for the project has been adopted as follows:

Table 5-3 Design Speed

Nature of Terrain	Cross Slope of the Ground	Design Speed (Km/hr)
Plain	Less than 10 percent	120
Rolling	Between 10 and 25 percent	100

This, the horizontal and vertical alignment for the proposed road have been designed for a maximum **Design speed of 120 Km/hr**

5.2.3 Right-of-Way

The recommended minimum Right of Way in Plain/Rolling terrain for expressways is provided as under in IRC: SP: 99.

Table 5-4 Right of Way in Plain /Rolling Terrain

Section	Right of Way Width (ROW)
Rural Section	90 m – 120 m
Rural Sections passing through semi-urban areas	120 m

Considering the embankment heights, number of bridges and grade separated structures, future expansion due to traffic projections, safety, etc. a **Right of Way (ROW) width of 120 m is desirable for the road alignment.**

5.2.4 Road Width

5.2.4.1 Lane Width of Carriageway

Lane width has a significant influence on the safety and comfort. The design traffic and capacity of a roadway is mainly affected by the lane width. The lane width as per IRC: 73-1980 is 3.5 m for design speed of 100 km/h. In general, safety increases with wider lanes. IRC SP 99-2013 'Manual of Specifications and Standards for Expressways', para 2.4 recommends a lane width of 3.75 m. Considering these provisions and potential movement of large number of trucks with containers on this road, a lane width of 3.75 m is recommended.

5.2.4.2 Median including Edge Strip

Median on divided roads is important for safety, access control, traffic discipline and aesthetics. As per IRC SP 99-2013 'Manual of Specifications and Standards for Expressways', a desirable median width of 15 m is required to be provided for a 'depressed median' while a median width of 4.5 m is recommended for 'flush median'. However, as per directions from JNPT officials, a median width of 3 m was considered during preparation of DPR (2018).

Thus, a median width of 3 m has also been considered for this study with suitable antiglare measures such as metal/plastic screens to reduce headlight glare from opposite traffic. The total height of screen including the height of the barrier would be 1.5 m.

5.2.4.3 Crossfall, Cross Slope or Camber

Camber is provided to create a drainage gradient so that water runs off the road surface efficiently to the drainage system. The provisions of IRC: SP: 99 and IRC: SP:73 are applicable. Based on the annual rainfall of more than 1000 mm in the project area, a design crossfall of 2.5 % on straight sections of the proposed road has been considered for carriageway, paved shoulders, edge strip and flush median.

The crossfall for earthen/granular shoulders on straight portion as per IRC: SP: 99, has to at least 1% more than what has been provided for the carriage way. Accordingly, a 3.5% crossfall has been considered in design for such locations

On super elevated sections, the earthen portion of the shoulder on outside of the curve will be provided with reverse crossfall.

5.2.4.4 Shoulders

Shoulders are to be provided on both sides as emergency stopping lanes for vehicles and to provide access for emergency and maintenance vehicles. As per IRC: SP:87-2013 'Manual of Specification and Standards for Six Laning of Highways through Public Private Partnership' following shoulder widths are recommended:

Table 5-5 Width of Shoulders in Plain and Rolling Terrain

Type of Section	Width of Shoulder (m)		
	Paved	Earthen	Total
Open country with isolated built-up area	1.5	2.0	3.5
Built up area (2-lane section)	2.5	-	2.5
Built up Area (4-lane section)	-	-	-
Approaches to grade separated structures	2.0	-	2.0
Approaches to bridges	1.5	2.0	3.5

Provision in IRC SP 99 in Clause 2.6.1 are as under:
The shoulder on the outer side (left side of carriageway) shall be 3 m wide paved plus 2 m wide earthen. The shoulder composition shall be as below:

- The composition and specification of the paved shoulder shall be as that of the main carriageway
- The earthen shoulder shall be provided with 200 mm thick layer of non-erodible/granular material for protection against erosion.

For this project, the previous JNPT DPR (2018) adopted 1.5m 'Paved' shoulder in addition to 1.0m 'Gravel' shoulder. The same has been adopted in this study too.

5.2.4.5 Total Road Way Width

The total width of roadway depends upon the width of carriageway, shoulders and median. The typical cross section of 8 lane expressway as per IRC SP: 99 and as proposed for this project are given in this Report.

5.2.5 Horizontal Alignment

A good 'Horizontal' alignment design aims at providing as much straight (tangent) alignment as possible. Wherever horizontal curves are required, due to various topographic and directional constraints, the same shall be of largest practical radius with provision of spiral transitions on either side so as to ensure design speed of 120 Km/hr. over the curve. The essential elements of the 'horizontal alignment' are as under

- Radius of Horizontal Curve
- Super elevation
- Transition length

- Sight Distance

These are briefly discussed as under:

5.2.5.1 Horizontal Curves

The guiding principles for design of horizontal curvature are as under:

- The curves should be designed to have the largest possible radius and in no case less than the ruling value corresponding to the design speed
- Long curves with suitable transitions should generally be provided
- Sharp curves should not be introduced at the end of long tangent
- Reverse curves should be avoided as far as possible
- Horizontal alignment should be coordinated well with the vertical alignment

The desirable minimum and absolute minimum radii of horizontal curve adopted are given in the table below:

Table 5-6 Radii of Horizontal Curve

Design Speed (km/h)	120	100	80
Absolute Minimum Radius (m)	670	440	260
Desirable Minimum Radius (m)	1000	700	400

To achieve the design speed of 120Km/hr throughout the proposed road a curve radius of 1000 m or more has been aimed with isolated locations having radius less than the absolute minimum radius of 670 m.

5.2.5.2 Super Elevation

As per IRC: 73-1980, Super-elevation to fully counteract the centrifugal force for 75% of the design speed of 120 km/h without taking the lateral friction into consideration is adopted in design. The super elevation 'e' is calculated from the formula:

$e = (v)2/225 R$

Where:
V = Speed in Km/hr;
R = Radius in metre and
e = Super elevation in metre per metre

Super elevation obtained from the above expression should however be kept limited to the following values:

a) In plain and rolling terrain : 7 percent
b) In snow-bound areas : 7 percent
c) In hilly areas not bound by snow : 10 percent

In the horizontal alignment design, super elevation has been limited to 7 percent, if radius of curve is less than the desirable minimum radius. It is limited to 5 percent if radius is more than or equal to the desirable minimum. Super elevation cannot be less than the minimum specified crossfall.

5.2.5.3 Transition curve:

The curves have been provided with transitions on either end. The minimum length of the transition curves as provided in IRC: SP: 99-2013 for design speed of 120 km/hr should be 100 m and for speed of 100 Km/hr this should be 85 m. The same has been adopted.

5.2.5.4 Sight Distance

Safe stopping sight distance and desirable minimum sight distance in m for various speeds is shown as under (reference IRC: SP: 99)

Table 5-7 Safe Sight Distance

Design Speed (Km/hr)	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m) (Intermediate Sight Distance)
120	250	500
100	180	360
80	120	240

A desirable minimum sight distance of 500 m for design speed of 120 Km/hr has been adopted throughout the section with isolated exceptions of adoption safe stopping distance of 250 m. For isolated stretches, where the curvature limits the speed, this could be further reduced, if there are severe constraints, as per above table.

5.2.6 Vertical Alignment

The vertical alignment design should be such that there are not many grade changes. The vertical alignment should blend well with the topography without visual discontinuities and frequent changes. Thus, the vertical alignment should provide for a smooth longitudinal profile. It is desirable not to have grade changes within a distance of 150 m. The provisions given in IRC: 73 and IRC: SP: 23 have been considered for this project.

5.2.6.1 Gradient

The Ruling and Limiting gradients are given in below table:

Table 5-8 Gradient

Terrain	Ruling Gradient	Limiting Gradient
Plain	2.5 %	3 %
Rolling	3.0 %	4 %

Even though Ruling gradient as above can be adopted, our aim is to design the vertical alignment with gradient which is easy for the loaded trucks which will be plying in this section without losing power and also without losing average high speeds.

For the design of Longitudinal Section (L-Section/Profile) for this project, a flatter design gradient of 1 in 100 (1%) has generally been adopted to give better & smooth drive with less probability of breakdown & thus improving efficiency.

In cut-sections, minimum gradient adopted for drainage considerations is 0.5 percent (1 in 200) if the side drains are lined; and 1.0 percent (1 in 100) if these are unlined.

5.2.6.2 Vertical Curve

Minimum grade change requiring vertical curves as provided in IRC: SP: 99 is 0.5%. At such locations, minimum 100 m length of Vertical Curve has been provided for design speed of 120 Km/hr.

5.2.6.3 Median Openings

Median openings with detachable barrier have been provided at a spacing of 5 km avoiding super elevated curves locations.

5.3 Fencing and Boundary Stones

5.3.1 Fencing

Fencing will be provided all along the Expressway at 2 m inside the ROW boundary. The fencing will be of type and design given in Section-10 of IRC: SP: 99 which stipulates as under:

"Fencing shall be provided on entire length on either side of the Expressway to prevent entry of pedestrians, animals and vehicles, leaving space for utilities. The fencing shall be 2.5 m high above ground level and shall comprise of mild steel sections and welded steel wire mesh up to full height, firmly welded with steel section. The fencing posts shall be embedded in concrete of minimum M15 grade and shall be designed to take care of wind forces and other loads likely to occur. All exposed metal surfaces shall be painted with anticorrosive paint."

5.3.2 Boundary Stones

The ROW will be demarcated by installing Road Boundary Stones at the edges.

5.4 Formation Design

5.4.1 Embankment Design & Slope Protection

The L section design and the corresponding height of embankment is determined, based on the following principles, as per Clause 4.2. of IRC: SP: 87:

- The bottom of the sub-grade is at least 1.0 m above the high flood level/high Water Table/Pond level.
- However, in exceptional circumstances where it is difficult to fulfil this criterion, a minimum difference of 0.6 m between the top of sub-grade and HFL/High Water Table/Pond Level shall be ensured.
- The embankment material will generally be as per IRC and MORTH standards required for various embankment heights. The material to be used in sub-grade will satisfy the design California Bearing Ratio (CBR) at the specified density and moisture content.
- Side slopes will not be steeper than 2H:1V unless soil is retained by suitable soil retaining structures.
- The side slopes and the earthen shoulders will be protected against erosion by providing a suitable vegetative cover, kerb channel, chute, stone/cement concrete block pitching or any other suitable protection measures depending on the height of the embankment and susceptibility of soil to erosion
- Slope stability of embankments will be assessed based on IRC: 75 provisions

5.4.2 Side Slopes for Embankments

Slope of 1V: 2H has been proposed for earthen embankments. Embankments of height 6.0 m or above have been designed in accordance with IRC: 75 taking into account slope stability, bearing capacity, consolidation, settlement and safety considerations based on geotechnical investigation data. Where the embankment is to be supported on a weak stratum, appropriate remedial/ground improvement measures will be designed with slope stabilization measures such as gabions/ retaining structures etc.

5.4.2.1 Side Slopes for Cutting

The side slopes of the cut section are governed by the geotechnical properties of stratum. Generally following slopes on the cuttings have been adopted. This would further be fine-tuned based on further soil/rock geotechnical investigations.

Table 5-9 Slopes and Cut Sections

Type of Soil	Slope (H:V)
Ordinary Soil	3:1 to 2:1
Rock	1/2:1 to 1/8:1 (Depending upon quality of rock)

5.5 Pavement Design

The pavement for the proposed expressway has been designed as a flexible pavement. IRC: 37-2018 - Guidelines for the design of Flexible Pavements have been adopted for design of pavements for the expressway.

5.6 Interchanges

5.6.1 Intersections

The road will have connections to NH-08 and Mumbai-Vadodara Expressway. It is assumed that both the intersecting roads (NH-08 and Mumbai – Vadodara) are toll roads under closed system and toll booths on ramps are not required. The system needs to cater for high speed of operation. The toll collection arrangements need to be considered on integrated basis. The system of toll collections will have to be decided in consultation with National Highway Authority of India (NHAI). FAS Tag, which is an electronic toll collection system in India, operated by NHAI, which employs Radio Frequency Identification (RFID) technology for making toll payments directly from the prepaid or savings account linked to it will have to be considered at these two interchange points. The modalities for the same need to be suitably addressed by JNPT.

5.6.2 Layout

The interchanges at both the location are to handle high volume of traffic. The connecting ramps can be directional, semi-directional and large radius loops as well. The aspect of toll sharing between adjacent concessionaires needs to be integrated. The basic forms may comprise of three legs or four legs. These configurations generally require multi-level structures.

Based on the requirement, typical plans of interchange have been studied and the most favourable plan recommended considering traffic needs and site conditions.

5.6.3 Spacing between interchanges

The interchanges for the port road are at two locations one to connect the port road to the proposed Mumbai – Vadodara Expressway and the next interchange at NH-08. Both the interchanges are essential to ensure for dispersion of the traffic to hinterland through these major expressways. The distance between these two interchanges is approximately 12.00 Km.

5.6.4 Ramps

Ramps have been provided at interchanges for desired turning movements. Based on movement requirements, the connecting ramps are classified as Direct, Semi-direct and Loop ramps.

5.6.5 Ramp design speed

Recommended design speeds for interchange ramps are given in Table below:

Table 5-10 Ramp Design Speed

Configuration	Type of Ramp	Range of Expressway Design Speeds (km/h)	
		100-120	80-100
		Range of Ramp Design Speeds	
System Interchange	Semi-Direct	50-70	40-60
	Loop	70-90	60-80
	Direct	80-100	70-90
Service Interchange	Semi-Direct	40-60	40-60
	Loop	60-80	60-70
	Direct	60-90	60-80

5.6.6 Ramp Width

Each ramp will have two lanes. Applicable extra wide of carriageway has been provided, as needed.

5.6.7 Acceleration/deceleration lanes

Each entry and exit of ramp will have acceleration/deceleration lane for the Expressway. The length of the acceleration/deceleration lanes has been decided on the differential speed of the Project Road traffic and the speed permitted on the ramps.

Drivers exiting an interchange are required to reduce speed to meet with toll payment where such a scheme exists. Drivers entering an expressway from a ramp accelerate until the adjacent through lane speed is reached.

For safety, expressway exits should be located on tangent sections, wherever possible to provide maximum sight distance and optimum traffic manoeuvrability operation.

The following recommendations should be considered from safety aspect as per MORTH Guidelines for Expressways:

Table 5-11 Minimum Acceleration Length is for Entry (Grades of 2 percent or Less)

Expressway Design	Acceleration Length L (m)

Speed V (km/h)	V Speed on Entry Curve at A (km/h)				
	40	50	60	70	80 OR More
80	145	115	65	-	-
100	285	255	205	110	45
120	490	460	410	325	245

Table 5-12 Minimum Deceleration Lengths for Exit (Grades of 2 percent or Less)

Expressway Design Speed V (km/h)	Acceleration Length L (m)				
	V Speed on Entry Curve at A (km/h)				
	40	50	60	70	80 OR More
80	100	80	90	55	-
100	145	135	120	100	85
120	175	170	155	140	120

5.7 Design of Structures (Bridges and Grade Separator)

This Section summarises major design features/criteria that have been adopted for Structures (Bridges Structures, Underpass / Overpass Structures). As much as feasible, the bridge components would be of 'Standard' designs.

5.7.1 Standards and Specifications

Design of all components of structures will be carried out in accordance with the provisions of the following Standards/Codes of Practice

Table 5-13 Standards & Specifications for Bridges & Structures

Standards and Specifications for Bridges and Structures	
IRC:5	Standard Specifications and Code of Practice for Road Bridges, Section 1 – General Features of Design
IRC: 6	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses
IRC 21	Standard Specifications and Code of Practice for Road Bridges, Section III – Cement Concrete (Plain & Reinforced)
IRC: 22	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Second Revision)
IRC: 24	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)
IRC: 78	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure
IRC: 83	Section IX (Part II), Elastomeric Bearings; Section IX (Part III), POT, POT cum PTFE, Pin and metallic Guide Bearings
IRC: 89	Guidelines for design and construction of River Training and Control Works for Road Bridges

IRC: 112	Code of Practice for Concrete Road Bridges
IRC: SP: 13	Guidelines for the Design of Small Bridges and Culverts
IRC: SP: 65	Guidelines for Design & Construction of Segmental Bridges
IRC: SP: 66	Guidelines for Design Continuous Bridge
IRC: SP: 69	Guidelines & Specifications for Expansion Joints
MORTH (REV 5)	Specification for Road and Bridge Works – 2013 (Ministry of Road Transport & Highways)
IRC: SP-90	Manual for Grade Separators and Elevated Structures
IRC: SP: 99	Manual of Specification and Standards for Expressways
IRC: 89	Guidelines for Design and Construction of River Training & Control Works for Road Bridges

5.7.2 General

All structures will be designed in accordance with the relevant Codes, Standards and Specifications, Special Publications and Guidelines of the Indian Roads Congress.

Construction of all culverts, bridges and grade separated structures will conform to MORTH Specifications for Road and Bridge Works.

- The provision of bridges and grade separated structures will be for 8-lane Standards.
- The width of median in the culverts and bridges will, as far as possible, be kept same as that in the approaches. In case width of median is different from that of approach section due to site constraints, transition @ 1 in 50 will be provided near approaches for guiding vehicular traffic.
- Duct for utility service will be provided on all the structures

5.7.3 Width of Structures

Width of the culverts, bridges and grade separated structures has been adopted as below:

5.7.3.1 Culverts

The pipe culverts will extend (Barrel length) so as to ensure the side slopes at the culvert as of the adjoining embankment.

