

No. NH-12014/20/2024/TN/South-II (Part) (C. No. 267308)
Government of India
MINISTRY OF ROAD TRANSPORT & HIGHWAYS
(South Zone)
Transport Bhawan, 1, Parliament Street, New Delhi-110001.

Date: 22.04.2026

REPLY TO PRE BID QURIES

Subject: Construction of 4 Lane Bypass to Vellore Town starting from Km 47.400 of NH- 75 & ending at km 12.650 of NH-38 (Length 20.492 km) in the state of Tamil Nadu.

Tender ID : 2026_MoRTH_902456_1

S.NO	Section / Clause No./ Page No.	Original Clause in the Tender	Query/ Suggestion /Modification Requested by the Bidder	Reply
1.	RFP clause No.1.2.3 / Page No. 10	The complete Bidding Documents including the draft Agreement for the Project is enclosed for the Bidders. The Feasibility Report / Detailed Project Report prepared by the Authority/consultants of the Authority (the "Feasibility Report/Detailed Project Report") is also enclosed.	In the web site, the said Feasibility Report /Detailed Project Report" is found missing. Hence, we request you to provide the Feasibility Report/Detailed Project Report for our detailed study and assessment.	Copy of Feasibility Report /Detailed Project Report" is enclosed for reference purpose only. However, Bidders have to do their own assessment after site visit/inspection and quote their bid price accordingly.
2.	General	Land acquisition	Kindly provide the current status of land acquisition, including details of possession and availability of encumbrance-free land.	Rate determination per Sec. 3G of the NH Act 1956 has been completed for the area notified under Sec. 3D of the Act. Disbursement of compensation is presently in progress, and 90% of the land shall be made free from encumbrances on the Appointed Date.

3.	General	The estimated value put to tender is Rs. 498.14 Cr for a total length of 20.492 km (4-lane: 12.702 km, 6-lane: 7.790 km). Considering the quantum of works involved, the estimated value appears to be abnormally low.	Kindly confirm the year of the Schedule of Rates (SoR), Tamilnadu, that has been considered for the preparation of the cost estimate. Further, as per the Government of Tamil Nadu Gazette Notification dated 20.02.2025, an additional royalty/tax titled "Tax on mineral bearing land" at the rate of Rs. 45 per MT has been introduced. We request clarification on whether this has been accounted for in the cost estimate. If not, it is requested that the Estimated Value put to Tender shall be revised accordingly.	The cost estimate has been prepared based on Schedule of Rates (SOR) 2024-25, which came into effect from 15.07.2024 and does not account for subsequent changes in statutory taxes, royalties, or levies. The estimate is indicative and for guidance purposes only. Being an EPC contract, the Bidder shall be responsible for assessment of its cost as per local condition and local taxes and includes all applicable taxes, duties, royalties, and levies (except those expressly stated otherwise in the Contract Agreement) while quoting the Bid Price.
4.	Schedule-H/Item No.5/Electrical Utilities and Public Health Utilities(water pipe lines and sewage lines)	The estimated value of Rs. 498.14 Cr put to Tender includes Rs 6.63 Cr(@1.33% of 498.14 Cr.)	These relocation/shifting of utilities are to be executed in consultation with & under the supervision of the respective Departments in accordance with their specifications & Estimates approved duly by MoRTH. Hence, kindly furnish their approved Estimates along with the year of SoR/Tamil Nadu based on which they are prepared. If they are not prepared based on 2025-26 SoR, the	Shifting/relocation of utilities shall be carried out in coordination with the concerned utility agencies in accordance with their norms and applicable specifications. The utility shifting provisions included in the estimate are indicative. The Contractor shall be responsible assessment of cost and coordination, execution, and associated costs as per

			variation/price Escalation shall be paid/reimbursed in addition to the amount of Rs 6.63 Cr provided in the Bid.	the provisions of the Contract Agreement
5.		General	We hereby notify that the Government of Tamil Nadu levies the following taxes in addition to Royalty on Borrow earth/Gravel: 1. Tax on mineral bearing land at the rate of Rs. 45 per MT. 2. Cost of minerals at the rate of Rs. 50 per MT. You may please refer to the format of taxes charged by the Government of Tamil Nadu in royalty in one of our ongoing projects for reference. However, these two taxes have not been considered in the Schedule of Rates (SoR) of Tamil Nadu. Hence, we request you to confirm whether these taxes have been taken into account by MORTH in the current estimate put to tender or not.	The estimate has been prepared based on SOR 2024-25 and does not account for subsequent changes in statutory taxes, royalties, or levies. Being an EPC contract, the Contractor shall be responsible for assessment and inclusion of all applicable taxes, duties, royalties, and levies (except those expressly stated otherwise in the Contract Agreement) while quoting the Bid Price.

			(Please refer to Government of Tamil Nadu Gazette Notification dated 20-02-2025 (Annexure -1) & a proof for various Taxes/Royalties/Fees collected by GOTN for an ongoing project (Annexure - 2) are enclosed).	
6.		General	Taxes on stone aggregates: Kindly confirm whether the Tax on mineral bearing land at the rate of Rs. 90 per MT has been considered in the estimate put to tender or not. It is pertinent to mention that this tax is not included in the Schedule of Rates (SoR) for Tamil Nadu. (Please refer to the Government of Tamil Nadu Gazette Notification dated 20-02-2025 Annexure-1 enclosed)	As replied at Sl.No.5 above

7.		Schedule B / Clause 5.3 Design Requirements / Pavement Thickness / APPENDIX-B1/TYPICAL CROSS SECTION	Kindly clarify whether the contractors are allowed to modify the thickness of the pavement/thicknesses of different layers as per their own design, while maintaining the MSAs mentioned in the documents?	The pavement design shall be carried out by the Contractor in accordance with relevant IRC Codes, MoRTH Specifications, and provisions of Schedule-B / Clause 5.3 of the Contract Agreement. The design shall be subject to review by the Authority's Engineer.
8.		General	Request for Details of Approved stone quarries Kindly provide the details of the approved stone quarry locations identified for sourcing various aggregates (including GSB, WMM, stone aggregates for Concrete /Bituminous works), along with the corresponding lead/distances from the project road, which were considered while preparing the estimate.	Locations of material sources indicated in the estimate are for indicative purposes only. The Contractor shall make independent arrangements for sourcing all materials, including aggregates, earth, and other construction materials, and shall obtain all necessary approvals, clearances, and permits under applicable laws. No assurance is given by the Authority regarding availability, suitability, or lead distances of such sources. .