- For the slab and box type culverts, the outer face of the left crash barrier on the structure will be in line with the outer edge of the earthen shoulder. On the inner side, the culvert will extend up to full width of median. Joint between the structures of two sides will be provided at the middle of median.
- The slope of the adjoining embankment will be suitably graded to merge with the top level of culvert with longitudinal slope not steeper than 6H:1V.
- Cross-sections of the pipe culverts for 8-lane expressway is given in figure below for flush type median on approaches:

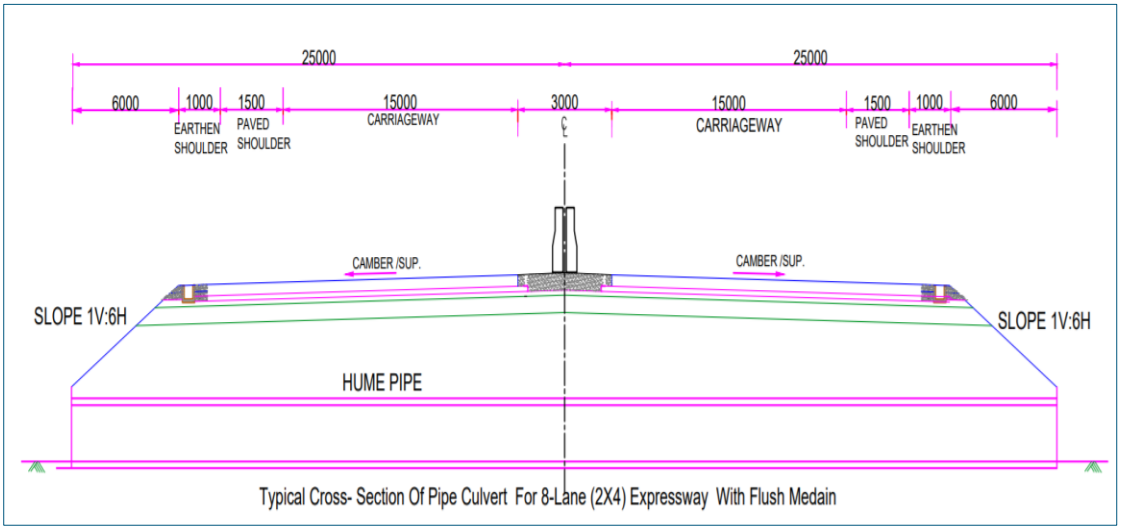


Figure 5-1 Cross section of pipe culverts for 8-lane expressway for flush type median

Cross section of the slab and box type culverts for an 8-lane expressway is given in figure below for flush type median on approaches:

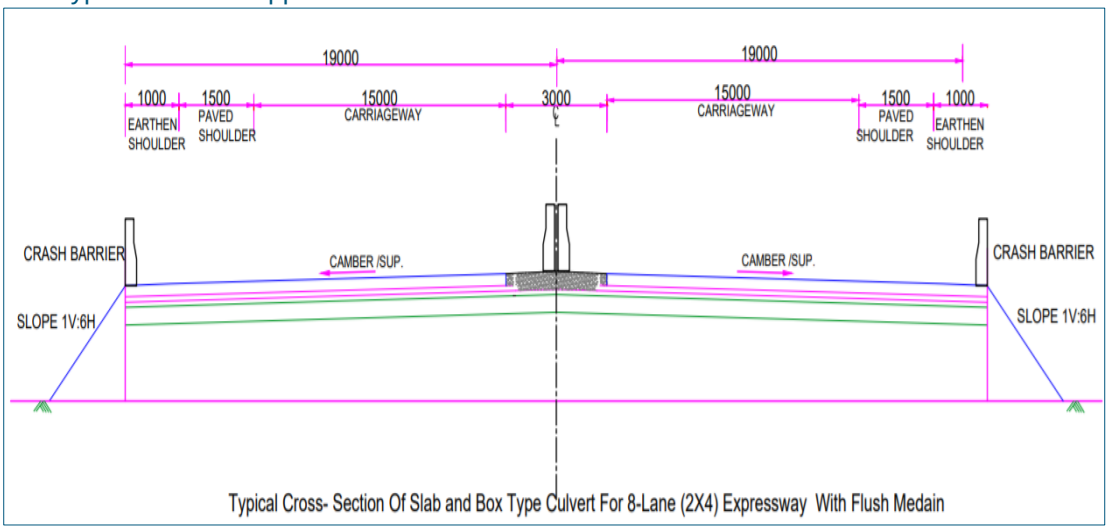


Figure 5-2 Cross section of slab & box type culverts for 8-lane expressway for flush type median

5.7.3.2 Bridges and Grade Separated Structures/ROBs

The overall width of structures will be such that the outer face of left crash barrier on the structure is in line with outer edge of earthen shoulder and inside crash barrier is located at a clear distance of 0.75 from the edge of outermost carriageway of adjoining road (the paved edge strip of 0.75 m on median side shall continue on the structure also).

Cross section of bridges and grade separated structures for an 8-lane expressway for one side is given in Figure below. These are applicable both for depressed median and flush type median on the approaches.

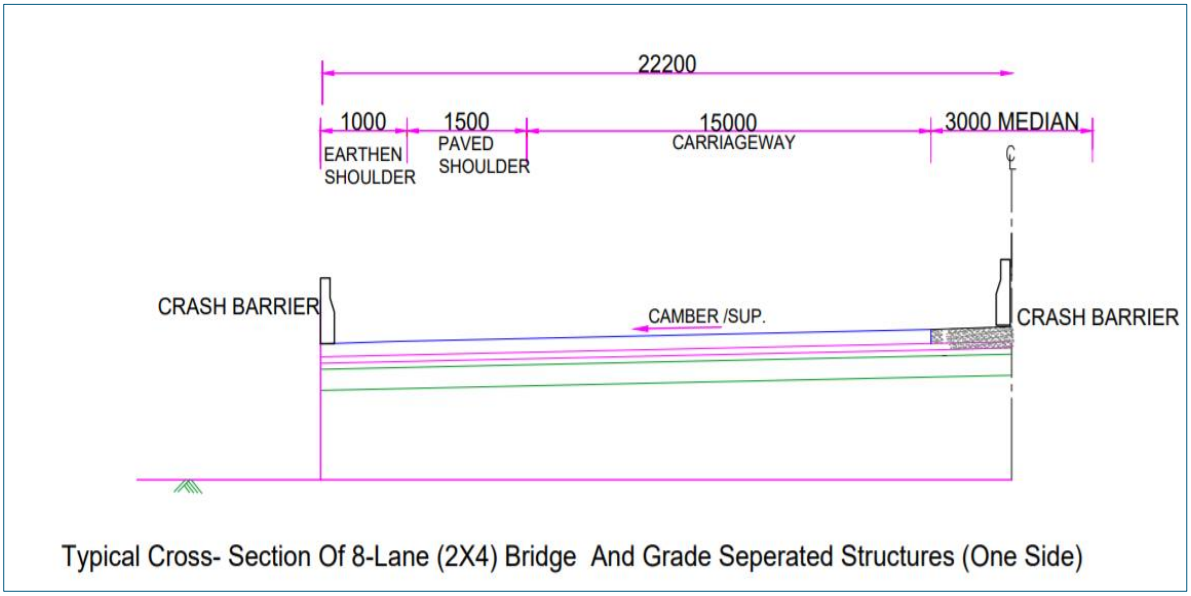


Figure 5-3 Cross section of 8 lane Bridge & Grade separated structures (one side)

5.7.4 Lateral and Vertical Clearance at Underpasses

Road Under Bridges (RUBs) will generally be the preferred crossing for 'Cross Roads' i.e., the cross roads will generally be taken below the road through Road Under Bridges (RUBs). Minimum clearances at underpasses will be as follows:

5.7.4.1 Lateral Clearance

- Full roadway width of the cross road will be provided throughout the underpass. For Vehicular Underpasses, the lateral clearance will not be less than 12m (7m carriageway +2x2.5 m shoulder width on either side)
- For light vehicular Underpass, the lateral clearance will not be less than 10.5 m including 1.5 m wide raised footpaths on either side

5.7.4.2 Vertical Clearance

The vertical clearance at underpasses will not be less than the values given in table below:

Table 5-14 Vertical Clearance at underpasses

Vertical Clearance at Underpasses	
Vehicle Underpass	5.5 m
Light Vehicular Underpass	3.5m
Pedestrian, Cattle Underpass	3.0m

5.7.5 Lateral and Vertical Clearance at Overpasses

Wherever any structure is provided over the road i.e. Road Over Bridges (ROBs); the minimum clearances will be as follows:

5.7.5.1 Lateral Clearance

The ROB will be of full cross road width including shoulders and would span across the road. The abutments and piers will be provided with suitable protection against collision of vehicles.

5.7.5.2 Vertical Clearance

A minimum 5.5m vertical clearance will be provided from all points of the carriage way to the soffit of ROB.

5.7.6 Design Loads and Stresses

- The design loads and stresses will be as per IRC:6 appropriate for the width of carriageway. Each new bridge will be designed for combination of live load specified in Table 2 under clause 204.3 of IRC: 6 depending upon the carriageway width. The bridge will also be checked for 3 lanes of Class A or 1 lane of Class -70R + 1 lane of Class -A.
- All structures will be designed for the condition that paved shoulder and edge strip on median side is also used as carriageway.
- All the components of structures will be designed for a service life of 100 years except appurtenances like crash barriers, wearing surface, expansion joints and bearings.

5.7.7 Seismic Analysis

The bridges/ structures will be designed for seismic forces as per IRC: 6. As per seismic map given in IRC:6, the project road passes through Seismic Zone III.

5.7.8 Material Characteristics

- PSC superstructure - M45, M50
- RCC superstructure - M40, M45
- Substructure - M30, M35
- Pile Foundation - M35
- Open foundation - M30, M35
- RCC Crash Barriers - M40
- RCC Retaining Wall - M35
- RE Facia Panel - M35

5.7.8.1 Concrete Design Mixes:

Grade of concrete for various components of the bridges will be adopted as follows:

5.7.8.2 Reinforcement

TMT Deformed bars Grade designation Fe500 confirming to IS 1786 will be used.

5.7.8.3 Pre-stressing Steel

Prestressing steel cables consisting of uncoated, stress relieved, low relaxation strands, confirming to IS 14268 will be used in design of bridge structure wherever required.

5.7.9 Approach Slabs

Reinforced concrete approach slabs will be provided at all bridges and grade separated structures covering the entire width of the roadway, with one end resting on the structure designed to retain the earth and extending for a length of not less than 3.5 m into the approach. The approach slab will be provided as per Clause 217 of IRC:6

5.7.10 Bridge Bearings

Bridge Bearings will be designed depending on the loads, forces and type of superstructure. POT-PTFE and Elastomeric bearings will be proposed. Suitable permanent arrangements will be made for inspection of bearings from bridge deck. Design and specifications of bearings will be as per IRC:83 (Part I, II and III). Spherical bearings, if used, will conform to the requirements of BS:5400 and

materials of such bearings may conform to the relevant BIS codes nearest to the specifications given in BS:5400.

All bearings will be designed in such a way that it gives easy access for inspection, maintenance and replacement.

5.7.11 Types of Bridge structures

The proposed road primarily comprises of cross drainage bridge structures, vehicular underpasses, one major river crossing (over river Surya), Road Over Bridge (over Down and Up mainlines of Western Railway, Down and Up line of Proposed MRVC lines for new suburban lines and Down and Up mainline of Western Dedicated Freight Corridor lines), Two major interchanges; one to give connectivity to proposed Mumbai- Vadodara Expressway and another to give connection to NH-08.

Following types of bridges are envisaged on the proposed port road

(a) RCC Box Bridges for cross drainage works and vehicular Underpasses
(b) RCC Boxes as interchange connectors
(c) Major bridge over Surya river and interchange connectors made up of open/Pile foundations, RCC Piers and abutments with PSC pre-stressed Box /I beam Super structure
(d) Bridge over Railways provided with Steel composite Bow Girders over RCC Piers and Abutments over Pile foundations

Other important components of the bridges are as under:

I. **Foundations:** Depending upon the hydrology of the channel and type of founding strata, open or pile foundations will be proposed.
II. **Substructure:**
    a) Abutments for major bridge structure would be hollow rectangular wall type or solid wall type
    b) Pier: Hollow Rectangular Wall type or Solid Wall Type or Circular type depending upon the site conditions
III. **Super Structure:** Appropriate super structure will be proposed for each location, bearing in mind the span, width, appearance, construction scheme etc.
IV. **Crash Barriers:** These will be provided over all the bridges in accordance with IRC: 5
V. **Drainage sprouts:** Drainage Spouts will be provided in accordance with MORT&H standard plans.
VI. **Protection Works:** Protection works at Surya River will be provided as per provisions of IRC: 89 considering the characteristics of the river and its flood history.

5.7.12 Expansion Joints

Bridge Structures will have minimum number of expansion joints. This will be achieved by adopting longer spans, making the superstructure continuous or by adopting integrated structures. Expansion joints will conform to IRC: SP: 69.

5.7.13 Reinforced Earth Retaining Structures

The design and construction of reinforced earth structures, wherever required, will conform to section 3100 of MORTH Specifications.

5.7.14 Road-Rail Bridges

5.7.14.1 Road over bridge (road over railway line)

- The road over bridge over the Railway lines will be provided as per the norms of the Indian Railways.
- Railways normally do not allow construction of solid embankment in their right of way. The horizontal and vertical clearances to be provided on the railway land will be as per requirement of the Railway authorities.
- The approach gradient will not be steeper than 1 in 40.
- The vertical clearance at such locations will not be less than 8.5 m from Rail level to bottom of the proposed bridge girder. This clearance is required to take care of the schedule of dimensions for Western Dedicated Freight corridor of DFCCIL wherein the route standards being adopted are for running double stack container trains under electrified traction.

5.7.14.2 Road under bridges (Road under railway line)

The proposed road does not have any location where the road has to be taken under the Railway line. In case it is planned to provide a service connection to an establishment of the Vadhavan Port services, the same will be considered based on actual requirement at site in regard to vertical and horizontal clearance.

5.7.15 Drainage on Bridges

An effective drainage system for the bridge deck will be planned, designed and installed so as to ensure that water from the deck is taken down to ground level/drainage courses by adequate size of drainage spouts and pipes. Drainage will be designed as per IRC: 99: Section-9.

5.7.16 Safety Barriers

- Reinforced Cement Concrete crash barriers will be provided on the edges of all slab/box type culverts bridges and grade separated structures.
- The design loading for the crash barriers will be as per Clause 209.7 of IRC: 6.
- The type design for the crash barriers will be adopted as per IRC: 5
- High Containment type crash barrier will be provided on the Road Over Bridges and Vehicle crash barrier type will be provided on all other structures. The sketches of concrete crash barriers extracted from IRC: 5 are given in Figure below for Vehicular Crash barrier and High Containment type Crash barriers respectively.
- Crash barriers on the structures will be suitably continued and connected with safety barriers on approaches on either side of the structures to have smooth transition.

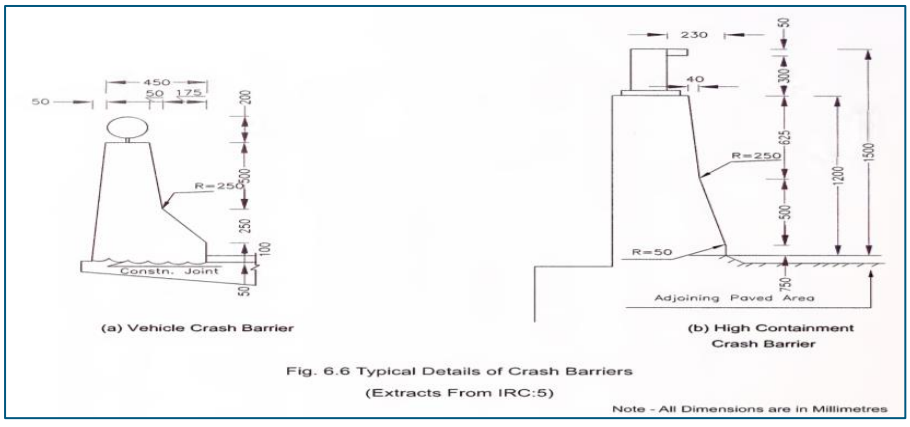


Figure 5-4 Design of Crash Barrier

5.7.17 Hydraulic Design of Bridges

Hydraulic designs of bridges is an important aspect to determine the design discharge, required waterway, design High Flood Level and foundation of the bridges proposed on the new alignments / bypasses. Due to changes in the alignment and changes in topographic survey data the hydraulic calculation of bridges will be revisited during detailed design stage.

5.7.17.1 Design Parameters:

- Rainfall: Rainfall from Central Water Commission Flood Estimation Report for Western Himalayas Zone 7.
- As per the guidelines for IRC: SP-13, IRC: SP-84 and CWC report, flood return period for the hydrological and hydraulic design of bridges shall be adopted as below.

  - 25 years for Culvert
  - 100 years for Bridges

    - Coefficient of Runoff (P) for the catchment characteristics is to be adopted from Table 4.1 of IRC: SP-13.
    - The energy slope which may be taken equal to the bed slope, measured over a reasonably long reach.
    - Rugosity coefficient, n is to be taken as per Table 5.1 of IRC: SP: 13-2004 However, judgement and experience are necessary in selecting a proper value of n

5.7.17.2 Discharge Calculations

Discharge shall be calculated by various methods as specified in IRC: SP-13 and CWC Report. The brief of various methods is as below:

1. Dicken's Formula

Dicken's formula is commonly used for computation of flood discharge based on catchment area of the stream. Peak Design Discharge, Q = CM3/4 IRC: SP: 13:2004: Clause 4.2
Where:
C = 11 - 14 where the annual rainfall is 60-120 cm
= 14 - 19 where the annual rainfall is more than 120 cm
= 22 in Western Ghats

2. Rational Formula

Q = 0.028*P*f*A*Ic

Where:

- P = Co-efficient of run-off for the catchment characteristics
- f = Spread factor for converting point rainfall into area mean rainfall
- A = Area of catchment in hectares
- IC = Critical intensity of rainfall in cm per hour
- IC = (F/T) * (T+1) / (TC+1)
- F = Total Rainfall of T hours duration (24 hrs.) in cm corresponding to 100 years return period.
- T = Duration of total rainfall (F) in hours= 24 hrs.
- TC = Time of concentration in hour.

Total rainfall in 24 hrs is adjusted corresponding to TC for finding critical rainfall intensity IC from the rainfall distribution curve (Duration vs conversion ratio) of CWC report.

Times of concentrations (TC) are determined by Dicken's (empirical) formula.
TC = [0.87(L3/H)] 0.385

Where L is the length of catchment in km and H is the elevation difference in meter in length L. Point rainfall values are to be adjusted for areal mean value using spread factors as per IRC: SP-13 and CWC report.
Rational formula is applicable for the catchment up to 50 sq. km area.

3. Inglis Formula
This empirical formula was devised for erstwhile Bombay Presidency

Where:

- Q = Maximum flood discharge in m3/s
- M = The area of the catchment in sq. km
- Detailed Hydraulic Calculation is given as an Appendix 1.4

5.7.17.3 Fixing of Design Discharge

As recommended in IRC: SP-13, discharge values obtained from above three methods shall be compared and the highest of these values shall be adopted as design discharge, provided it does not exceed the next highest discharge by more than 50%. If it does then the design discharge value has to be restricted it to that limit. (As per Article 6.2.1 of IRC: SP: 13-2004).

5.7.17.4 Synthetic Unit Hydrograph Method

A unit hydrograph is defined as the hydrograph of direct runoff resulting from one-unit depth of rainfall excess occurring uniformly over the basin and at a uniform rate for a specified duration. Synthetic unit hydrograph is derived by using empirical equations of regional validity which relate salient hydrograph characteristics to the catchment characteristics. Physiographic parameters given in CWC report for Zone 7 are to be used for the derivation of synthetic unit hydrograph. Then the flood hydrograph is to be derived by multiplying the unit hydrograph ordinates with the rainfall excess values.
This method is applicable for catchment area greater than 25 sq. km.

5.8 Summary of Design Features of Port Road

Following are the design parameters adopted for proposed Road:

Table 5-15 Summary of the Proposed Road

Parameter	Description	Provision
No. of Lane	Lane	8 Lane
Guidelines & Standards	IRC, NHAI, MoRTH	
Type of Traffic	Total traffic	34,284/day (for 2040) 1429/hr
	Heavy Vehicle:	
	Container	40 ft
	General Cargo/Coastal Cargo	10 M.T.

<table>
<tr><th>Parameter</th><th>Description</th><th>Provision</th></tr>
<tr><td rowspan="3"></td><td>Liquid</td><td>18 M.T.</td></tr>
<tr><td>Dry Bulk</td><td>10 M.T.</td></tr>
<tr><td>IRC Class 70R</td><td>Multi Trailer Vehicle</td></tr>
<tr><td rowspan="2">Wheel Load (Class 70R)</td><td>Single Axle Load</td><td>20 tonne (As per IRC 6-2017: Clause 204.1.3)</td></tr>
<tr><td>Single Wheel Load</td><td>5.1 tonne</td></tr>
<tr><td>Total Truck Load Considered</td><td>100 t = 980665 N</td><td>(As per IRC 6-2014: Clause 204.1.3)</td></tr>
<tr><td rowspan="11">Road Alignment Details</td><td>Design Speed</td><td>120 Kmph (as per IRC SP 99-2013: Clause 2.2.1)</td></tr>
<tr><td>Right of Way</td><td>120 m</td></tr>
<tr><td>Lane width</td><td>3.75 m (as per IRC SP 99-2013: Clause 2.4)</td></tr>
<tr><td>Median</td><td>Adopted 3 m Flush median as per JNPT advice against Recommended= 4.5m as per IRC: SP: 99-2013: Clause 2.5.1</td></tr>
<tr><td>Paved Shoulder

Earthen Shoulder</td><td>Adopted 1.5 m paved shoulder against 3 m provided in IRC: SP 99 clause 2.6.1
Adopted 1.0 m gravel shoulder against 2 m provided in IRC: SP 99 clause 2.6.1</td></tr>
<tr><td>Super elevation</td><td>As per IRC for designed speed of 120 km/hr</td></tr>
<tr><td>Crossfall (Camber)</td><td>2.5% (Unidirectional (IRC SP 99 Clause 2.8)</td></tr>
<tr><td>Radius of Horizontal Curve</td><td>Desirable minimum 1000 mm for 120 Km/hr</td></tr>
<tr><td>Length of Transition Curve</td><td>
<table>
<tr><th>Design Speed (Km/h)</th><th>Minimum Length of Transition Curve (m)</th></tr>
<tr><td>120</td><td>100</td></tr>
<tr><td>100</td><td>85</td></tr>
<tr><td>80</td><td>70</td></tr>
</table>
Adopted 100 m for design speed of 120 Kmph (IRC: SP: 99 Clause 2.9.2.4)
</td></tr>
<tr><td>Sight Distance (m)</td><td>Desirable minimum sight distance is of 500 m and for Isolated stretches it will be 250 m</td></tr>
<tr><td>Gradient</td><td>Ruling Gradient of 1 in 100 (except 1 in 40 at ROB approaches)</td></tr>
<tr><td></td><td>Pavement Type
Pavement Thickness</td><td>Flexible Pavement
Pavement thickness 625 mm</td></tr>
<tr><td></td><td>Vehicular Underpass - Vertical Clearance</td><td>5.5m</td></tr>
<tr><td></td><td>Vehicular Underpass- Lateral Clearance</td><td>12.0m</td></tr>
</table>

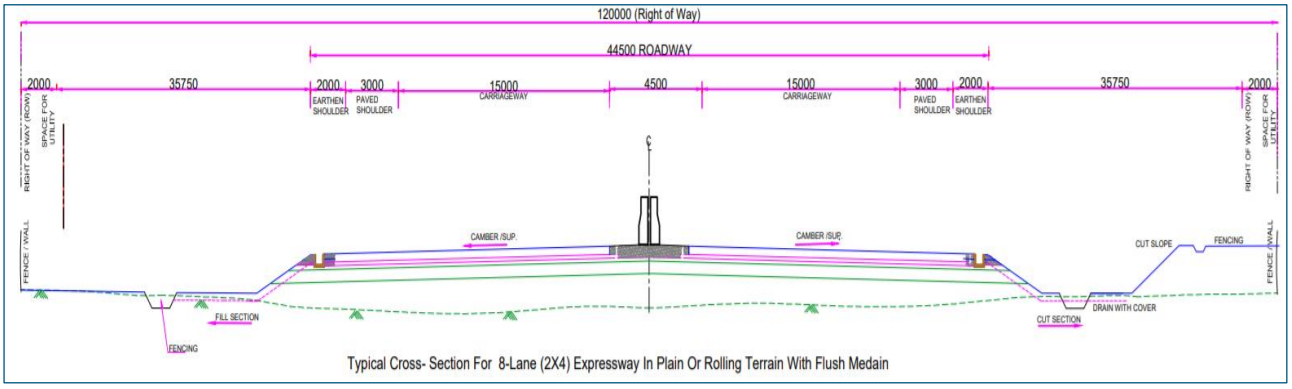


Figure 5-5 Typical Cross Section for 8 Lane Expressway as per IRC: SP: 99

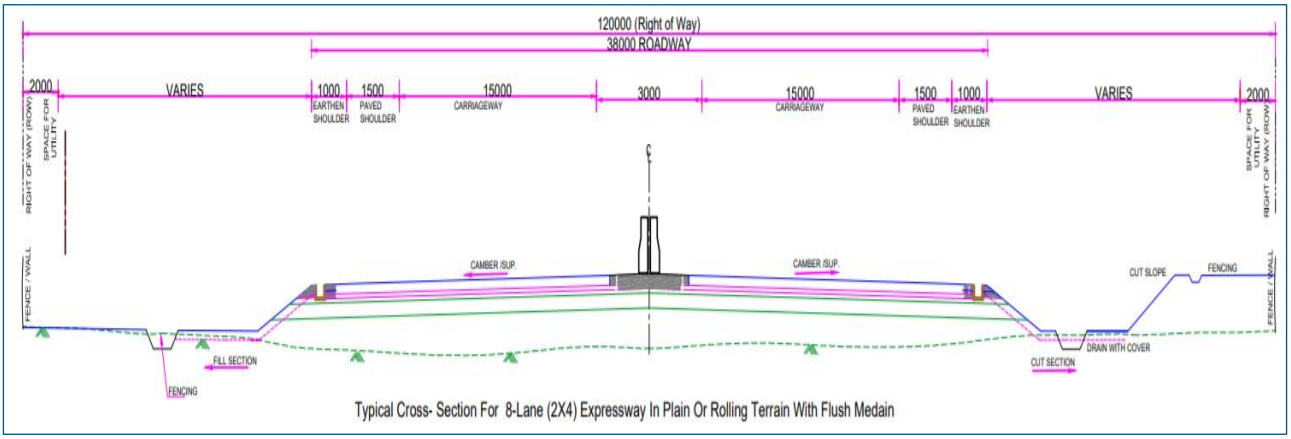


Figure 5-6 Typical Cross Section for 8 Lane Expressway as per proposed

6 Design Review - Issues

6.1 Critical Issues – Design of Road Alignment

6.1.1 Curvature

The JNPT DPR (2018) did not provide details of all curves of the entire route. The project sheets also did not provide these details at some of the locations.

Due to changes in the alignment, the alignment has been redesigned. Following table gives the list of curves. It will be observed that the entire length of the road has a speed potential of 120 Kmph.

Table 6-1 Curvature of the Alignment

Curve No.	Station		Length of Curvature (m)	Radius (m)
	Start	End		
1.	1841.68	2059.68	217.99	1000
2.	2311.81	2739.93	428.12	1000
3.	3415.55	3781.14	365.59	800
4.	6327.61	6661.59	333.98	1000
5.	7768.20	7985.60	217.40	700
6.	8514.03	8734.29	220.25	700
7.	9910.06	10091.46	181.40	1200
8.	11781.24	11952.56	171.32	800
9.	12528.31	12689.16	160.85	800
10.	13271.70	13781.34	509.64	700
11.	15003.31	15289.56	286.26	1000
12.	15483.66	15698.55	214.89	1000
13.	16106.03	16308.66	202.62	1000
14.	17151.67	17515.22	363.55	1000
15.	19003.42	19213.64	210.22	1000
16.	22319.42	22603.61	284.20	1000
17.	23808.90	24096.16	287.25	1000
18.	25065.66	25603.06	537.40	1000
19.	25621.69	26098.94	477.25	1000
20.	26644.19	27109.86	465.66	700
21.	27304.63	27865.58	560.95	670
22.	28936.19	29225.11	288.92	670
23.	29982.61	30272.96	290.35	1000
24.	30982.73	31366.64	383.91	1000

As per the above table, the total Length of curve as per radius is as follows:

Table 6-2 Total Length of Curve as per radius

S. No.	Radius (m)	Total Length (m)
1.	1200	181.40
2.	1000	4517.99
3.	800	849.87
4.	700	1412.96
5.	670	697.75
	Total	**7659.97**

The curvature summary shows that 100% of the route has a speed potential of 120 Kmph.

6.1.2 Road over Bridge over Railway

In the DPR (2018), the Railway connectivity to Western railway and DFC had shown that the MRVC Railway lines are proposed to be constructed on elevated section and surface connectivity was shown to connect the Railway line with Western and DFC lines.

The details provided for Road Over Bridge crossing at the same location does not show the proposed MRVC line as elevated. If the MRVC lines were elevated the Road Over Bridge would have to be lifted further and would have passed the railway location about 18 to 20 m height.

Since it has been now clarified during discussions with MRVC and Western Railway that the MRVC lines are not being provided on elevated section this mismatch has been corrected in this report. Hence, the height of Road Over Bridge (ROB) need not to be high.

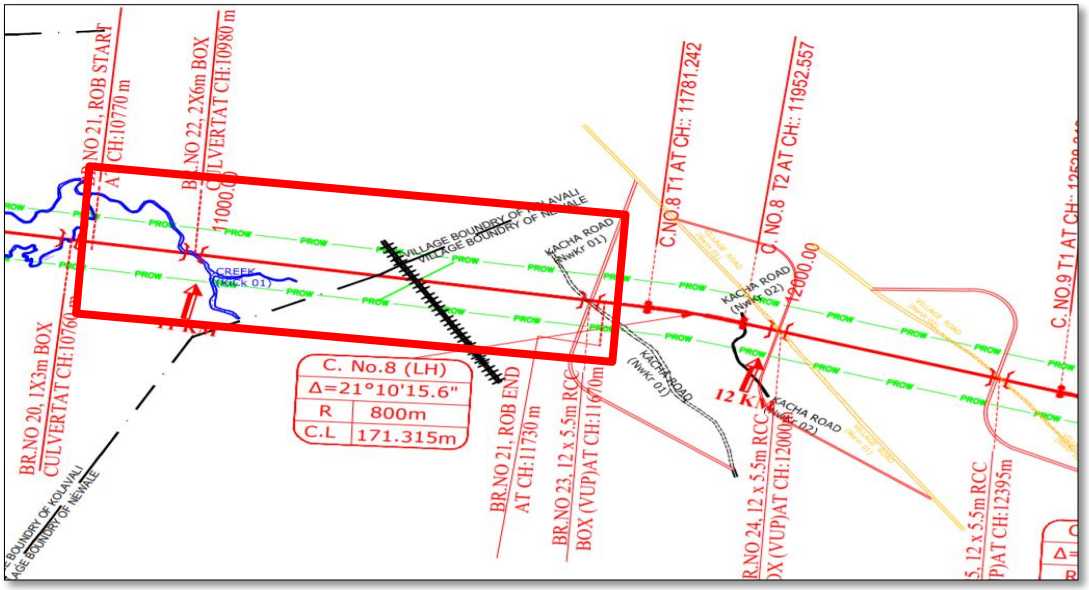


Figure 6-1Proposed Location of ROB

6.1.3 Surya River alignment design

As per the DPR (2018), two curvatures were proposed near Surya river. Details of Curvatures were not provided nor included in the project sheets. The missing information required review of land acquisition details at this location.

Based on discussion with JNPT, the alignment over Surya river was modified to make it straight which reduced the total length of the road. However, the alignment now passes through hilly terrain. The same has now been considered with overburden material being utilized for port land reclamation.

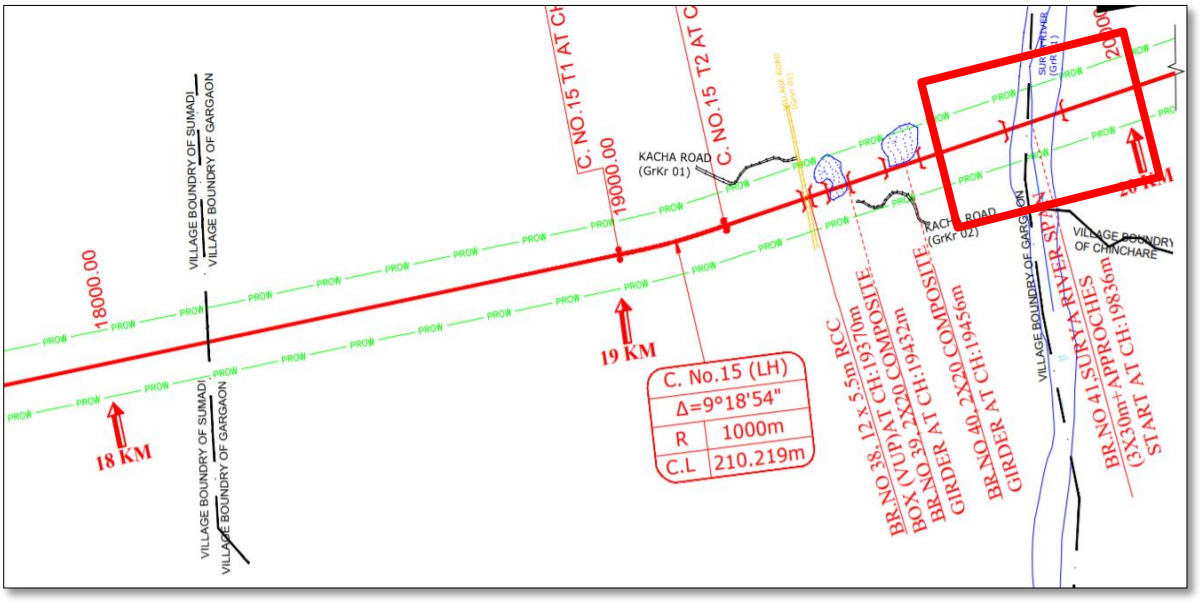


Figure 6-2 Proposed Location of Surya River

6.1.4 Adopting Railway Standard Culvert design in common ROW and on other road section

In the DPR (2018), cross drainage culverts of 1.2 m diameter pipe were proposed on road portion. The Railway standard is to provide minimum 2 m x 2 m RCC Box culverts. Considering that the Railway bridges need a minimum size of 2 m x 2 m RCC box, similar size box should have been provided in road portion. The same configuration of providing RCC box culverts for road and rail has been proposed in the road portion along the rail alignment i.e. instead of 1.2 m diameter pipe, 2 m x 2 m RCC box has been proposed.

6.1.5 Pavement design

The DPR (2018), the design for pavement had considered traffic of 30 million standard axles (MSA). Considering traffic of only 30 MSA is not commensurate with the level of traffic projected on the road in terms of Commercial Vehicles per day.