9.		General	Request for Details of Approved Borrow Areas for Earthwork Kindly provide the details of the approved borrow area locations identified for sourcing earth (including water bodies/irrigation tanks), along with the corresponding lead/distances from the project road, which were considered while preparing the estimate.	As replied at Sl.No.8 above
10		General	As a result of the ongoing geopolitical conflict between the United States/Israel and Iran, the prices of key construction materials including POL (Petroleum, Oil & Lubricants) and Bitumen-have witnessed a significant and volatile increase. The market conditions remain highly uncertain, with frequent fluctuations making it extremely difficult to reasonably assess and quote construction costs. In such a scenario, price indices are expected to play a critical and unpredictable role even	The contractor is required to quote rates based on prevailing market conditions. Further, the last date for submission of bids has been extended up to 07.05.2026.

			during the execution phase, thereby exposing contractors to substantial financial risk. In view of the above extraordinary circumstances, it is respectfully requested that the tender submission date be postponed by one month (27-05-2026) or until stabilization of the prevailing situation arising out of the ongoing conflict, whichever is later.	
11.	General	-	Extension of Timelines for Submission of Pre-Bid Queries and Bid Submission: 1. Extend the last date for submission of pre-bid queries by at least 10-15 days, and 2. Correspondingly extend the bid submission date by a minimum of 3-4 weeks thereafter, to enable comprehensive bid preparation.	The last date for submission of bid queries was extended up to 15.04.2026. and last date of bid submission has also been extended up to 07.05.2026
12.	General	-	Request the Authority to grant a minimum extension of 10 to 15 days for submission of pre-bid queries and, a corresponding extension of 10 to 15 days for submission of bids, in order to ensure adequate time for detailed examination of	As replied at Sl.No.11 above

			the tender documents and preparation of responsive and competitive bids.	
13.	RFP -NIT	-	Completion period is 24 months, whereas - 75% of the work is Structures oriented and spread across locations. Kindly clarify whether extension to 36 months will be considered.	As per RFP.
14.	Clause <u>8.2</u>		90% ROW (20.492 km x 50 m) to be provided on Appointed Date. Kindly provide status of land acquisition and details of pending stretches.	As replied at Sl.No.2 above.
15.	Schedule A/DCA	-	Annex 1V states Environmental clearances (EC) not required, whereas DCA 3.3 states EC shall be obtained before LOA. Kindly clarify which condition shall prevail.	Environmental clearances is not required.
16.	Schedule B-7.4.2	-	Design and construction of ROB to be as per Railway requirements. Kindly clarify roles of Authority and Authority Engineer, responsibility for approvals, and treatment of delays (EQT / sectional completion)	As per RFP and DCA
17.	Schedule B -13 Ccos		Length is approximate assessment and any variation in length is no COS - if Railway changes any dimensions during their evaluation, whether this will be considered as COS	As per RFP and DCA
18.	Appendix B1		Whenever the TCS changes from 2 and 3 to	Whenever the TCS changes from 2 and 3 to

			1 or vice versa, the service road is terminated and merged with MCW TCS 1. Service road vehicles can access MCW in these locations but it is mentioned that the project should be developed as an access-controlled highway. please clarify.	1 or vice versa, the service road is terminated and merged with MCW .
19.	Geotechnical Investigation		Please provide the geotechnical report of all the structures and RE wall locations. Please provide the hydrology report of bridge locations.	EPC contractor has to carryout geotechnical and hydrology investigation.
20.	Schedule B		Culverts: Clause 7.2.1 mentions that the overall width of the culverts shall be equal to the road way width. The road width in TCS 2,3,4 extends up to available ROW limit and in that case, land is not available for construction of culvert protection works. Please clarify whether additional land will be acquired for culvert protection work construction – Please Clarify	Culvert protection work will be constructed within proposed ROW only
21.	Schedule B		IS it allowed to alter the number of cells and spans in culverts and underpasses respectively?	As per Schedule-B
22.	Drawings		Please provide Railways approved GAD drawings, if any	Refer to tender document and DCA. .
23	Project facility – Lighting		Project facilities (vii): minimum number of lightings is provided . is	As per Schedule-C

			the contractor allowed to design the lighting arrangement as per SP 84 but below the minimum requirements mentioned in the agreement – Please Clarify	
24.	Schedule B		Clause 2 of Schedule B mentions provision of solar lighting. However, solar lighting is generally adopted only at junction locations, whereas conventional EB power supply is standard practice for highway stretches.	Lighting in the project stretch will be provided with conventional EB power. cost of power bill till end of DLP is to borne by the contractor
25.	Schedule C		Project facilities: it is mentioned that there is no provision for rest area, truck bay, bus bay in schedule C. However, in the notes it is mentioned that the changes in the number of these facilities will not constitute COS which is vague. Please clarify.	Please refer Schedule-C , No way side amenities has been proposed
26.	ROB Design		The tender specifies a bowstring girder for the 76 m span, whereas railways generally adopt a Backshoe girder for such spans. Kindly clarify whether to proceed with the bowstring girder or the Backshoe girder configuration.	As per RFP, DCA & Schedule-B subject to approval of GAD by the Railways.
27.	ROB Design		The tender specifies a composite steel girder for the 41 m span, whereas railways generally adopt a bowstring girder for	As per RFP, DCA & Schedule-B subject to approval of GAD by the Railways.

			such spans. Kindly clarify whether to proceed with the composite steel girder or the bowstring girder configuration	
28.	ROB		At ROB chainage 20+087, K value is given as 75, whereas the design speed is 100 kmph. Kindly confirm whether the profile indicated in the tender is to be followed.	Refer to DCA & Schedule-B and plan & profile
29.	Schedule H - stage of payments		A minimum quantity is furnished for billing. In Note (2) (a) (pre cast) - 90% can be paid is mentioned. How to apply this. Please explain.	payment will made as per Schedule H and Article 19 of DCA.

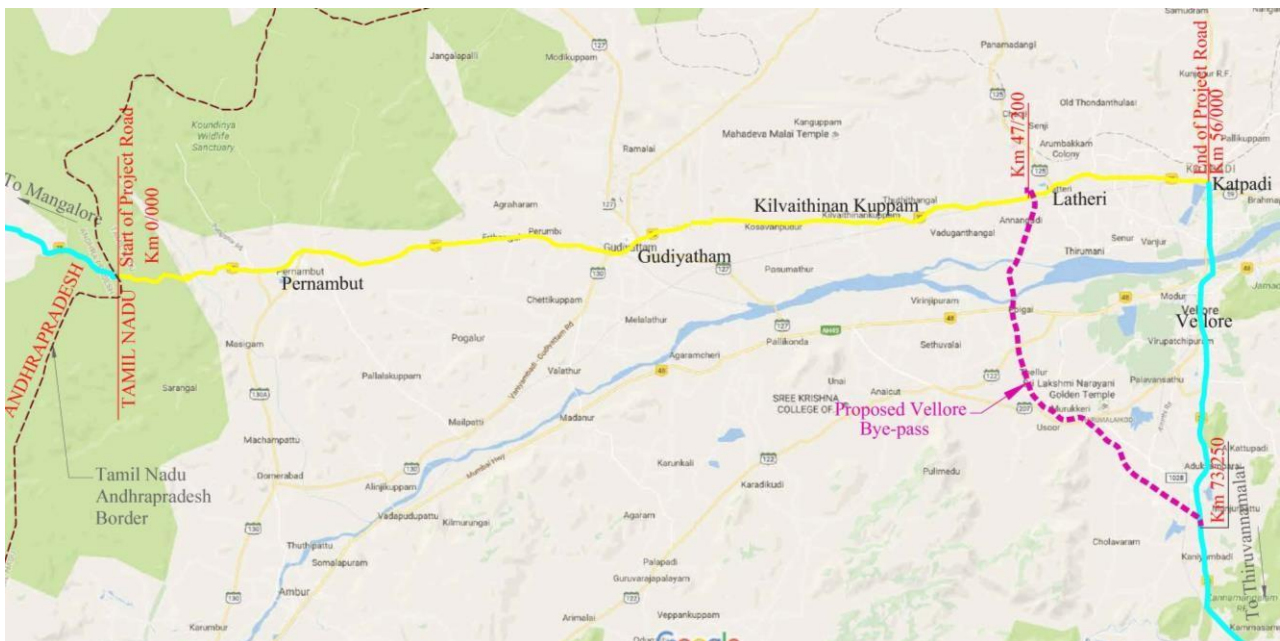
Note to all prospective Bidders: Based on the designs carried out during the feasibility study of proposed Project, all the project relevant factors have been taken into account and accordingly the scope has been well defined in the bidding documents. However, at the same time, bidders are expected to make their own assessment based on sound engineering principles/practices while bidding, keeping in view that detailed designing of the project is the responsibility of the EPC Contractor.