The Ministry of Road Transport and Highway in their letter number RW/NH – 24036/27/2010 - PPP dated 25.04.2018 on Revision of Normative Cost Norms for the National Highways had recommended adoption of 100 MSA for design traffic for 8 lane highway. Accordingly, based on the updated assumptions a pavement design with traffic of 150 MSA has been considered at this stage which will be further fine-tuned during detailed design stage.

6.1.6 Geotechnical Details

Previously, in all, for road alignment, a total of Seventy (70) bores (of about 15 m depth) were drilled with drill penetration of at least 5m in good quality rock. Clusters of bore hole were done for individual structure at Underpass and Flyover locations.

Further twenty-five (25) trial pits were also made to extract fresh soil sample at 0.5 m to 1 m depth below existing ground level for laboratory analysis.

Previous DPR study in 2018 reported the Geotechnical details in a separate document as **Report 1: Geotechnical Investigation Report for Road and Rail Corridor in Volume 3** and same has been considered.

The Borehole and Trial Pit locations on map is as indicated in the figure below as per DPR 2018:

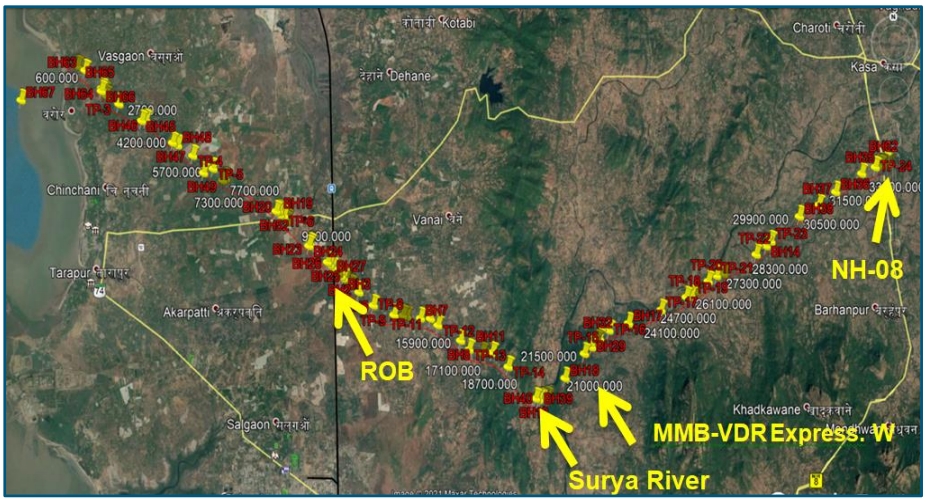


Figure 6-3 Bore log layout plan

From the above figure following are few observations:

- Average spacing of bore holes = 500 m
- Maximum spacing of bore holes = 2505 m
- Maximum spacing of trial pit = 3338 m
- Minimum spacing of trial pit = 171 m
- 10 Nos. of bore holes are provided near Surya river bridge
- 8 Nos. of bore holes are provided near ROB
- 7 Nos. of bore holes are provided near junction NH-08
- 4 Nos. of bore holes are provided near junction of Mumbai-Vadodara Expressway

As per IRC: SP: 84-2019 clause 4.4.2, along the alignment of the road, where unstable strata, soft material or poor subsoil condition is met with at the foundation level, the soil borings will be at maximum interval of 100 m to a depth of 2 m or more below the existing ground as necessary. During the phase of detailed engineering & construction, many more bore holes/trial pits may be required depending on geological condition, acquisition of new land and actual soil profile and soil nature, type of structure, loading etc.

6.1.6.1 Structural System

Structural System for Major Bridges

- As per recommendations of the geotechnical report pile foundation has been adopted for major structures such as major bridges, ROB
- Minimum grade of concrete for pile is M30.
- Geotechnical report does not mention recommended pile type, pile diameter, pile length, pile spacing, pile capacity, etc.

Following design parameters have been considered for pile foundation to carry out preliminary design, pile capacity & work out costing and estimation.

- Pile Section = Circular
- Type of pile = RCC-Cast-in-Situ
- Pile diameter = 1.2 m
- Minimum pile length = 15 m
- Pile spacing = 3 x pile diameter = 3 x 1.2 = 3.6 m

Pile capacity is worked out based on contributions from end bearing and skin friction. Pile will be embedded in hard rock.

As per geotechnical report

- End bearing= 500 t/m2
- Skin friction= 15 t/m2

- **Computation of Axial compression**
  - Pile Capacity = 500 x Ⲡ/4 x 1.2^2 + 15 x Ⲡ x 1.2 x 15
    = 565 + 849
    = 1414
  - Factor of Safety = 2.5
  - Allowable compression Axial load on pile = 1414/2.5 = 566 T
  - Group efficiency factor is assumed as 0.85
  - Pile capacity in compression = 566 X 0.85 = 481 T

- **Computation of Axial Tension**
  - Allowable Axial Tension load on pile = 15 x 3.14 x 1.2 x 15 = 849 T
  - Factor of safety = 3
  - Allowable Axial Tension load on pile = 849/3 = 283 T
  - Group efficiency factor = 0.85
  - Pile capacity in tension = 283 x 0.85 = 241 T
  - Horizontal load carrying capacity is assumed as 5% of Axial load carrying capacity = 5 x 481/100 = 24 T

These capacities need to be cross checked & verified with respect to the final approved geotechnical report & pile test results as per actual site conditions.

Actual pile length will vary as per site conditions, elevations, hardness of strata.

6.1.6.2 Structural System for Culverts & Underpasses

Culverts & underpasses are supported on stiff/hard soil at foundation depth of 3 to 6 m depending on height of box culverts/underpasses. Geotechnical report does not specify safe bearing capacity for shallow footings. In the absence of this data, SBC of 25 T/m^2 has been assumed for shallow foundations resting on medium stiff soil.

- Necessary dewatering will be required during excavation for this shallow type of foundation, depending on ground water conditions.
- Necessary rubble soling layer, lean concrete layer are considered below the footings.

These provisions & considerations will be checked during detailed engineering construction phase & necessary revisions /changes will be incorporated accordingly.

6.1.6.3 Structural foundation System for way side amenities

These structures are provided with shallow foundations, isolated or combined footings based on layouts & geometry. Foundation will generally be supported at 1.5 to 2.5 m below ground level based on actual soil conditions and strata.

Safe bearing capacity for foundation is assumed as 10 T/m^2.

Geotechnical report does not specify dry density, saturated density of soil, angle of internal friction of soil. In absence of these data, following values have been considered for carrying out preliminary sizing and estimation.

- Average dry density of soil = 1.9 T/m^2
- Average saturated density of soil = 2.1 T/m^2
- Average Angle of internal friction of soil= 12^o

These values will be checked and verified further during detailed design.

6.1.7 Additional Topographical Survey requirement

- Additional topographical surveys will be required to be done for following locations:
  - Near Surya river to finalise detail design of Bridge over Surya River as the design provided during DPR (2018) had not considered proper straight portion over the bridge. Present design has considered straight bridge. Highest flood level of Surya river has to be provided by the JNPT.
  - Around Railway crossing for Road over bridge over Railway (MRVC, WR and DFC lines) to improve preliminary design so that Road over bridge design developed is with least interface to Railway movement and the design is also acceptable to Railways. Existing rail top levels at an every 10 m interval has to be provided by the JNPT surveyor.

6.1.8 Variation in Cost Estimates

There are substantial changes in the estimated Project Cost of the previous JNPT DPR (2018) attributable to many reasons such as erroneous design criteria, underestimation of quantities and unit rates, and mismatch in various assumptions.

7 Quantity Assessment

7.1 Material Procurement

7.1.1 Material procurement for embankment and subgrade

Potential sources of earth for the construction of embankment and sub-grade for New Carriageway will be identified as the excavated materials obtained from tunnels and cut & fill sections.

7.1.2 Availability of Bitumen, Steel and Cement

Bitumen is available in market in Mumbai, which is around 100 km from the proposed project. The steel to be used as reinforcement for cross drainage structures will be Deformed Steel Bars. The cement of various types like Ordinary Portland Cement - 43 Grade, 53 Grade and Pozzolana Cement is required for the construction. The Steel and Cement are readily available near the project area.

Table 7-1 Availability of Bitumen, Steel and Cement

S. No.	Location from Proposed Port Expressway
	Bitumen
1.	Available at Mumbai
	Steel
2.	Available at Mumbai
	Cement
3.	Available at Vadhavan

7.1.3 Stone aggregates

The availability and quality of material as coarse and fine aggregate needs to be explored and samples collected from the nearest quarry were large quantities of stone aggregates available.

7.1.4 Identification of Quarry Material

The geological conditions in the study area are dominated by basalt. Successive eruptions of basalt have formed the Deccan plateau region of South West India.

- Hillocks of height varying from 120m from MSL to 400m from MSL can be located around port location. Nearest hillock can be identified approximately 19KM from proposed port at village Aine, village Dabhon and village Gargaon. It is a continuous range of hillock starting from village Aine in Dahanu taluka till Village Mahagaon and Kukde in Palghar Taluka. Second nearest hillock for mining purpose can be located approximately 25 KM starting from Village Nanivali to Village Pole and Village Pimpleshet.
- Quality of rock in identified nearest locations is of basaltic origin with weathered soft strata (moorum) carpet of 1m to 8 m thickness. Fractured and jointed amygdaloidal basalt is found below soft strata. Large size boulders predominantly are encountered in soft strata carpet. Visual observation of rock suggests good quality for reclamation purpose. Geotechnical properties can be further evaluated and confirmed before excavation.

7.1.5 Conclusion

- Total seven hillocks have been identified and proposed as prospective mining locations for moorum and stone to be used in reclamation of port and embankment of road and railway.
- Identified hillocks are situated in villages of Palghar Taluka.
- Hillocks located in villages of Dahanu Taluka are purposefully avoided since 'Dahanu Taluka' is environmentally protected zone and Honourable Dharmadhikari Committee constituted will object for any mining works. Detail proposal is as follows.

Table 7-2 Location of Quarry Material

S.No.	Village	Hillock	Distance from Port in (Km)	Approximate Height in 'm'	Projected Quantity in 'sq. m'	Projected Quantity in 'Brass'
1.	Gargaon	A	17	180	2,54,80,000.00	89,89,344.00
2.	Gargaon	B	17	160	4,57,60,000.00	1,61,44,128.00
3.	Khanivade	C	19	120	3,93,75,000.00	1,38,91,500.00
4.	Khanivade	D	19	124	3,74,00,000.00	1,31,94,720.00
5.	Mahagaon	E	20	127	4,23,00,000.00	1,49,23,440.00
6.	Mahagaon	F	20	110	1,45,00,000.00	51,15,600.00
7.	Nanivali	G	25	380	84,52,60,000.00	29,82,07,728.00
Total					**1,05,00,75,000.00**	**37,04,66,460.00**

Additionally, JNPT identified additional prospective private quarry sites for rock sourcing. The quarry details are as indicated below:

Table 7-3 Additional private quarry locations

S. No.	Quarry location (Hillock)	Distance from Port (km)	Ownership
1.	Borsheti	24	Private
2.	Kirat	25	Private
3.	Nagzari	26	Private
4.	Girnoli	28	Private

7.2 General Arrangement Drawings (GADs)

Following are the GADs prepared for preparation of Bill of Quantities of various structures.

GAD of ROB (Road Over Bridge).

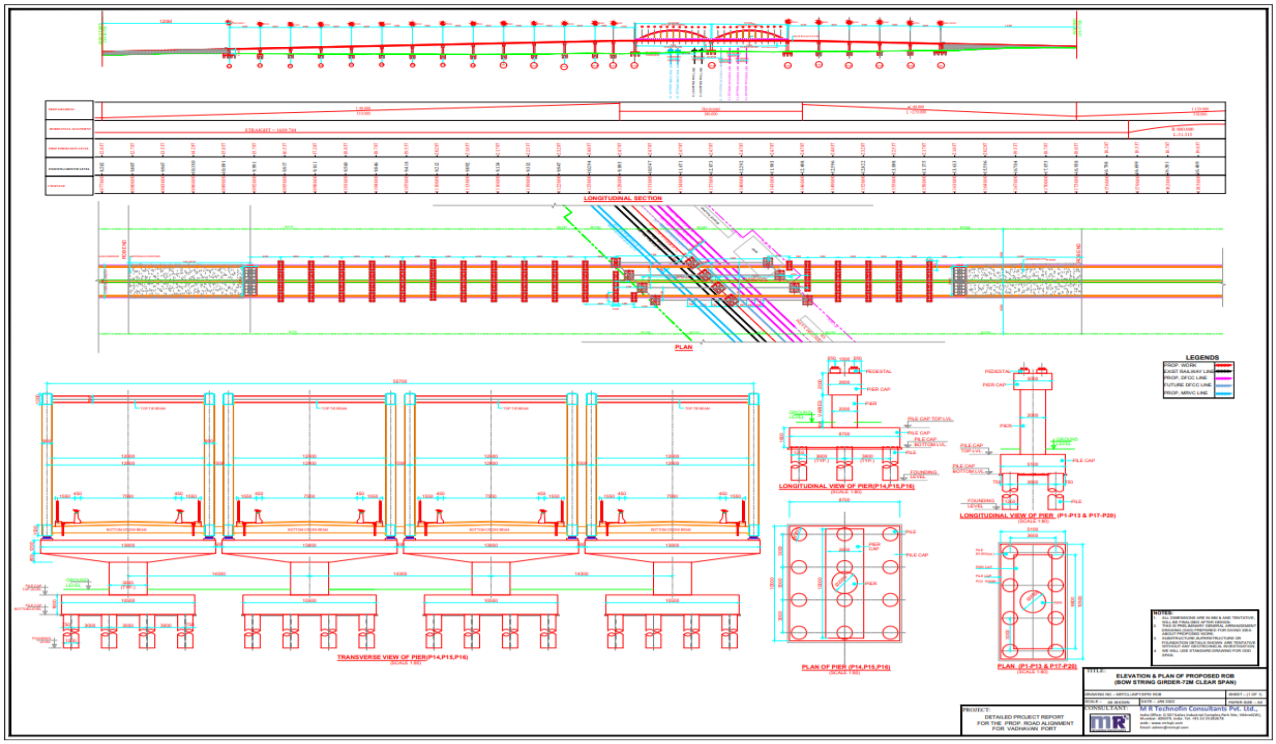
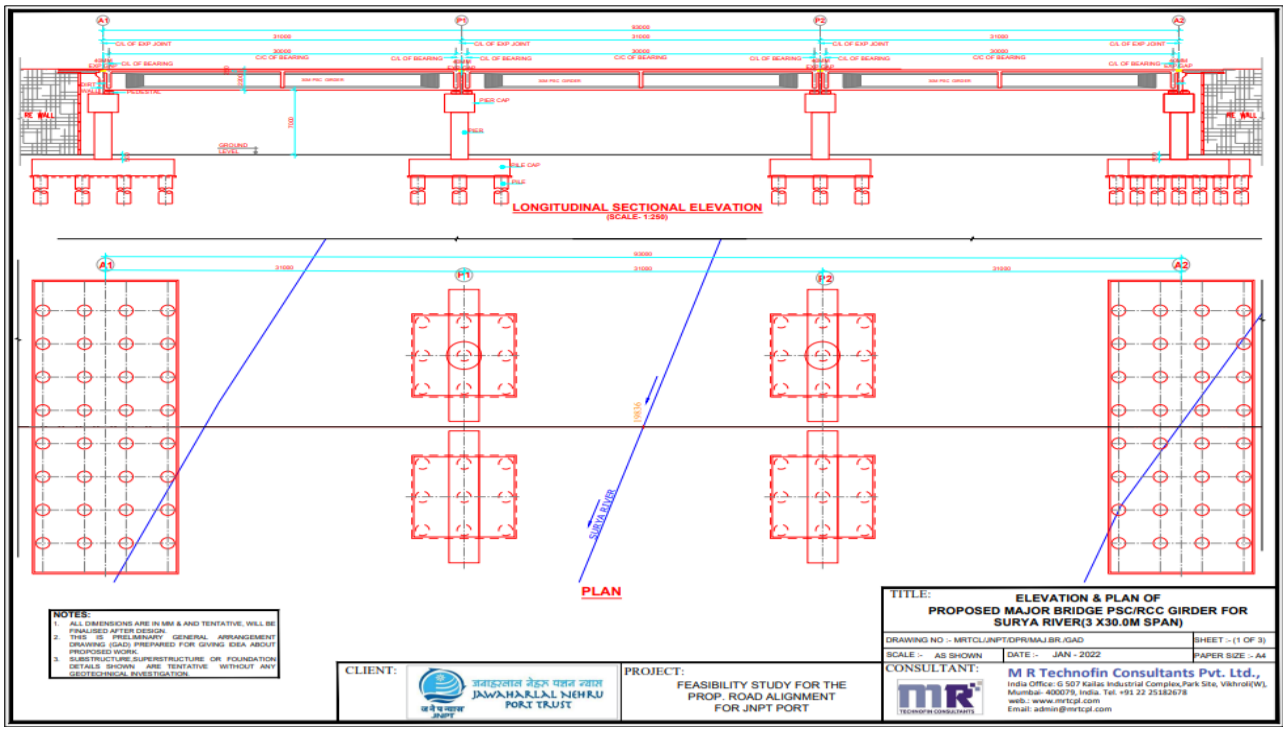


Figure 7-1 GAD of ROB

GAD of Surya River



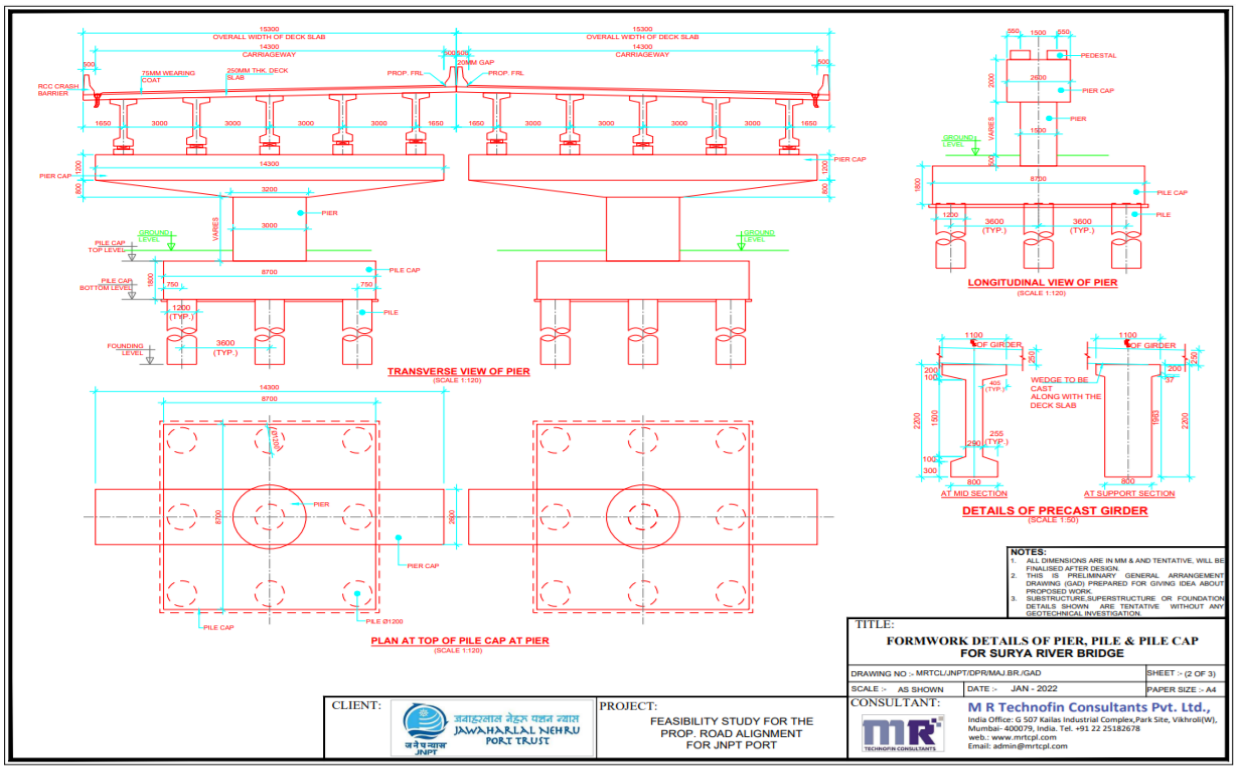


Figure 7-2 GAD of Surya River

GAD of RCC Box Culvert

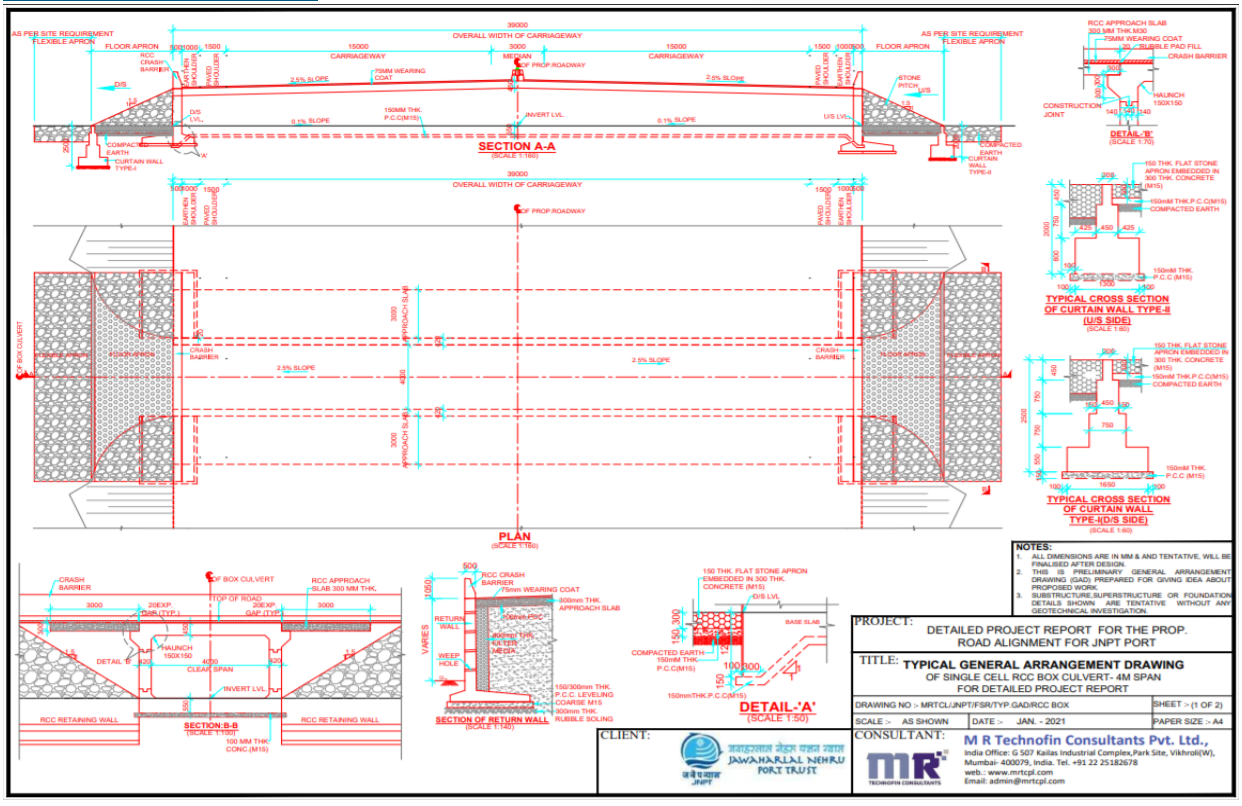


Figure 7-3 GAD of RCC Box Culvert

GAD of Vehicular Underpass

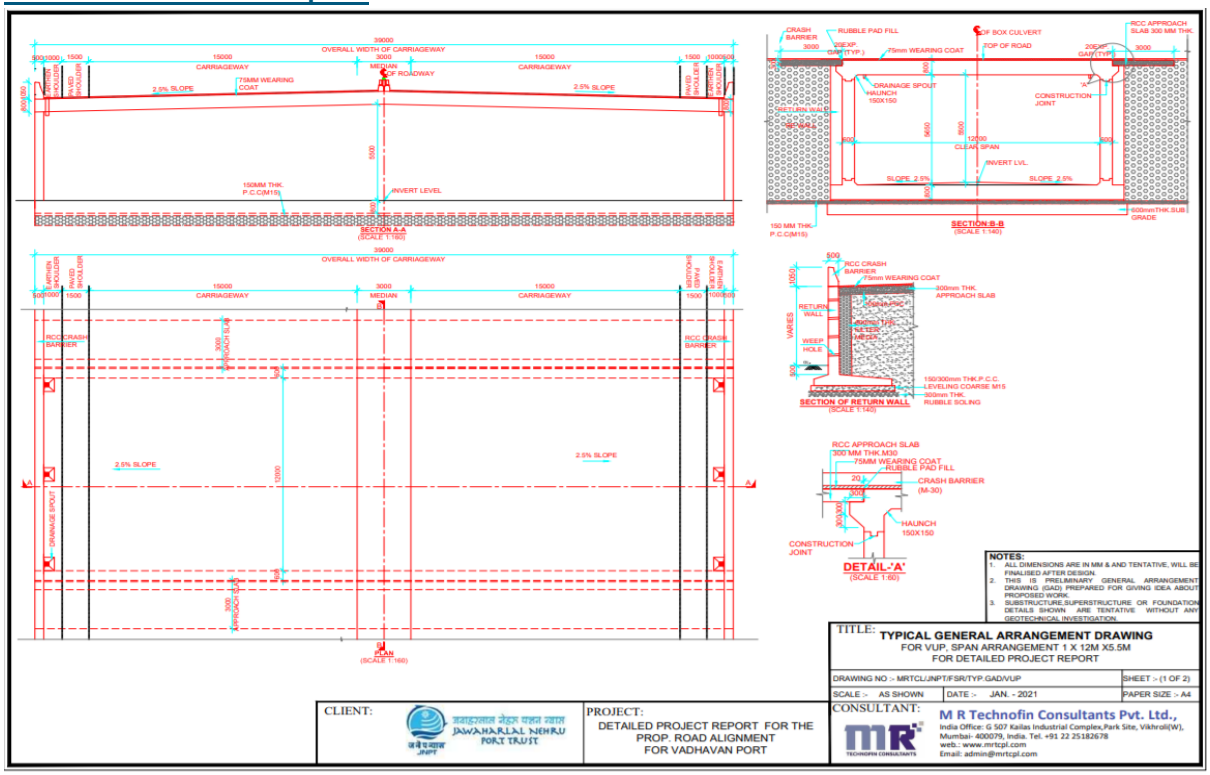


Figure 7-4 GAD of Vehicular Underpass

7.3 Quantity Estimation

The Quantity Estimation is based on the GADs prepared as above.

7.3.1 Bill of Quantities of Earthwork in Formation

Table 7-4 Bill of Quantities of Earthwork in Formation

Sr. No.	Description of Work	Unit	Quantity
1	Earthwork in **Filling in embankment**	cum	12,766,900
2	**Earthwork in Cutting**		
2(a)	In all conditions and classifications of soil except Rock	cum	158,200
2 (b)	Soft rock not requiring blasting in all conditions	cum	31,640
3	Turfing / planting, -**Slope Stabilization**	sqm	1,017,400
4	Leading cut spoil		
4(a)	Upto 1 KM	cum	31,640
4(b)	Upto 5 KM	cum	31,640
5	Extra for compaction of cut spoil	cum	31,640

7.3.2 Bill of Quantities of Flexible Pavement

Table 7-5 Bill of Quantities of Flexible Pavement

Sr. No	Description	Unit	Quantity.

1	**Sub Grade**	cum	4,26,360
2	**Granular Sub Base**	cum	2,66,475
3	Providing and laying 75 mm compacted thick design mix (approved by Engineer) **Dense Bituminous Macadam**	cum	1,33,238
4	Providing and laying hot mix hot laid **Bituminous concrete** 25/40 mm compacted thickness	cum	53,295
5	Providing and applying liquid **tack coat** type "A" comprising of a layer of bituminous binder @ 50kg/ 100 Sqm	sqm	21,31,800

7.3.3 Bill of Quantities of Side Drain, Fencing, Painting & Crash Barrier

Table 7-6 Bill of Quantities of Side Drain, Fencing, Painting & Crash Barrier

S. No.	Description of Work	Unit	Quantity
Side Drain			
1.	Excavation for foundation	Cum	77,600
2.	Leading Cut spoil		
	30 % of Total Excavation		
	Up to 1Km.	Cum	23,300
3.	PCC **M-15 (1:2:4**) in Foundation	Cum	15,600
4.	Providing & laying Cement Concrete **M-30** for RCC work in foundation, substructure & retaining wall at all height	Cum	**25,200**
5.	Providing & laying Precast Cement Concrete **M-30** for RCC work in Top slab including compacting by vibration, curing, formwork, bailing out water etc. complete.	Cum	11,700
6.	Providing and placing in any position cold twisted High Yield Strength Deformed bars.		
	HYSD 90 Kg /Cum	MT	3,400
Fencing			
1.	Providing and erecting 1.5-metre-high wire fencing with seven rows of barbed wire supported on M. S. Angles (50mm x 50mm x 6mm) at 2.5 Metres	M	64,600
Painting & Crash Barrier			
1.	**Painting** Line, Dashes, Arrows etc. on Roads in two coats on new work with ready mixed road marking paint confirming to I.S. 164 on Bituminous surface - Over 10cm Wide on New Surface	Sqm	12,59,700
2.	**Metal Beam Crash Barrier -** Type - A, W: Metal Beam Crash Barrier	M	64,600

7.3.4 Bill of Quantities of Junction arrangements

Table 7-7 Bill of Quantities of Junction arrangements

S. No.	Description	Unit	Quantity
Junction No. 1	**MMB-VDR Expressway & Proposed Road**		
1.	Flexible pavement	m	6,280
2.	Culvert	sq. m	360
3.	Minor Bridge	sq. m	315
4.	Stream/Canal to be divert	m	890
5.	Road to be divert	m	546
Junction No. 2	**NH-8 & Proposed Road**		
1.	Flexible pavement	m	6,710
2.	Underpasses	sq. m	360
3.	Minor Bridge	sq. m	525
4.	Stream/Canal to be divert	m	776
5.	Road to be divert	m	776

7.3.5 Bill of Quantities of cross structure

Table 7-8 Bill of Quantities of Underpasses, Rob & Surya River

Bridge No.	Chainage	Bridge Category	Unit	Quantity
1	590	Underpass	sq.m	720
2	590	Road to be divert	m	513
3	900	Underpass	sq.m	720
4	900	Road to be divert	m	455
5	1020	Road to be divert	m	264
6	1170	Underpass	sq.m	720
7	1170	Road to be divert	m	264
8	1650	Underpass	sq.m	720
9	1920	Underpass	sq.m	720
10	1920	Road to be divert	m	599
11	2140	Road to be divert	m	379
12	2380	Underpass	sq.m	720
13	4010	Road to be divert	m	132
14	4120	Underpass	sq.m	720
15	4120	Road to be divert	m	625
16	4600	Underpass	sq.m	720

Bridge No.	Chainage	Bridge Category	Unit	Quantity
17	6120	Road to be divert	m	661
18	6420	Underpass	sq.m	720
19	6420	Road to be divert	m	651
20	6790	Underpass	sq.m	720
21	6790	Road to be divert	m	683
22	7620	Underpass	sq.m	720
23	7620	Road to be divert	m	503
24	8370	Road to be divert	m	322
25	8650	Underpass	sq.m	720
26	8650	Road to be divert	m	346
27	8910	Underpass	sq.m	720
28	8910	Road to be divert	m	652
29	9120	Underpass	sq.m	720
30	9120	Road to be divert	m	499
31	10270	Underpass	sq.m	720
32	10270	Road to be divert	m	648
33	10770-11730	ROB	sq.m	29760
34	11670	Underpass	sq.m	720
35	11670	Road to be divert	m	828
36	12000	Underpass	sq.m	720
37	12000	Road to be divert	m	935
38	12395	Underpass	sq.m	720
39	12395	Road to be divert	m	799
40	13100	Underpass	sq.m	720
41	13100	Road to be divert	m	591
42	13750	Underpass	sq.m	720
43	13750	Road to be divert	m	455
44	14320	Underpass	sq.m	720
45	14320	Road to be divert	m	467
46	14661	Underpass	sq.m	720
47	14661	Road to be divert	m	758
48	14670	Stream/Canal to be divert	m	758
49	15150	Underpass	sq.m	720

Bridge No.	Chainage	Bridge Category	Unit	Quantity
50	15430	Underpass	sq.m	720
51	15840	Underpass	sq.m	720
52	16200	Underpass	sq.m	720
53	16500	Road to be divert	m	246
54	16950	Underpass	sq.m	720
55	16950	Road to be divert	m	524
56	19370	Underpass	sq.m	720
57	20880	Underpass	sq.m	1980
58	21290	Road to be divert	m	1091
59	22480	Underpass	sq.m	720
60	22805	Underpass	sq.m	720
61	22805	Road to be divert	m	323
62	24330	Underpass	sq.m	720
63	25110-25155	Stream/Canal to be divert	m	45
64	26630	Underpass	sq.m	720
65	26630	Road to be divert	m	545
66	27370	Underpass	sq.m	720
67	27370	Road to be divert	m	477
68	28740-29160	Stream/Canal to be divert	m	3
69	29640	Underpass	sq.m	720
70	30270	Underpass	sq.m	720
71	30270	Road to be divert	m	496
72	30860	Underpass	sq.m	720
73	31410	Underpass	sq.m	720
74	31410	Road to be divert	m	383
75	32230	Underpass	sq.m	1980

Table 7-9 Bill of Quantities of RCC Box Culvert

Bridge No.	Chainage	Bridge Category	Unit	Quantity
1	10450	Box Culvert	sq.m	240
2	10760	Box Culvert	sq.m	180

Table 7-10 Bill of Quantities of Minor Bridges

Bridge No.	Chainage	Bridge Category	Unit	Quantity
1	270	Minor Bridge	sq.m	660

Bridge No.	Chainage	Bridge Category	Unit	Quantity
2	570	Minor Bridge	sq.m	660
3	1775	Minor Bridge	sq.m	540
4	10980	Minor Bridge	sq.m	720
5	14670	Minor Bridge	sq.m	720
6	17310	Minor Bridge	sq.m	720
7	17515	Minor Bridge	sq.m	660
8	19422-19458.61	Minor Bridge	sq.m	1320
9	19546-19590	Minor Bridge	sq.m	1320
10	22440	Minor Bridge	sq.m	540
11	24150	Minor Bridge	sq.m	660
12	25380	Minor Bridge	sq.m	660
13	27560	Minor Bridge	sq.m	1200
14	28720	Minor Bridge	sq.m	990
15	32070	Minor Bridge	sq.m	990

8 Cost Estimates

8.1 Basis of Estimate

8.1.1 General

Cost estimation is important for the Detailed Study as it provides vital input to the economic and financial evaluation of the project. The cost estimates have been prepared for the project separately for new Eight Lane Greenfield Alignment comprising of ROB; Bridges and Cut & Fill sections, Cross drainage structures, longitudinal drains, junction improvements, road furniture, etc.