**MINISTRY OF ROAD TRANSPORT & HIGHWAYS
NATIONAL HIGHWAYS CHENNAI CIRCLE
VELLORE DIVISION**

FEASIBILITY REPORT

Construction of 4 lane Bypass to Vellore Town starting from km 47/400 of NH75 (NH-234) & Ending at Km 12/650 of NH38 (km 73/250 NH- 234) (Length 20.492 km) in the State of Tamil Nadu



VELLORE BYPASS MAIN REPORT

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EXECUTIVE SUMMARY

1 Project Background

Transport in the Republic of India is an important part of the nation's economy. Development of infrastructure within the country has progressed at a rapid pace, and today there is a wide variety of modes of transport by land, water and air.

The State of Tamil Nadu is situated in the South-Eastern part of India. The state has many distinctions by way of high literacy, promotion of family planning, industrialisation, and agricultural development. The state has a transportation network consisting of railways, roadways, and airways, which form the lifeline for the economic and social activities of the state. Road transport is a dominant mode in the State for the transport of goods and for the movement of passengers.

The Nation Highway (NH-234) is entirely falls within the state of Karnataka, Andhra Pradesh and Tamil Nadu. It links the Mangalore, Karnataka state to the Villupuram, Tamil Nadu state. It covers the distance of 780km. In which, it covers 509 km in Karnataka, 23 km in Andhra Pradesh and 234 km in Tamil Nadu State.

It Passes through the various town, such as Mangalore, Belthangady, Huliya, Sira, Chintamani, Venkatagirikota, Gudiyatham, Katpadi, Vellore, Thiruvannamalai and Villuppuram.

Now, Government of Tamil Nadu, National Highways, Chennai Circle desired to Construction of 4 lane Bypass to Vellore Town starting from km 47/400 of NH75 & Ending at Km 12/650 of NH38 (Length 20.942 km) in the State of Tamil Nadu.

2 Objectives

The objective of this consultancy is to undertake feasibility studies and prepare a Detailed Project Report of the Project Highway for the purpose of firming up the Authority's requirements in respect of development and construction of the Project Highway and Project Facilities and enabling the prospective bidders to assess the Authority's requirements in a clear and predictable manner with a view to ensuring:

- 1) Enhanced safety and level of service for the road users;
- 2) Superior operation and maintenance enabling enhanced operational efficiency of the Project Highway;

- 3) Minimal adverse impact on the local population and road users due to road construction;
- 4) Minimal adverse impact on environment;
- 5) Minimal additional acquisition of land; and
- 6) Phased development of the Project Highway for improving its financial viability consistent with the need to minimize frequent inconvenience to traffic that may be caused if additional works are undertaken within a period of seven years from the commencement of construction of the Project Highway.

3 Project Description

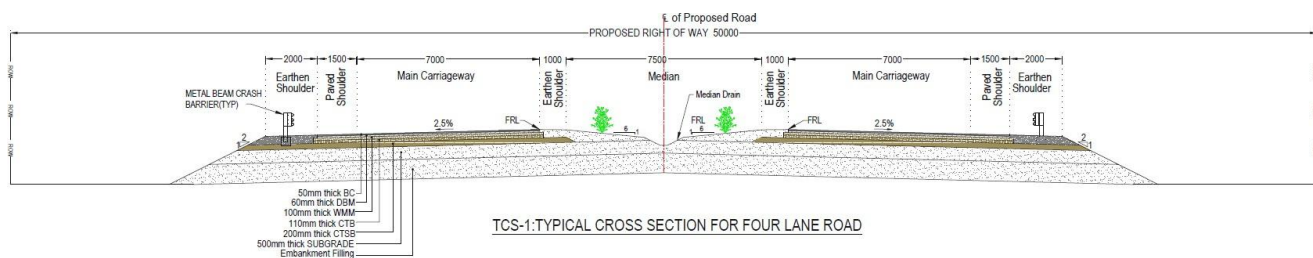
Vellore Bypass:

The approved alignment of Vellore Bypass alignment starts at the Mangalore - Villupuram Road (at km 47/200 of NH-234), crosses the railway track between (Latheri & Virinchipuram station) crosses the Palar River and then reach NH-48 (Krishnagiri – Ranipet Road) at km 109/750 near poigai. Then alignment crosses the SH-122 at km 1/800 near Poigai mottur village, crosses the ODR-97 near Sekkanur, reaches the MDR -1028 (Nelvoy Pallikonda Road) at km 7/000, travels in existing road for the length 3200m, it takes right and runs parallel to the existing road to cross the railway track between (Pennathur to Kaniyambadi station) and then reaches the NH-234 at km 73/250. The total length of proposed bypass is 20.85 km. The proposed alignment avoids the reserved forest.

The alignment passes through 13 nos. of villages such as Thirumani, Annankudi, Chozhamur, Kothamangalam, Poigai, Puthur, Thellur, Budur, Sekkanur, Ariyur, Pennathur, Sattumadurai and Nelvay.

4 Cross Section

The proposed bypass is designed as a four lane with paved shoulder carriageway (Access Control) with provision for Six lane in future.



5 Surveys and Investigation

Various engineering surveys and investigations were carried out as per TOR on the project corridor. These includes topographical survey, road and structural inventory/ condition survey and pavement investigation on the existing road sections which will be part of proposed bypass road, sub-grade soil investigation, etc.

6 Detailed Design

The project road components are designed as an partially access controlled road, as per the parameters recommended in the relevant standards of the Indian Roads Congress (IRC) and MoRTH circulars, based on the findings of field surveys and investigations. The ruling design speed of 100 kmph is considered in the project except at few locations where the minimum design speed of 80 kmph is considered due to site constrains.