8.1.2 Cost Methodology

8.1.2.1 Unit Rates

The rates of various items of construction work have been analysed as per procedure laid down in the "MORT&H Standard Data Book" and guidelines set therein. Market studies were made to ascertain the rates of various items of construction materials. The rates of earthworks and pavement layers, sand, moorum, gravel & aggregate, etc. have been collected from State Schedule of Rates 2019-2020.

Total seven hillocks have been identified and proposed as prospective mining locations for moorum and stone to be used in reclamation of port and embankment of road and railway. Identified hillocks are situated in villages of Palghar Taluka. Hillocks located in villages of Dahanu Taluka are purposefully avoided since 'Dahanu Taluka' is environmentally protected zone and Honourable Dharmadhikari Committee constituted will object for any mining work.

For machinery and equipment, rates of different categories of skilled and unskilled manpower, labour, etc. have been taken from the rates as provided in the latest NH-SSR of Maharashtra 2019-20. Block Cost Estimates for the development of proposed road corridor is based on NHAI & MoRTH practices.

The rates for this project have been adopted from the unit rates as above as well as based on similar projects which have been executed successfully. Detailed analysis of rates has been done for major items. Some of the item rates have been adopted based on 'In-house' database of the Consultant and Market intelligence.

8.1.2.2 Bill of Quantities

The major construction items covered in cost estimates are: site clearance; earthwork in new embankment, Subgrade, Pavement in carriageways and shoulders; culverts; Bridges; Junction improvement; Drainage and Protective works; Access Roads, ROB's, and Miscellaneous items which includes Pavement markings, Signages, etc.

8.1.2.3 Project Cost

The summary of project cost is as follows:

Table 8-1Summary of Project Cost for 8 lane flexible pavement

Sr. No.	Description of Work	Unit	%	Total Cost (In Crore)
1	2	3	4	6
Total Length of the Project Expressway = About 32.30 km				
A	**Civil Work**			
i	Site Clearance and Dismantling	Lumpsum		1.00
ii	Earthwork	Cum		397.00
iii	Flexible Pavement			214.00
iv	Underpasses & Road Diversion			327.00
v	Minor Bridges & Culverts			149.00
vi	Major Bridges			225.00
vii	ROB			372.00
viii	Junction (NH-08 & Mumbai-Vadodara Expressway)			110.00
ix	Drainage and Utilities & Fencing			65.00
x	Road Appurtenances (Crash Barrier, Painting etc.)			64.00
xi	Miscellaneous (Retaining Walls, River/Nalla training)	Lumpsum		20.00
	Total Cost of Civil Work(A)			**1,944**
B	**Contingency 3%**		3%	59.00
Total Civil Construction Cost (A+B)				**2,003**
C	**Other Charges**			
i	Preliminary & Establishment Cost		3.0%	60.00
ii	Design & Detailed Engineering		1.0%	20.00
iii	Road Safety		0.25%	5.00
iv	Supervision		3.0%	60.00
v	Maintenance after Construction for 3 years		5.0%	100.00
	TOTAL Cost of C			**245**
	TOTAL Project Cost (A+B+C)			**2,248**
D	**Environmental Mitigation Measures**		1.0%	20.00
E	**Utility Shifting**		0.5%	10.00
	Total Capital Cost of the Project (A+B+C+D+E)			**2,278**
	Inflation Adjusted (7.5%) Cost of the Project for Base Year 2022 (values rounded off)			**2,449.00**

Total Project Cost is around Rs. 2450 Cr. for 8 Lane Flexible Pavement.

Note:

1. Land Acquisition Cost is not included in the above estimate.
2. Up to approx. ±15% variation might be there once detailed designs are completed based on detailed field Investigations.
3. The above cost is excluding cost of quarrying of rocks between CH: 17520 to CH: 18990 approx. 1.5 km in the hilly portion near Surya river. It is assumed that the material will be procured & utilized for port land reclamation purpose.
4. Way side amenities cost is not included in the above estimate.

Appendix 1 - Data

A1 Appendix 1.1- List of Curvatures

Table 8-2 List of Curvatures as per Current DPR

S. No.	Start Station	End Station	Length of Curve (m)	Radius (m)
1.	1841.68	2059.68	217.99	1000
2.	2311.81	2739.93	428.12	1000
3.	3415.55	3781.14	365.59	800
4.	6327.61	6661.59	333.98	1000
5.	7768.20	7985.60	217.40	700
6.	8514.03	8734.29	220.25	700
7.	9910.06	10091.46	181.40	1200
8.	11781.24	11952.56	171.32	800
9.	12528.31	12689.16	160.85	800
10.	13271.70	13781.34	509.64	700
11.	15003.31	15289.56	286.26	1000
12.	15483.66	15698.55	214.89	1000
13.	16106.03	16308.66	202.62	1000
14.	17151.67	17515.22	363.55	1000
15.	19003.42	19213.64	210.22	1000
16.	22319.42	22603.61	284.20	1000
17.	23808.90	24096.16	287.25	1000
18.	25065.66	25603.06	537.40	1000
19.	25621.69	26098.94	477.25	1000
20.	26644.19	27109.86	465.66	700
21.	27304.63	27865.58	560.95	670
22.	28936.19	29225.11	288.92	670
23.	29982.61	30272.96	290.35	1000
24.	30982.73	31366.64	383.91	1000

A2 Appendix 1.2 - List of Gradients

Table 8-3 List of Gradient as per Current DPR

	Chainage		Gradient (1 in n)		Distance (m)	Cumulative Distance (m)
	From	To	Rise	Fall		
1	0	780	115		780	
2	780	2220	350		1440	2220
3	2220	2760	110		540	2760
4	2760	3330		-110	570	3330
5	3330	4410	290		1080	4410
6	4410	4650	130		240	4650
7	4650	5670		-200	1020	5670
8	5670	6210	100		540	6210
9	6210	6690		-650	480	6690
10	6690	6990	100		300	6990
11	6990	8010		-700	1020	8010
12	8010	8790		-150	780	8790
13	8790	9690	Level		900	9690
14	9690	10110	200		420	10110
15	10110	10770		-100	660	10770
16	10770	11280	40		510	11280
17	11280	11460	Level		180	11460
18	11460	11730		-40	270	11730
19	11730	12240	120		510	12240
20	12240	12450		-100	210	12450
21	12450	13230	2500		780	13230
22	13230	13800	300		570	13800
23	13800	14430	150		630	14430
24	14430	15720		-300	1290	15720
25	15720	16650	150		930	16650
26	16650	18960	Level		2310	18960
27	18960	19380	250		420	19380
28	19380	19710		-125	330	19710

29	19710	19980	Level		270	19980
30	19980	20940		-600	960	20940
31	20940	21990	100		1050	21990
32	21990	22620	234		630	22620
33	22620	22950		-100	330	22950
34	22950	23730		-500	780	23730
35	23730	24960	175		1230	24960
36	24960	26100	650		1140	26100
37	26100	26610	300		510	26610
38	26610	27030		-300	420	27030
39	27030	27870	112		840	27870
40	27870	28650		-350	780	28650
41	28650	29250	Level		600	29250
42	29250	29910	100		660	29910
43	29910	30390		-150	480	30390
44	30390	30930	130		540	30930
45	30930	31470	Level		540	31470
46	31470	32300		-100	830	32300

A3 Appendix 1.3 - List of Bridges & Road Crossings

Table 8-4 List of Pipe Culvert as per previous JNPT DPR 2018

S. No.	Proposed Chainage	Type of Structure	Dia. of Pipe	Remark
1.	420	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
2.	990	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
3.	1600	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
4.	2850	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
5.	3570	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
6.	5300	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
7.	8200	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
8.	8800	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
9.	9420	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m

S. No.	Proposed Chainage	Type of Structure	Dia. of Pipe	Remark
10.	**10230**	**Box Culvert**	**4X5**	Provide 4m X 5m single span box culvert
11.	10680	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
12.	11550	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
13.	12600	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
14.	12880	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
15.	13290	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
16.	13710	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
17.	**14790**	**Box Culvert**	**3 X 3**	Provide 3m X 3m single span box culvert
18.	15660	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
19.	17780	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
20.	20320	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
21.	21230	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
22.	22280	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
23.	23950	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
24.	24400	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
25.	25030	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
26.	25640	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
27.	26900	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
28.	27400	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
29.	30140	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
30.	30630	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
31.	31200	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
32.	32610	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m
33.	33620	Pipe Culvert	1.2	Provide 1 pipe of dia.1.2m

Table 8-5 List of Pipe Culvert as per current DPR

S. No.	Prop. Chainage	Prop. Type of Structure	Size of the Proposed Box Culvert (m)
1.	10450	Box Culvert	1x4
2.	10760	Box Culvert	1x3
3.	MMB-VDR Junction	Box Culvert	1x6

4.	MMB-VDR Junction	Box Culvert	1x6

Table 8-6 List of Road Crossings/River bridges as per previous JNPT DPR 2018

S. No	Underpass/ROB & Bridge No.	Chainage In (m) As Per Old DPR	Type of Structure	Size (M)	Vertical Clearance (m)
1.	1	700	Underpass	12X5.5	5.5
2.	2	1510	Underpass	12X5.5	5.5
3.	3	2230	Underpass	12X5.5	5.5
4.	4	3705	Underpass	12X5.5	5.5
5.	5	4415	Underpass	12X5.5	5.5
			Road Divert		
6.	6	5970	Underpass	12X5.5	5.5
7.	7	6520	Underpass	12X5.5	5.5
9.	8	8640	Underpass	12X5.5	5.5
10.			Road Divert		
11.	9	10080	Underpass	12X5.5	5.5
12.	10	10760-12540	ROB With Approach	19X1780	8.05 from IR Rail Level
14.	11	12915	Underpass	12X5.5	5.5
15.	12	13920	Underpass	12X5.5	5.5
16.	13	14700	Underpass	12X5.5	5.5
17.			Road Divert		
18.	14	15300	Underpass	12X5.5	5.5
19.	15	16220	Underpass	12X5.5	5.5
20.			Road Divert		
21.	16	17440	Underpass	12X5.5	5.5
22.	17	19495	Underpass	12X5.5	5.5
23.	18	19560 - 20170	Bridge With Approach (Over Surya River)	19x610	6.2
24.	19	20750	Underpass	12X5.5	5.5
25.	20	21740	Underpass	12X5.5	5.5
26.		22170-22310	Mumbai Vadodara express way	12X5.5	
27.	21	22835	Underpass	12X5.5	5.5
28.	22	25840	Underpass	12X5.5	5.5
29.	23	27150	Underpass	12X5.5	5.5

30.	24	28815	Underpass	12X5.5	5.5
31.	25	30330	Underpass	12X5.5	5.5
32.	26	31670	Underpass	12X5.5	5.5

Table 8-7 List of Road Crossings/River bridges as per Current DPR

Bridge No.	Chainages	Bridge Category	Span		Vertical Clearance (m)
			No.	Length (m)	
1	590	Underpass	1	12	5.5
2	590	Road to be divert	1		
3	900	Underpass	1	12	5.5
4	900	Road to be divert	1		
5	1020	Road to be divert	1		
6	1170	Underpass	1	12	5.5
7	1170	Road to be divert	1		
8	1650	Underpass	1	12	5.5
9	1920	Underpass	1	12	5.5
10	1920	Road to be divert	1		
11	2140	Road to be divert	1		
12	2380	Underpass	1	12	5.5
13	4010	Road to be divert	1		
14	4120	Underpass	1	12	5.5
15	4120	Road to be divert	1		
16	4600	Underpass	1	12	5.5
17	6120	Road to be divert	1		
18	6420	Underpass	1	12	5.5
19	6420	Road to be divert	1		
20	6790	Underpass	1	12	5.5
21	6790	Road to be divert	1		
22	7620	Underpass	1	12	5.5
23	7620	Road to be divert	1		
24	8370	Road to be divert	1		

25	8650	Underpass	1	12	5.5
26	8650	Road to be divert	1		
27	8910	Underpass	1	12	5.5
28	8910	Road to be divert	1		
29	9120	Underpass	1	12	5.5
30	9120	Road to be divert	1		
31	10270	Underpass	1	12	5.5
32	10270	Road to be divert	1		
33	10770-11730	ROB with approaches	1	2 X 74 + 17X30 +1X18 +1X21+approaches	9.254
34	11670	Underpass	1	12	5.5
35	11670	Road to be divert	1		
36	12000	Underpass	1	12	5.5
37	12000	Road to be divert	1		
38	12395	Underpass	1	12	5.5
39	12395	Road to be divert	1		
40	13100	Underpass	1	12	5.5
41	13100	Road to be divert	1		
42	13750	Underpass	1	12	5.5
43	13750	Road to be divert	1		
44	14320	Underpass	1	12	5.5
45	14320	Road to be divert	1		
46	14661	Underpass	1	12	5.5
47	14661	Road to be divert			
48	14670	Stream/Canal to be divert			
49	15150	Underpass	1	12	5.5
50	15430	Underpass	1	12	5.5
51	15840	Underpass	1	12	5.5
52	16200	Underpass	1	12	5.5
53	16500	Road to be divert	1		
54	16950	Underpass	1	12	5.5

55	16950	Road to be divert	1		
56	19370	Underpass	1	12	5.5
57	19691-19981	Surya River with approaches	3	30	9.6
58	20880	Underpass	1	33	5.5
59	21290	Road to be divert	1		
60	22480	Underpass	1	12	5.5
61	22805	Underpass	1	12	5.5
62	22805	Road to be divert	1		
63	24330	Underpass	1	12	5.5
64	25110-25155	Stream/Canal to be divert	1		
65	26630	Underpass	1	12	5.5
66	26630	Road to be divert	1		
67	27370	Underpass	1	12	5.5
68	27370	Road to be divert	1		
69	28740-29160	Stream/Canal to be divert	1		
70	29640	Underpass	1	12	5.5
71	30270	Underpass	1	12	5.5
72	30270	Road to be divert	1		
73	30860	Underpass	1	12	5.5
74	31410	Underpass	1	12	5.5
75	31410	Road to be divert	1		
76	32230	Underpass	1	33	5.5
77	Junction NH-08	Stream/Canal to be divert	1		
78	Junction NH-08	Road to be divert	1		
79	Junction NH-08	Underpass	1	12	5.5
80	Junction MMB-VDR Exp.	Stream/Canal to be divert	1		
81	Junction MMB-VDR Exp.	Stream/Canal to be divert	1		
82	Junction MMB-VDR Exp.	Road to be Divert	1		

A4 Appendix 1.4- Variation Between Road Alignment As Per DPR 2018 and Current DPR 2022

Table 8-8 Variation Between Road Alignment As Per DPR 2018 and Current DPR 2022

Sr. No.	Description of Item	DPR 2018	Current DPR 2022 (As per Partial Survey Data)
A. Major Location Changes in the Alignment			
1	Near Varor	It takes 2 curvature of 200 m radius from start point.	It is about 1.5 km straight from the start point.
2	Near Tanashi	The alignment was crossing concrete structure.	To avoid crossing of concrete structure alignment shifted about 200 m towards north.
3	Near Vangaon	The alignment was passing through settlement.	The road realign to avoid settlement.
4	Near Newale	The ROB was proposed in curvature.	The ROB has been proposed as a straight portion.
5	From Shigaon- Akoli	The alignment avoiding hill cutting and crosses Surya river in curvature.	The alignment passing through hilly terrain and crossing Surya river in straight portion. Also the previous MMB-VDR Expressway junction has also shifted about 500 m towards north.
6	Near Akegavhan	The alignment was passing from the edge of Temple wall.	The slightly alignment shifted towards north. The distance between road ROW and edge of temple wall is about 2 m.

Sr. No.	Description of Item	DPR 2018	Current DPR 2022 (As per Partial Survey Data)
7	Near Nanivali	The alignment was passing through settlement.	The road realign to avoid settlement in which the alignment shifted about 300 m towards north.
B. Number of Structure changes in the Alignment			
1	Length of the Alignment	33.60 km	32.30 km
2	Length of the ROB	1.78 km including approaches	0.96 km including approaches
3	Surya River Alignment and bridge length.	The alignment at Surya river considered to avoid hill cutting. The bridge length was 610 m including approaches.	The alignment at Surya river passing through hill terrain. As per new location of bridge the length is 290 m including approaches.
4	Underpasses	24 underpasses had been proposed.	Instead of 24 underpasses 40 underpasses have been proposed.
C. Major Cost Variation			
1	In previous DPR 2018, the quantity of Bridge on Surya river was considered for 4 lanes. The up-dated DPR considers it for 8 lanes.		
2	In previous DPR 2018 quantity and cost of junction arrangements with NH-08 and proposed Mumbai -Vadodara Expressway were not considered. In current DPR, 2 numbers of junction i.e. NH-08 junction and Mumbai-Vadodara expressway junction have been considered.		
3	• In previous DPR, the quantity of ROB was considered for 4 lanes. The up-dated DPR considers it for 8 lanes. • Railway do not allow bridges Pier/ Abutment in railway's ROW. Hence, in up-dated DPR, the Bow String Girders of 2 X 74 m have been considered for ROB which are costly. Procurement, Fabrication, Launching and Erection (over railway running lines) of Bow String Girders will be difficult and very costly.		