7 Pavement

The pavement is designed for a life of 20 years. As per clause 5.4.1, IRC:SP:84-2019, design traffic for main carriageway designed for 90 MSA. The design traffic for service road is 20 MSA.

Proposed Pavement Composition for New Formation

Bypass	Section	Design MSA	Design CBR	Pavement Layer Thickness (mm)					Total (mm)
				BC	DBM	WMM	CTB	CTSB	
Vellore Bypass	Entire Length	90	10%	50	60	100	110	200	520

Proposed Pavement Composition for Service Road

Bypass	Section	Design MSA	Design CBR	Pavement Layer Thickness (mm)				Total (mm)
				BC	WMM (ALL)	CTB	CTSB	
Vellore Bypass	Entire Length	20	10%	50	100	110	200	460

8 Bridges and Culverts

The proposed Bypass starts at NH234 @ km 47+200, where Roundabout cum Grade separator is proposed with 17.5m (Existing NH Portion) & 29.5m wide in Bypass Portion overall width includes median, crash barrier & dual Two lane Carriageway, then crosses National Highways (NH-48) at Ch. 6+490, where another Grade Separator is proposed and state Highway (SH-122) & SH-207, where Vehicular underpass is proposed with 29.5m overall width. There are two Railway level crossings at Ch. 0+592 and Ch.20+085, where Six lane ROB is proposed respectively.

The proposed bypass crosses Palar River at Ch. 4+002 & Ch.5+404, where Major High-level Bridge is proposed. There are 5 Nos. of minor bridges & 47 Nos. of Culverts is proposed, where the river/stream crossing locations of alignment.

9 Junction Improvements

The Vellore bypass has 2 Nos. of Grade Separator at Start of Vellore Bypass & NH-48 crossing, 3 no. VUP @ SH-122, SH-207 & MDR-1028, 2 Nos of VUP @ Ch 11+015 & Ch. 18+000 and also Major At-grade Junctions (Merge with End of Vellore Bypass).

10 Project Facilities

The project facilities including through out service roads etc are proposed as per the standards. The project road is designed as access controlled road due to its high-speed traffic movement.

As the project road is like a bypass/ring road, no other wayside amenities like truck-layby, rest area, etc are proposed. Closed Tolling (Toll Plaza on Start and End and 2 locations for Lateral Entry) for the functional of fully Access Control.

11 Cost Estimate

Detailed cost estimate have been worked out based on Rate Analysis /Current Schedule of Rates (2024-25) / Local Market rates and latest data approved by MoSRT&H. Total Civil Construction Cost is Rs. 498.14 Cr.

12 Environmental and Social Screening

Environmental and social screening was conducted along the project alignment. Environmental screening indicates that there are no major environmental concerns in construction of the project road. Land acquisition is required for the project. Hence the

project will have social impact in terms of loss of livelihood or shelter for which suitable mitigation plan should be prepared.

13 Economic Analysis

The economic analysis of the project road has been carried out through HDM 4 -Version 1.3 which allows accessing the physical, functional and economic feasibility of the specified project alternative by comparing against a base case or a 'without project' alternative. From the analysis, it has been observed that with only VOC and travel time saving the EIRR value works out to be 20.55% for Vellore Bypass.

Development of educational, health and commercial/ industrial activities around the corridor is anticipated. Considering the above and other social and development benefits, the project may be considered to be viable.

14 Financial Analysis

It is clear from the results of the Financial options shows that the project is financially viable in Hybrid Annuity Mode. Therefore, the project is not financially viable in BOT. If government planned to execute this project as a socioeconomic importance, the implementation shall be EPC/HAM mode is recommended.

15 Conclusion and Recommendations

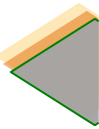
The project corridor will be an important transport corridor and provide better connectivity around Vellore Town. This road will provide connectivity from all the radial roads in turn provide efficient commercial transportation. Hence forming bypass is essential.

Cost of the project is very high due to its configuration and extent of land acquisition. The project is Economic viability in terms of running cost and also provide connectivity from all the radial roads in turn provide efficient commercial transportation and also Economic development all along the project corridor. Hence forming bypass is essential.

Implementation of the project can be taken up after acquiring the land and R&R works. Project required shifting of existing utilities, so continuous interaction among the implementing authority, contractor and various utility departments would be necessary during construction period.

CHAPTER - 1

OVERVIEW OF NH



CHAPTER 1

OVERVIEW OF NATIONAL HIGHWAYS, GOTN

1.1 National Highways, GOTN, Establishment

Government of Tamil Nadu has the unique distinction of creating a separate Highways Department as early as in 1946 exclusively to attend to roads and bridges in the State. Tamil Nadu was the forerunner in bringing out standard specifications for the roads and bridges in the year 1954. The objectives of the department are to maintain and improve the roads under the control of the Government, and to provide all weather road connectivity to rural habitations. A new post of Secretary to Government, Highways Department came into being in 1996. Minor Ports were later brought under the purview of this Department. Subsequently, this Department was renamed as Highways and Minor Ports Department.

The National Highway roads serve as through corridors for the movement of people and freight across State capitals, major ports, industrial areas and connects to popular tourist destinations of the nation. These roads are therefore subjected to heavy traffic intensity. The length of National Highways in the State of Tamil Nadu is 4994 km out of which 1985 km are maintained by National Highways wing and the balance 3009 km are maintained by the National Highways Authority of India (NHAI). The Tamil Nadu National Highways wing is headed by Chief Engineer who administratively controls four circles and eight divisions.

1.2 Vision

“The vision of the Highways Department is to increase the capacity, connectivity, efficiency and safety of the Highways System so as to enable balanced socio-economic development of all sections of the people and all regions of the state.”

1.3 Functions

National Highways Development comprises plan works and maintenance of roads and bridges on National Highways.

Nation Highways:

- NH (Original) works
- Periodical Renewal (PR)/ Improvement of Riding Quality programme (IRQP) works

Centrally Sponsored Scheme works:

- Revamped Central Road Fund Scheme (RCRF).
- Inter State Connectivity Scheme (ISC)
- Economic Importance scheme works.
- Western Ghats Development Programme works

- Hill Area Development Programme works
- Rehabilitation of Bridges / Culverts
- Setu Bharatam - Construction of ROB/RUBS in lieu of Level Crossings on NHs.
- Pradhan Mantri Gram Sadak Yojana (PMGSY).

1.4 Finance Mechanisms

Nation Highways:

The National Highways works comprises of Original and Maintenance works which are exclusively funded by the Ministry of Road Transport and Highways (MoRT&H), Government of India.

Centrally Sponsored Schemes:

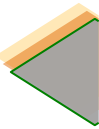
The Government of India with the accruals from 50% cess levied on the consumption of High Speed Diesel and entire 100% cess on Petrol, formulated the Central Road Fund. Out of this, 30% of the amount is allocated annually for development and maintenance of State roads under Revamped Central Road Fund/ Economic Importance/ Inter State Connectivity Schemes.

Pradhan Mantri Gram Sadak Yojana (PMGSY)

The PMGSY / Bharat Nirman Programme was launched by Ministry of Rural Development with the funds from the accruals of 50% cess levied on High Speed Diesel to provide road connectivity to the unconnected habitations of rural India and upgradation of existing rural roads. Out of this, upgradation of Other District Roads which have been included in the Core Network are being executed by the National Highways wing.

CHAPTER - 2

PROJECT DESCRIPTION



CHAPTER 2

PROJECT DESCRIPTION

2.1 General

Transport in the Republic of India is an important part of the nation's economy. Development of infrastructure within the country has progressed at a rapid pace, and today there is a wide variety of modes of transport by land, water and air.

The State of Tamil Nadu is situated in the South-Eastern part of India. The state has many distinctions by way of high literacy, promotion of family planning, industrialisation, and agricultural development. The state has a transportation network consisting of railways, roadways, and airways, which form the lifeline for the economic and social activities of the state. Road transport is a dominant mode in the State for the transport of goods and for the movement of passengers.

The Nation Highway (NH-234) is entirely falls within the state of Karnataka, Andhra Pradesh and Tamil Nadu. It links the Mangalore, Karnataka state to the Villupuram, Tamil Nadu state. It covers the distance of 780km. In which, it covers 509 km in Karnataka, 23 km in Andhra Pradesh and 234 km in Tamil Nadu State.

It Passes through the various town, such as Mangalore, Belthangady, Huliya, Sira, Chintamani, Venkatagirikota, Gudiyatham, Katpadi, Vellore, Thiruvannamalai and Villuppuram.

Now, Government of Tamil Nadu, National Highways, Chennai Circle desired to widening and forming the paved shoulder from km 0/0 (Tamil Nadu/Andhra Pradesh Border) to km 56/0 (Katpadi) including the formation of Gudiyatham & Vellore Bypass. In this connection, Superintending Engineer, National Highways, Chennai Circle appointed M/s. CMEC-Megastar (JV), to prepare the DPR for Providing Paved Shoulders in km 0/0 to km 56/0 of NH-234 including Vellore and Gudiyatham Bypasses.

2.2 Objective and Scope of Services

The objective of this consultancy is to undertake feasibility studies and prepare a Detailed Project Report of the Project Highway for the purpose of firming up the Authority's requirements in respect of development and construction of the Project Highway and Project Facilities and enabling the prospective bidders to assess the Authority's requirements in a clear and predictable manner with a view to ensuring:

- 1) Enhanced safety and level of service for the road users;
- 2) Superior operation and maintenance enabling enhanced operational efficiency of the Project Highway;
- 3) Minimal adverse impact on the local population and road users due to road construction;
- 4) Minimal adverse impact on environment;
- 5) Minimal additional acquisition of land; and
- 6) Phased development of the Project Highway for improving its financial viability consistent with the need to minimise frequent inconvenience to traffic that may be caused if additional works are undertaken within a period of seven years from the commencement of construction of the Project Highway.

2.3 Scope of Services

The scope of consultancy services would demand a very high level of professional competence with optimal approach to meet all the objectives stated above as it would require review of all available studies, data, records, information, interaction with concerned agencies and identification of constraints besides carrying out necessary surveys. The scope of work of the consultants includes but is not limited to the following:

- a) Traffic surveys and demand assessment
- b) Engineering surveys and investigations
- c) Location and layout of toll plazas
- d) Location and layout of truck lay-byes
- e) Location and layout of bus bays and bus shelters
- f) Social impact assessment
- g) Environment impact assessment
- h) Preparation of designs for road (Embankment/Pavement/Geometric Design/Protective works/Drainage/PUPs/VUPs/cattle passes etc.,)
- i) Preparation of designs for Cross Drainage works (Major/Minor bridges, culverts) and their components.
- j) Preparation of Land Plan Schedules and Utility Relocation Plans
- k) Preparation of BOQ and Cost Estimates
- l) Final Detailed Project Report and final drawings.
- m) Preparation of Schedules required for the Concession Agreement.

2.4 Project Road

Feasibility of that bypass alignment shall be evaluated based on the site condition. Various options for the proposed alignment of Vellore bypass shall be studied are illustrated below,

2.4.1 Vellore Bypass

Vellore is an important city, which is the headquarters of vellore district located around 140 kms from the State capital. Two National Highways NH-48 (Krishnagiri - Ranipet) and NH-234 (Mangalore – Villupuram) are running perpendicular to the city. Two State highways, SH-207 (Vellore – Usoor) and SH-83 (Vellore – Chittoor) is originating from the city.

Due to rapid improvements of Tourism, Education Institutions etc, in and around the vellore city, attracting larger number of people to the city, thereby increasing the traffic congestion along the NH-234.

The NH-234 passes through heavily built up town portion of vellore corporation having narrow ROW, which leads to congestion in the town limit. The traffic from Villupuram side & Mangalore side crossing the vellore town, which takes nearly 50-75 minutes during peak hours. Hence, future traffic determination and also consider the social impact of vellore town, the bypass is proposed.

Alignment Options:

There are three alignment options proposed for vellore bypass and their alignment plan is given in **Fig. 2.2**. The comparison of Vellore bypass options in technical/engineering aspect is given in **Table -2.3**.

Option -1: (Cyan Colour)

The proposed option-1 (shows in cyan Colour) vellore bypass starts at the Mangalore - Villupuram Road (at km 50/200 of NH-234) in latheri and cross the railway track between (Katpadi & Latheri station) and then cross the Palar river and then reach NH-48 (Krishnagiri – Ranipet Road) at km 109/750 near Poigai. Then alignment cross the SH-122 at km 1/850 near Poigai mattur village and cross the ODR-97 at km 1/900 near Jamalpuram and then cross the SH-207 (Vellore –Anaicut Road) at km 7/900 near Thirumalaikodi and then travel in MDR-1028 (Nelvoy Pallikonda Road) for the length of 2.4km and then take right run parallel to the existing road to cross the railway track between (Pennathur to Kaniyambadi station) and then reach the NH-234 at km 72/800 near Residential area. The total length of proposed bypass is 21.5 km. The proposed alignment avoids the reserved forest. The

alignment passes through villages such as latteri, Ramapuram, Poigai, Jamalpuram, kuppam, Thirumalaikodi, sripuram, kattuputhur & Allivaram.