Sr. No.	Description of Item	DPR 2018	Current DPR 2022 (As per Partial Survey Data)
	• The exact length of ROB can only be decided once the configuration of expanded New Palghar Station of WDFC is finalized. The length is likely to increase substantially.		
4	• In DPR (2018), the quantity of 24 underpasses was considered. The up-dated DPR 40 underpasses have been considered. In DPR (2018) road diversions for Underpasses were not considered. In current DPR, 25 nos. of road diversions have been considered.		
5	In DPR (2018), details regarding cost of Drainage, Utilities & Fencing, Road Appurtenances(Crash Barrier, Painting etc.), Miscellaneous (Retaining Walls, River/Nalla training) were not given separately or might not been considered.		
6	In current DPR, charges such as Preliminary & Establishment Cost, Design & Detailed Engineering, Road Safety, Supervision, Maintenance after Construction for 3 years, Environmental Mitigation Measures, Utility Shifting and Other have been considered.		

Appendix 2 - Drawings

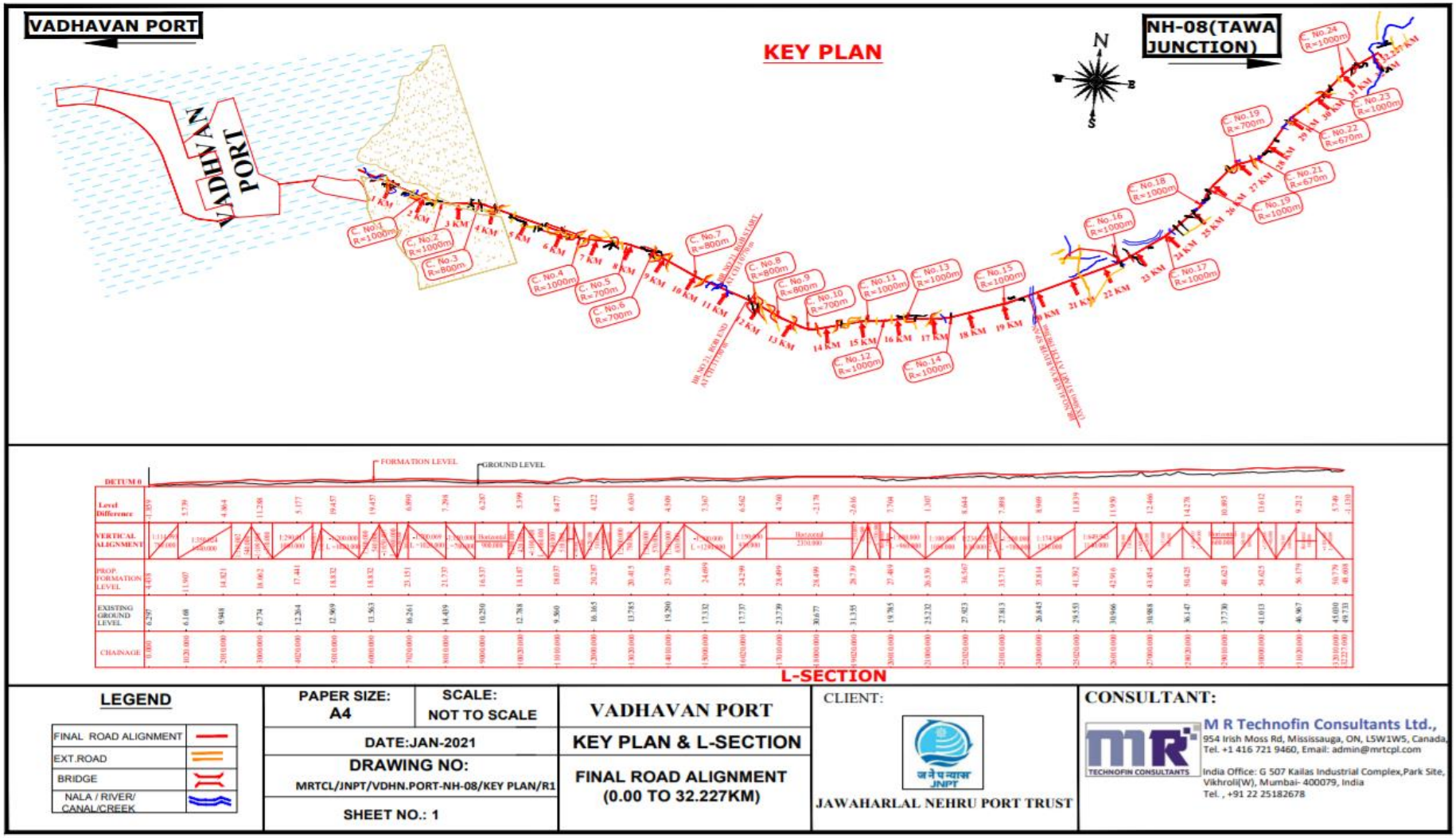


Figure 8-1Key Plan of Port Road Connectivity to NH-08

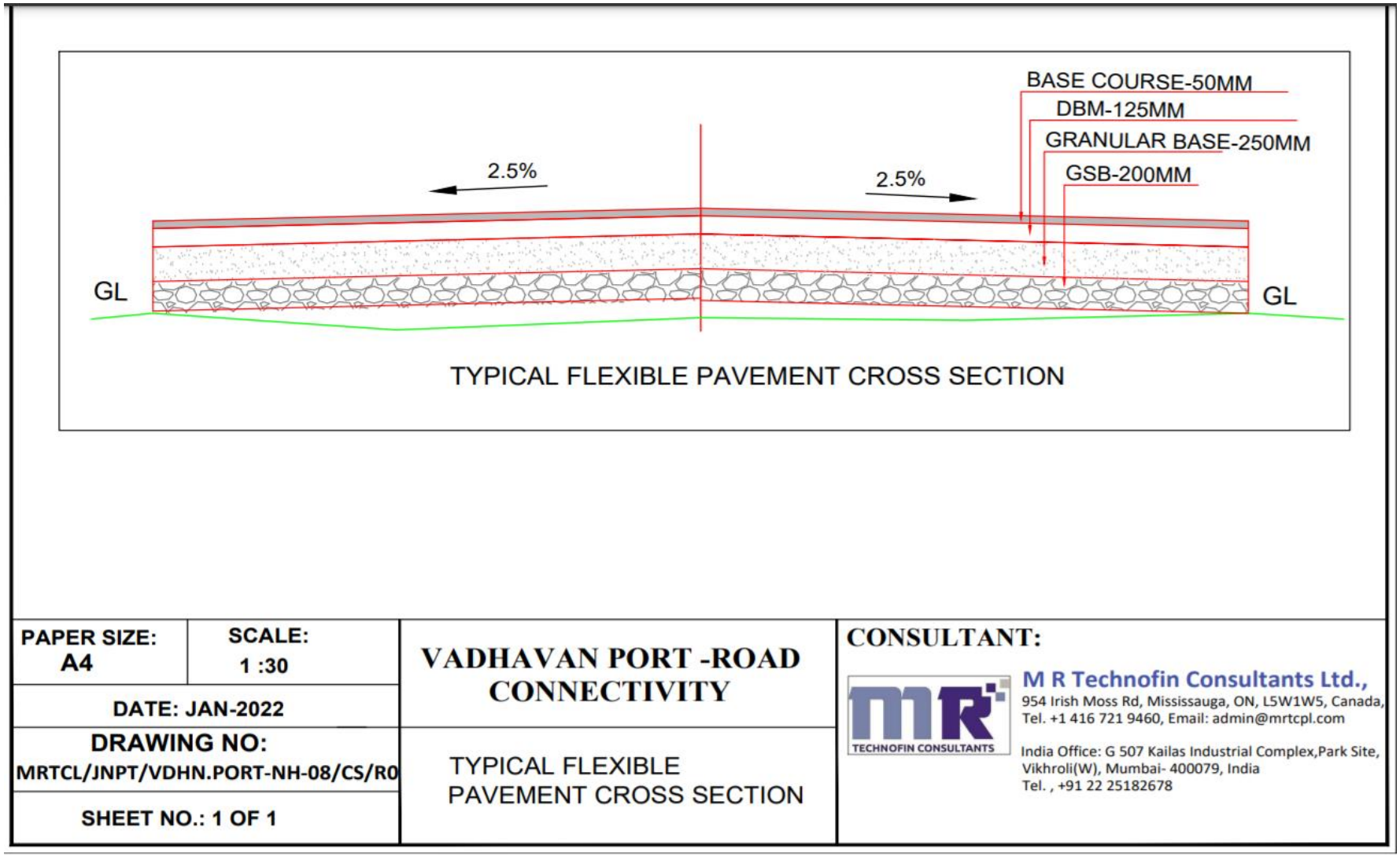


Figure 8-2 Typical Cross Section of Flexible Pavement of Port Road

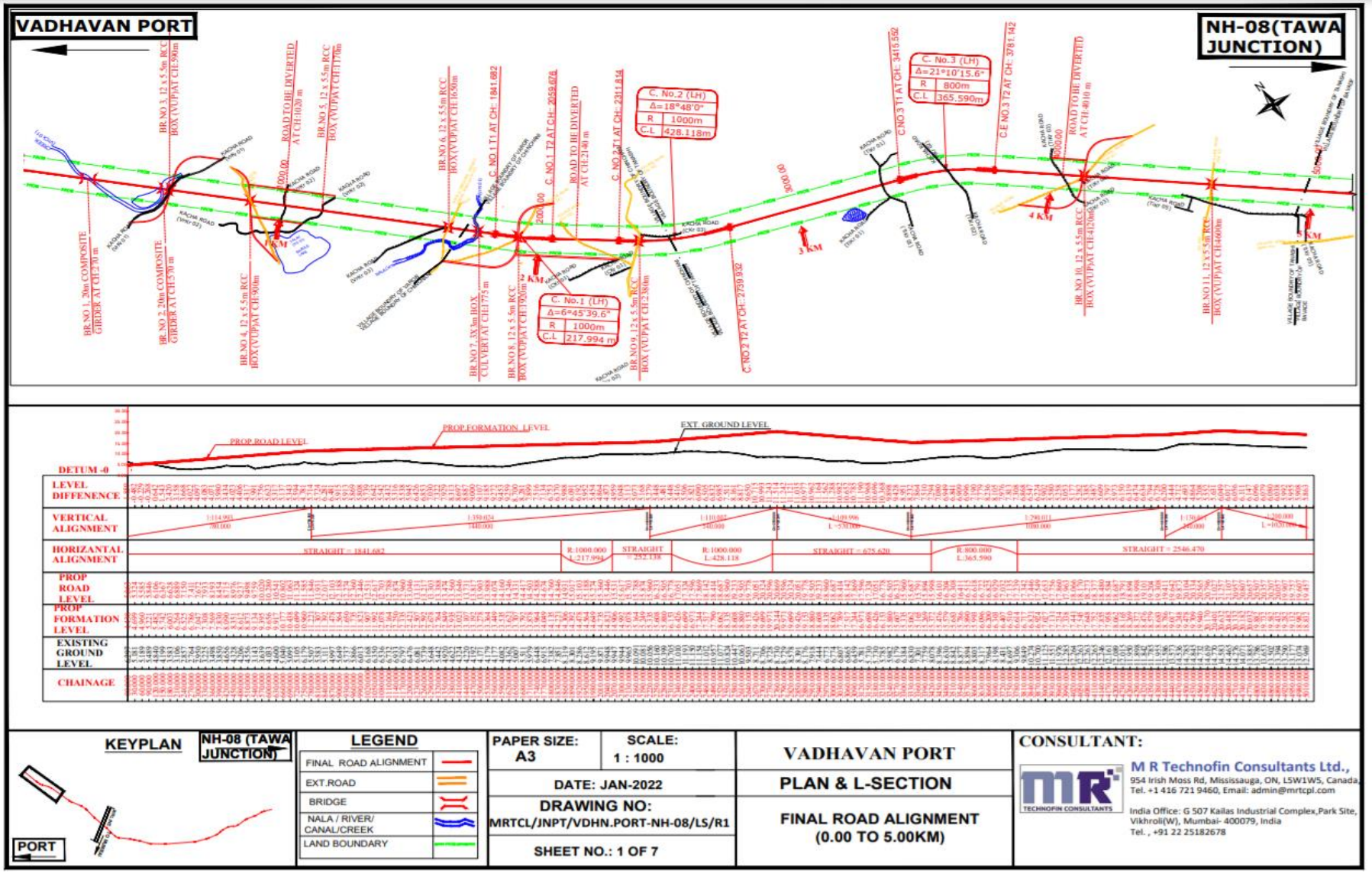


Figure 8-3 Plan & L-Section of 0 -5 Km

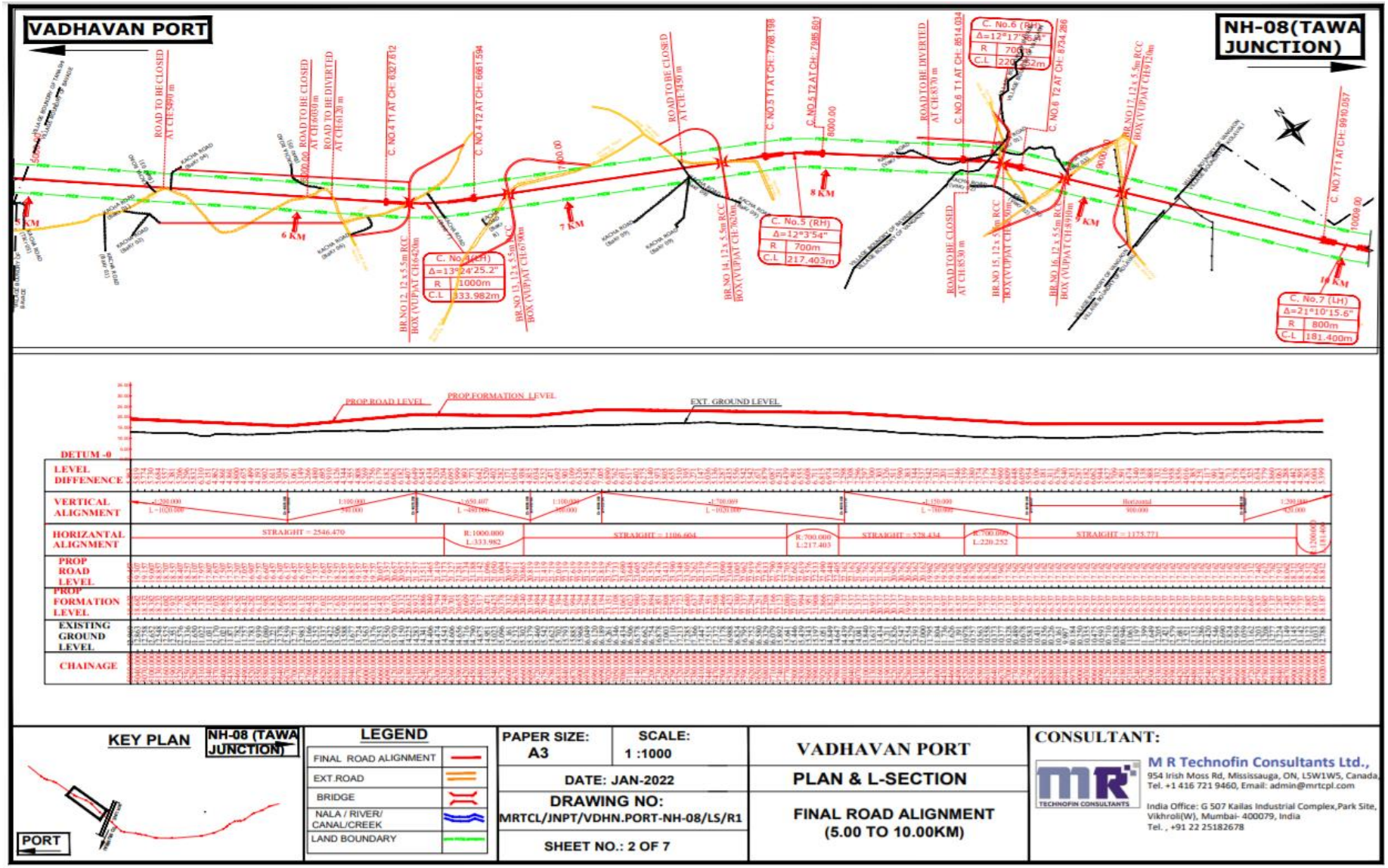


Figure 8-4 Plan & L-Section of 5-10 Km

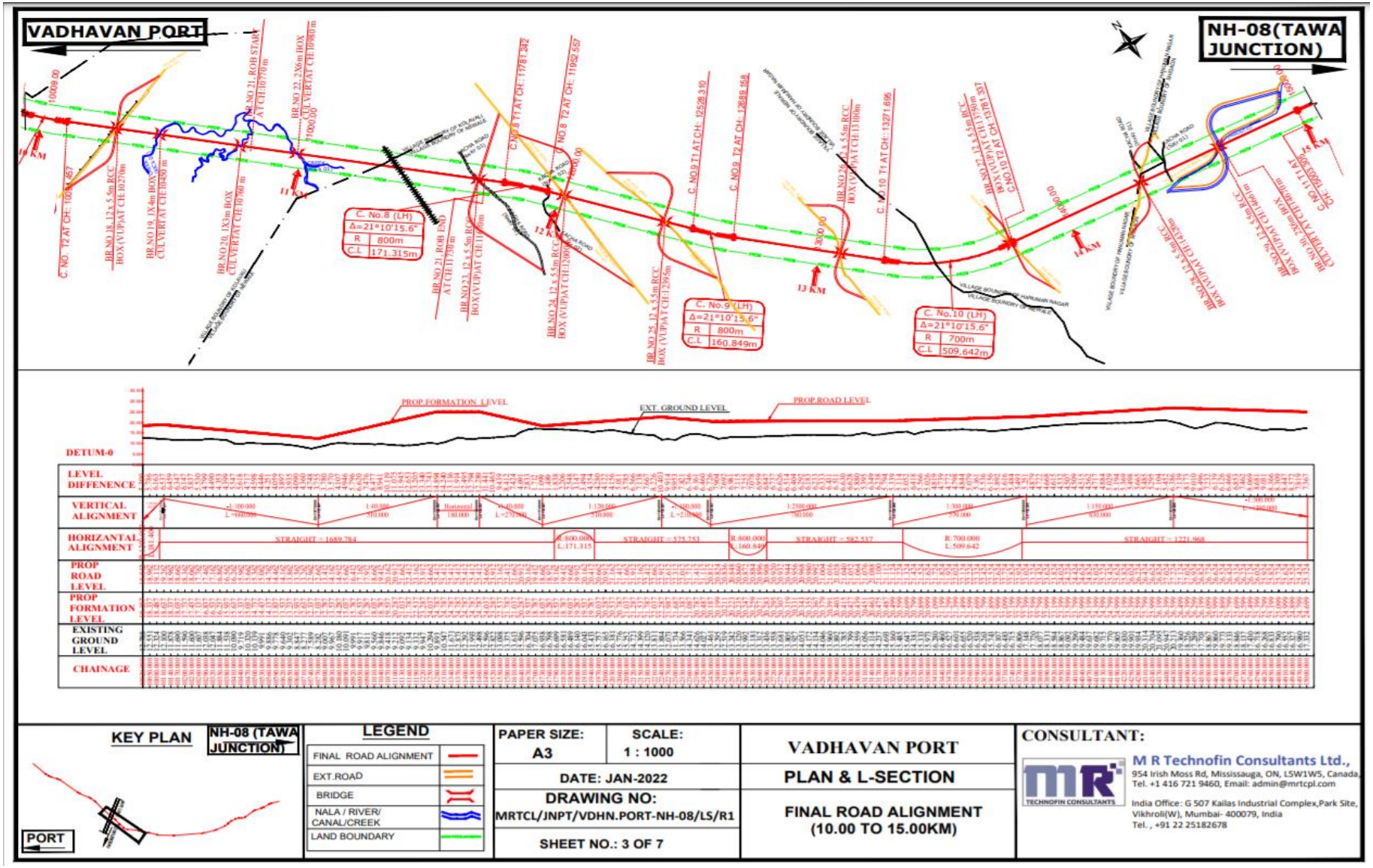


Figure 8-5 Plan & L-Section of 10-15 Km

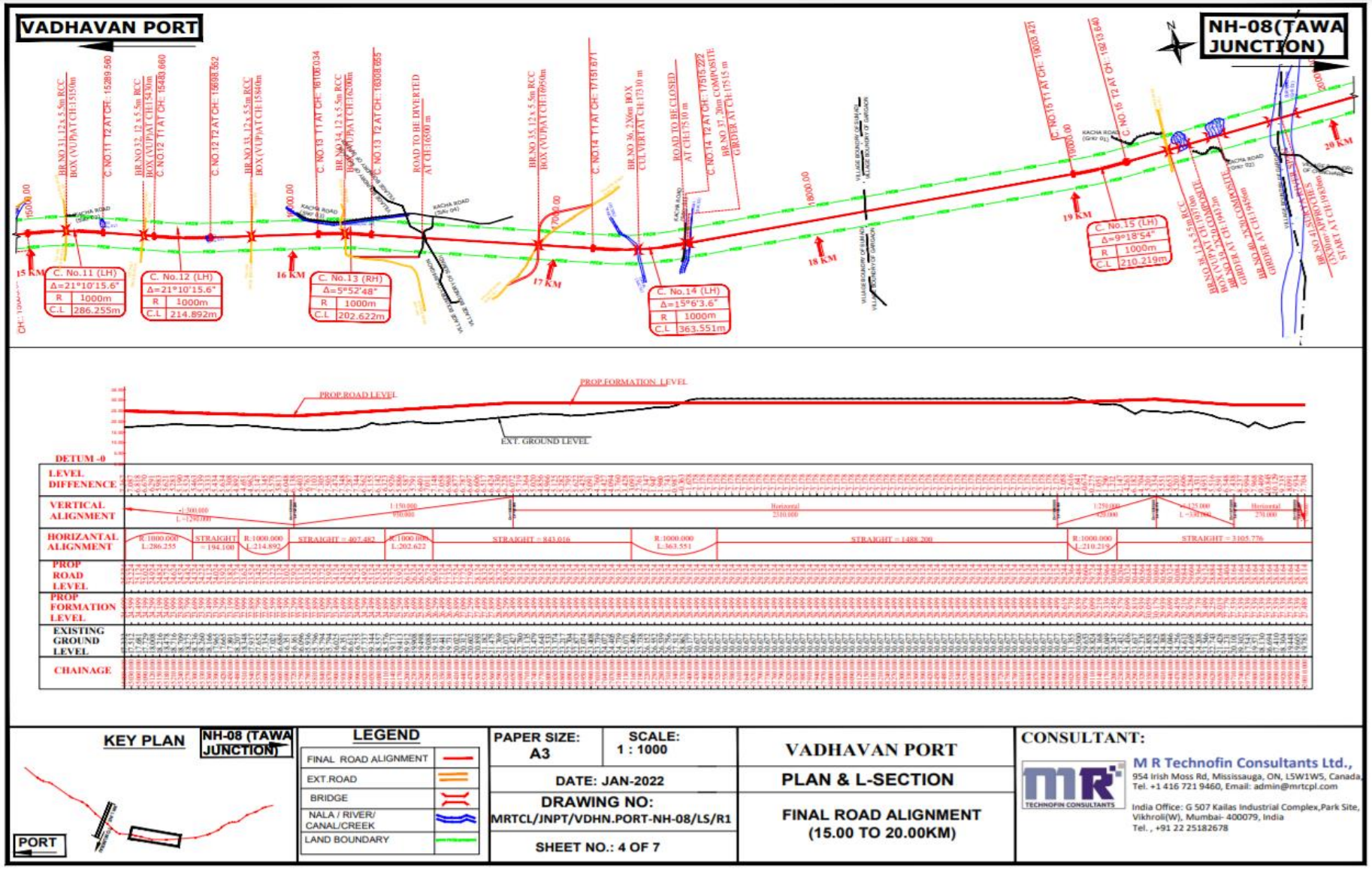


Figure 8-6 Plan & L-Section of 15-20 Km

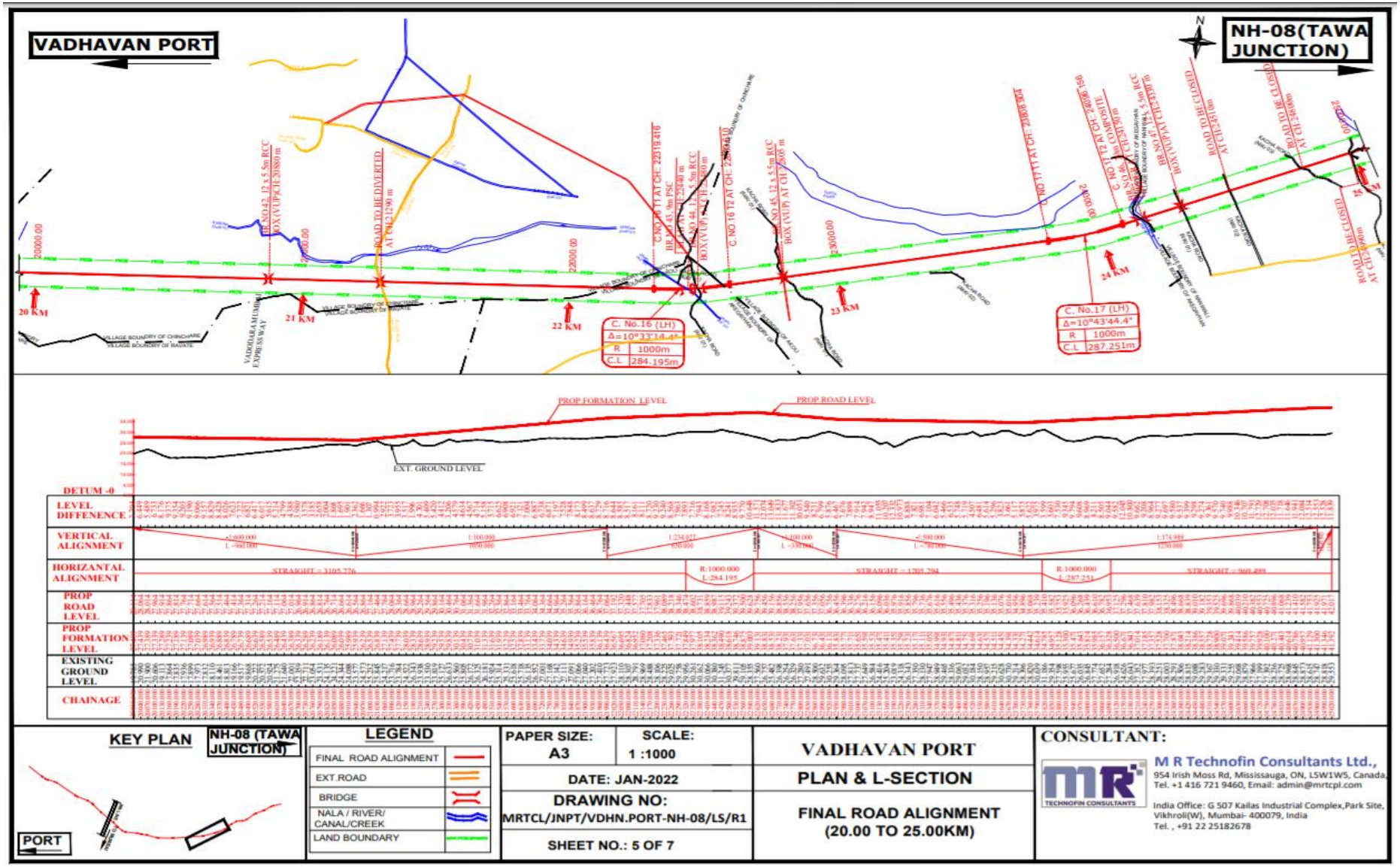


Figure 8-7 Plan & L-Section of 20-25 Km

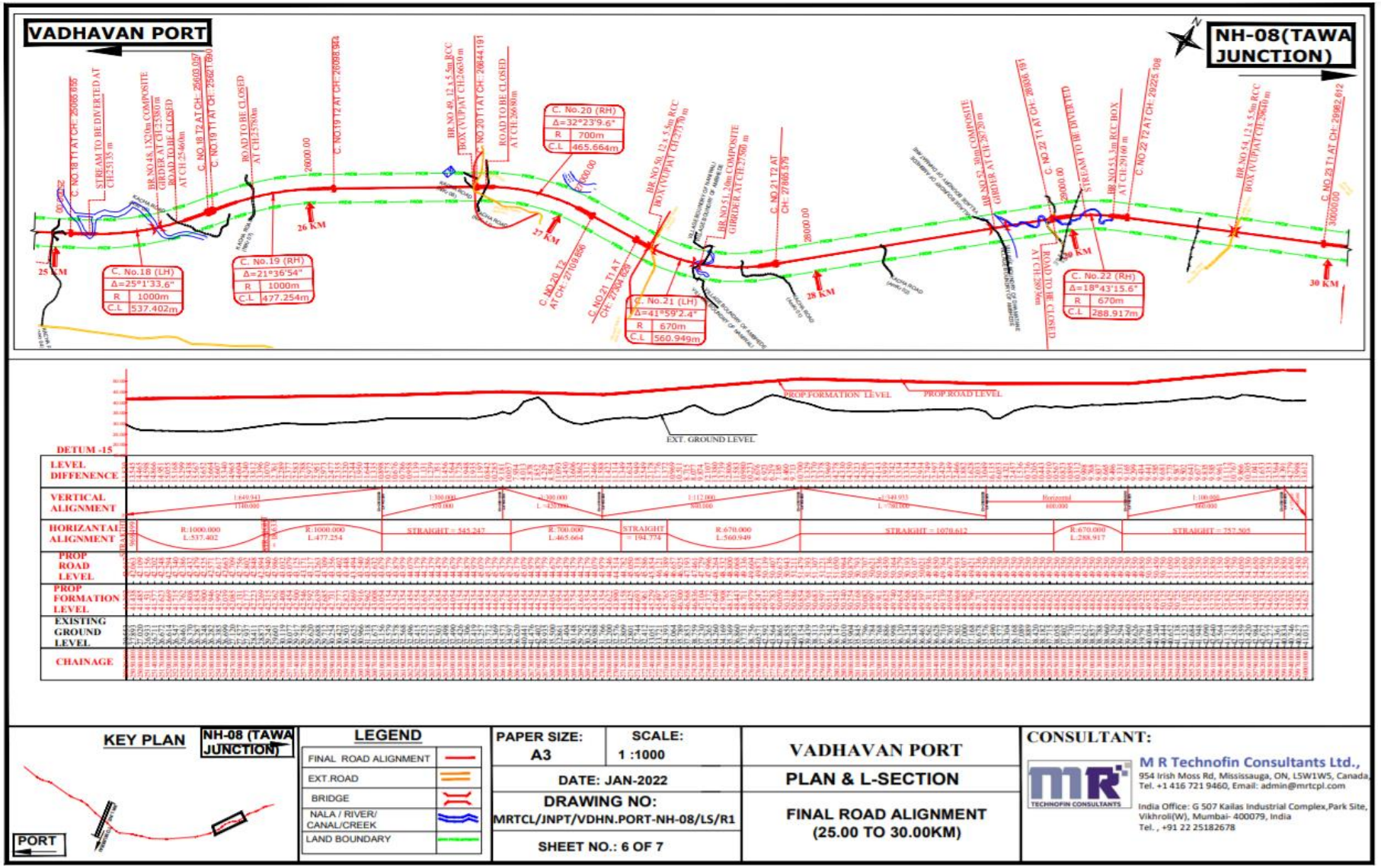


Figure 8-8 Plan & L-Section of 25-30 Km

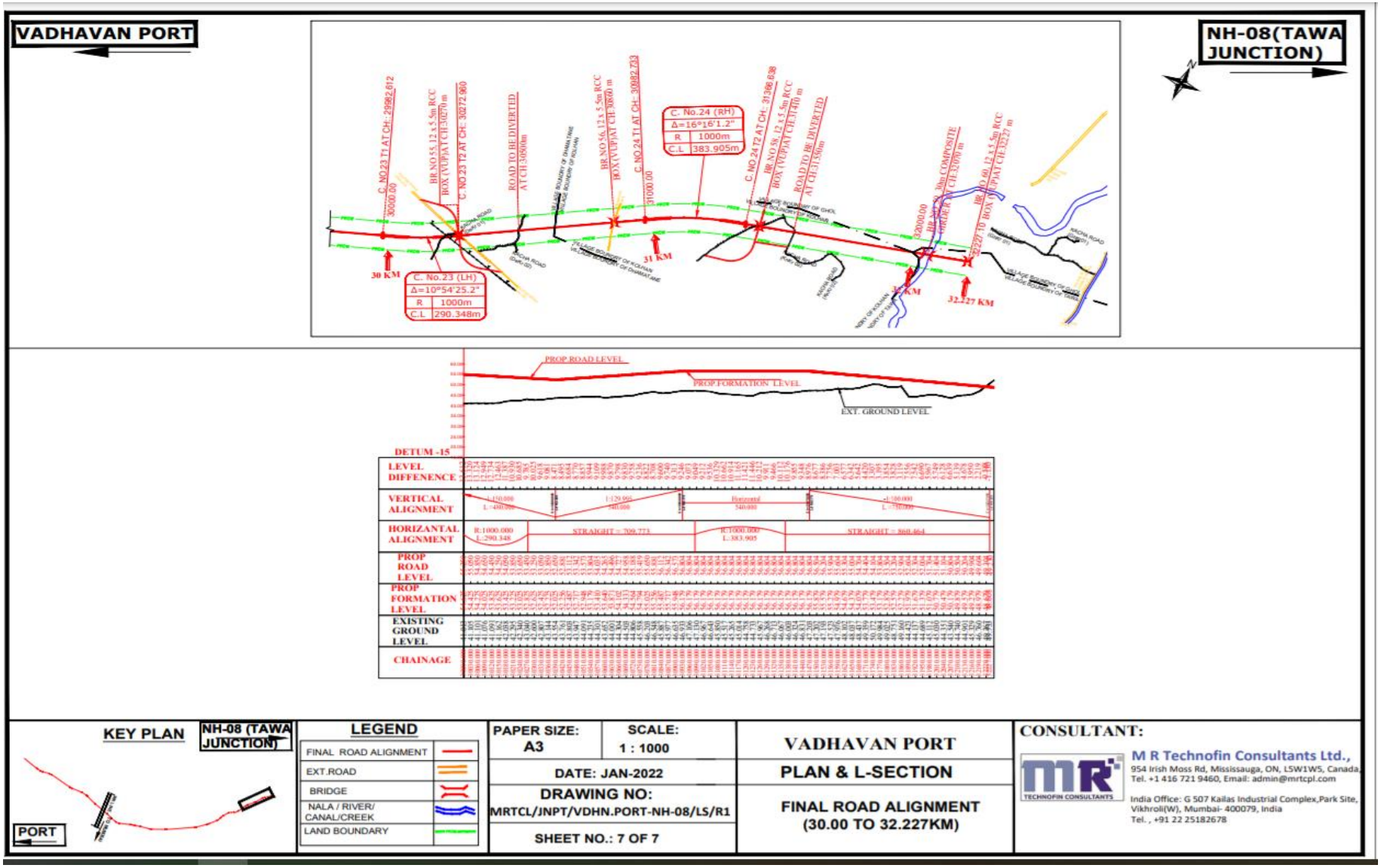


Figure 8-9 Plan & L-Section of 30-32.27 Km