Option -2: (Red Colour)

The proposed option-2 (shows in Red Colour) vellore bypass starts at the Mangalore - Villupuram Road (at km 47/800 of NH-234) in latteri and cross the railway track between (Latheri & Virinchipuram station) and then cross the Palar river and then reach NH-48 (Krishnagiri – Ranipet Road) at km 110/000 near poigai. Then alignment cross the SH-122 at km 1/800 near Poigai mattur village and cross the ODR-97 at km 1/900 near Jamalpuram and then cross the SH-207 (Vellore –Anaicut Road) at km 7/900 near Thirumalaikodi and then travel in MDR-1028 (Nelvoy Pallikonda Road) for the length of 3.2km and then take left for bypass of Pennathur village and then travel in MDR -1028 for the length of 1.4km to cross the railway track (existing Level crossing no. 117) between (Pennathur to Kaniyambadi station) and then reach the NH-234 at km 72/400. The total length of proposed bypass is 19.6 km. The proposed alignment avoids the reserved forest. The alignment passes through villages such as latteri, Ramapuram, poigai, Jamalpuram, kuppam, Thirumalaikodi, Sripuram & Pennathur.

Option -3: (Magenta Colour)

The proposed option-3 (shows in Magenta Colour) Vellore Bypass alignment starts at the Mangalore - Villupuram Road (at km 47/200 of NH-234), crosses the railway track between (Latheri & Virinchipuram station) crosses the Palar River and then reach NH-48 (Krishnagiri – Ranipet Road) at km 109/750 near poigai. Then alignment crosses the SH-122 at km 1/800 near Poigai mottur village, crosses the ODR-97 near Sekkanur, reaches the MDR -1028 (Nelvoy Pallikonda Road) at km 7/000, travels in existing road for the length 3200m, it takes right and runs parallel to the existing road to cross the railway track between (Pennathur to Kaniyambadi station) and then reaches the NH-234 at km 73/250. The total length of proposed bypass is 20.85 km. The proposed alignment avoids the reserved forest.

The alignment passes through 13 nos. of villages such as Thirumani, Annankudi, Chozhamur, Kothamangalam, Poigai, Puthur, Thellur, Budur, Sekkanur, Ariyur, Pennathur, Sattumadurai and Nelvay.

Table 2.1 Comparison of Vellore Bypass Options

Sl No	Description	Option - 1	Option - 2	Option - 3
1	Length	21.50 km	19.60 km	20.85 km
	i) New Alignment	19.30 km	15.20 km	17.50 km
	ii) Improvement of existing roads	2.20 km	4.40 km	3.20 km
2	Major Structures	7	8	7
3	Proposed ROW	45m	45m	45m
4	Tentative Land Acquisition	102 Ha (Wet-43Ha, Dry-52Ha, Others-7Ha)	95 Ha (Wet-42Ha, Dry-44Ha, Others-9Ha)	99 Ha (Wet-48Ha, Dry-43Ha, Others-9Ha)
5	Tentative LA Cost	151 Cr	162 Cr	143 Cr
6	Tentative Construction Cost (2-Lane with PS)	212 Cr	203 Cr	208 Cr
7	Economic Internal Rate of Return (20 Years) for Through Traffic	18.35%	20.16%	21.52%
8	Merits	Feasibility to form Ring Road	1) Length of Proposal is around 1.9 km less than TNHD proposal 2) Existing Level Crossing No. 117 (km 141/500-600) is converted to ROB	1) Avoids the Sri Lakshmi Narayani Golden Temple Open Land by travel in Existing MDR-1028 for length 0.9km.
9	De-merits	1) Alignment also falls in approach of Poigai VUP in NH-48 @ km 109/750 2) It also travel in Sri Lakshmi Narayani Golden Temple Open Land (it cause Social Impact issues during LA process) 3) Alignment falls in settlement and habitation.	1) Forming Ring Road of Vellore Town requires to travel in NH-234 for the length of 1.2km in Latheri Town 2) Only Possible to acquire lesser ROW upto 10m in Existing Road (MDR-1028) for 1.5km on both sides in End of Alignment (Existing Road ROW 20-24m) Major Social Impact will occurs.	1) Forming Ring Road of Vellore Town requires to travel in NH-234 for the length of 1.6km in Latheri Town

Final Approved Alignment

The final alignment is selected from these possible above said alternatives. The Ministry has suggested to adopt the (Option -3 shown in Magenta Colour) Vellore Bypass alignment vide letter No. RW/NH-12014/102/2015-TN (P-7).

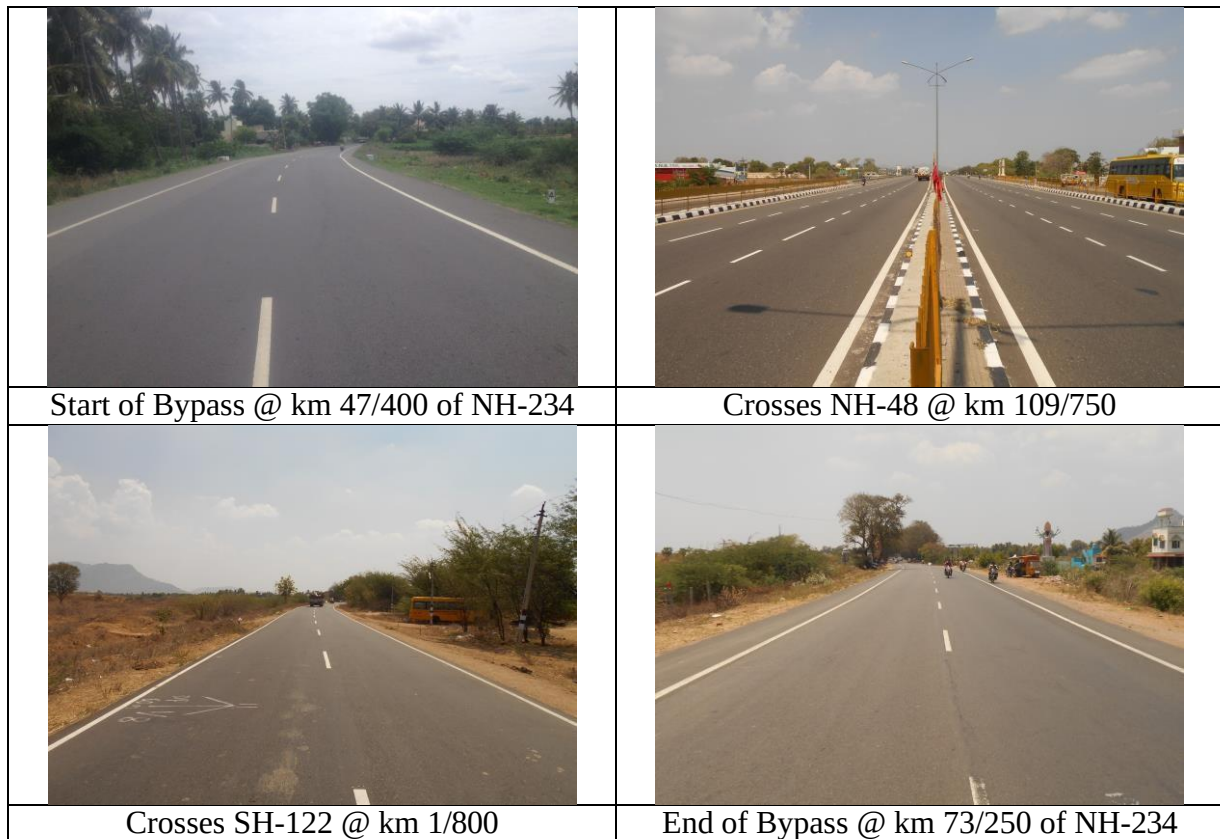


Fig. 2.1 Alignment Plan for Vellore Bypass

2.5 Structure of the Report

As per the ToR, following reports are submitted in this Feasibility Report.

Volume - I	Main Report
Volume - II	Drawing Volume
Volume - III	Technical Specifications
Volume – IV	Rate Analysis
Volume - V	Cost Estimate
Volume - VI	Bill of Quantities

This Main Report (Volume I) contains the following chapters and the Annexures are given as separate booklet.

- Chapter 1:** Overview of National Highways, GOTN
- Chapter 2:** The present chapter gives the brief of the project and presents the scope of the study and the structure of the report.
- Chapter 3:** Discuss about Social-Economic profile of the project influence area
- Chapter 4:** Deals with the Methodology adopted for the study
- Chapter 5:** Discusses about the various traffic surveys carried out and their analysis and also about the demand forecasting and projection as per the observed traffic growth rate.
- Chapter 6:** Elaborates about the design Standards
- Chapter 7:** Elaborates detailed design and brief note about improvement proposals
- Chapter 8:** Elaborates Environmental Screening & Preliminary Assessment
- Chapter 9:** Elaborates Social Assessment & Preliminary Land Acquisition & Re-settlement Action Plan
- Chapter 10:** Elaborates the project cost estimates
- Chapter 11:** Deals with the Economic Analysis of project Road
- Chapter 12:** Deals with the Financial Analysis of project Road
- Chapter 13:** Conclusion & Recommendation



Government of India
Ministry of Road Transport & Highways

Transport Bhawan, 1, Parliament Street,
New Delhi-110001.

No. RW/NH-12014/102/2015-TN(P-7)

New Delhi, the 31st July, 2017

To,

Chief Engineer,
National Highways,
Gundiy,
Chennai-600025

Sub: DPR for providing paved shoulder from km 0/0-56/0 of NH 234 including Vellore & Gudiyatham bypass in Tamilnadu – Approval of alignment reg.

Ref: Letter no. 7082/Sa3/NH/2015, dated 12.5.2017 & 17/7/2017

Sir,

Please refer to your letters cited above forwarding therewith alignment plan of existing stretch from km 0/0-56/0 of NH 234 including alternative alignment plan of Vellore & Gudiyatham bypass in Tamilnadu for approval.

2. Based on various merit & de-merits of different alternatives, presentation made in Ministry and as recommended by the State PWD, the Competent Authority has approved Alignment-II (Magenta Colour) of Gudiyatham bypass & modified Alignment-III (Magenta Colour) of Vellore bypass on NH 234 in Tamil Nadu.

3. As discuss in the presentation it is request to submit widening including 1.5 paved shoulder proposal in km 0/0-56/0 except Vellore & Gudiyatham bypass stretches as standalone project without land acquisition.

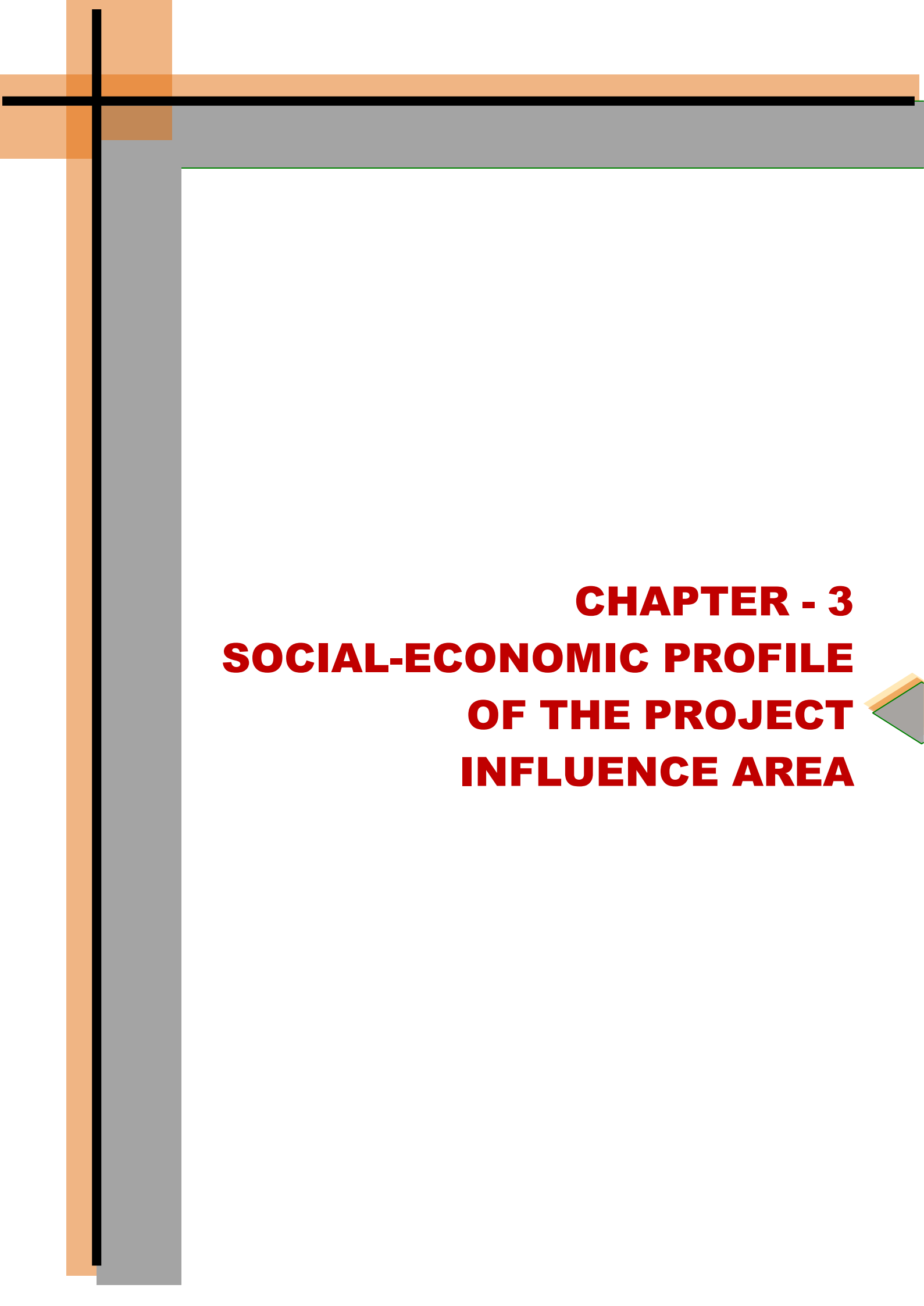
(Jitendra Kumar Meena)
Graduate Engineer (P-7)

For Director General (RD) & Spl. Secretary

Copy to Regional Officer, MoRT&H, C-I-A, Rajaji Bhawan, Besant Nagar, Chennai-600009-for kind information.

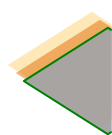
(Jitendra Kumar Meena)
Graduate Engineer (P-7)

For Director General (RD) & Spl. Secretary



CHAPTER - 3

SOCIAL-ECONOMIC PROFILE OF THE PROJECT INFLUENCE AREA



3.1 Introduction

The State of Tamil Nadu has a total population of 62.5 million with a literacy rate of 73.5%. Tamil Nadu state has a very good road, rail, sea and air connectivity. The length of road network in Tamil Nadu is nearly 1.70 lakh km. Tamil Nadu has a total railway track length of 6,693-kms and there are 690 railway stations in the state. Main rail junctions in the State include Chennai, Madurai, Tiruchirapalli, Salem, Coimbatore, etc. An international airport at Chennai (Madras) links the state to major capitals as well as to domestic airports at Trichy, Coimbatore and Madurai. The State has two major all-weather ports at Chennai (Madras) and Tuticorin. There are two intermediate and six minor ports which are currently capable of handling over 32 million metric tonnes of cargo annually. Tamil Nadu is a well-developed industrial state in the country with economic activity spread in various field which aggregate Manufacturing- 34%, Services- 45% and Agriculture - 21%.The entire project road falls in Vellore District. General information on the project influenced districts is presented below.

Vellore District Profile

Vellore district is one of the 32 districts in the Tamil Nadu state of India. It is one of the biggest district in Tamil Nadu. Vellore City is the headquarters of this district. As of 2011, the district had a population of 3,936,331 with a sex ratio of 1,007 females for every 1,000 males. Vellore district lies between 12° 15' to 13° 15' North latitudes and 78° 20' to 79° 50' East longitudes in Tamilnadu State. The geographical area of this district is 6077 sq. k.m.

3.2 Demographic Features

As per Census of India 2011, population of India is **1,210,193,422** out of which Tamilnadu population is **72,138,958** (5.96% of total). Tamilnadu is seventh largest state in India in terms of population. Various demographic features influencing project road are described as below:

The proposed bypass for Vellore pass through Vellore districts and it is expected that the population of Vellore districts are likely to be benefited, i.e., **3,936,331** persons which is about 5.45% of the total population of Tamil Nadu will be directly or indirectly benefited by the implementation of the project. The percentage share of the affected population in various districts adjacent to Vellore district is as presented in **Table 3.1**.

Table: 3.1 Populations of State & Related Districts

Sl.No.	Name of State/District	Total Population
1	India	121,01,93,422
1	Tamil Nadu	72,138,958
2	Vellore	3,936,331
3	Tiruvallur	3,728,104
4	Kanchipuram	3,998,252
5	Tiruvannamalai	2,464,875
6	Krishnagiri	1,879,809

3.2.1 Rural and Urban Population

In the state of Tamil Nadu, 51.60% of the total population is rural as compared to 48.40% of urban population. In Vellore district, 56.76% population is the rural population and 43.24% is the urban population.

3.2.2 Sex Ratio

The sex ratio of the state (996 females per 1000 males) is lower than Vellore District of (1007 females per 1000 males). The sex ratio of children between 0-6 years of age of the state (943 females per 1000 males) is also lower than Vellore District of (967 females per 1000 males).

3.2.3 Decadal Growth Rate

Population growth in India is 17.64% and Tamilnadu State is 15.60% in 2001-2011 respectively. In similarly, Vellore district is affected by 13.20% growth rate during the period of 2001-2011.

3.2.4 Vulnerable Population

Generally, the population belongs to Scheduled castes & Scheduled tribes, physically handicapped, women headed household, families below Poverty line, disabled persons, and destitute persons are considered as vulnerable population. The Scheduled caste and Scheduled tribe population of Vellore district is 860,212 & 72,955.

3.3 The Social Services

3.3.1 Literacy and Education

The literacy rate of Tamilnadu (80.33%) is slightly higher than the literacy rate of India (74.04%) in 2011. The Vellore District is (79.65%) slightly lower than entire Tamilnadu State but higher than Overall India based on 2011 census.

3.4 Economic Features

3.4.1 Distribution of Population by Workers and Non-workers

Agriculture is the main occupation of the people in the project-influenced districts. More than 40% of the people are engaged in agriculture and allied activities. The percentage of people engaged in household industry is scanty in all the project-affected districts, as shown in **Table 3.2**.

Table 3.2 Classification of Workers - 2011 Census

SI.No.	Category of Workers (Main and Marginal)	Total Population	Males	Females
1	Cultivators	175108	120351	54757
2	Agricultural- Labourer's	391955	200660	191295
3	Household & Industrial Workers	136415	57277	79138
4	Other Workers	985852	745586	240266
5	Non Workers	2247001	837814	1409187

3.5 Environment and Climate

The vellore district has a semi-arid climate with high temperatures throughout the year and relatively low rainfall. The topography is almost plain with slopes from west to east. There are no notable mineral resources. Black loam soil is found in parts of Vellore Taluk. The other type of soil in the vellore district is chiefly gravelly, stony and sandy of the red variety.

Vellore district experiences hot and dry weather throughout the year. The temperature ranges from a maximum of 43.5°C to a minimum of 18.4°C. April to June are the hottest months and December to January are the coldest. Vellore receives 996.7 mm of rainfall every year. The southwest monsoon, with an onset in June and lasting up to August, brings scanty rainfall.

The bulk of the rainfall is received during the northeast monsoon in October, November and December. The humidity ranges from 40%–63% during summer and 67%–86% during winter.

3.6 Transportation Links

3.6.1 Transport Linkage to Chennai

Chennai is well connected by rail and roads through NH-46 & other state highways. Chennai has Ports, Harbor & International airport.

3.6.2 Transport Linkage to Other Parts of State

Vellore is well connected to other parts of state by National Highways (NH-234, NH-46 & NH-4) and also by State Highways & Other Roads.

Vellore is also well connected by Rail Route through (Chennai – Jolarpettai). There is a major railway junction in Vellore District is Katpadi on the Chennai- Jolarpettai broad-gauge line running to Chennai, Bangalore, Tirupati and Trichy. More than 150 trains cross the Vellore-Katpadi Junction daily.

3.7 Tourism

Tourism is travel for recreational, leisure or business purposes. Vellore City, the district capital, located on the banks of Palar River. A brief summary of tourist spots of Vellore districts are as follows:

3.7.1 Vellore Fort

The Vellore Fort is the primary tourist attraction in the district headquarters Vellore. During British rule, Tipu Sultan's family and the last king of Sri Lanka, Vikrama Rajasinha, were held as royal prisoners in the fort. It houses a church, a mosque and a Hindu temple, the latter known for its carvings. The first rebellion against British rule erupted at this fort in 1806 and it witnessed the massacre of the Vijayanagara royal family of Emperor Sriranga Raya.

3.7.2 Golden Temple

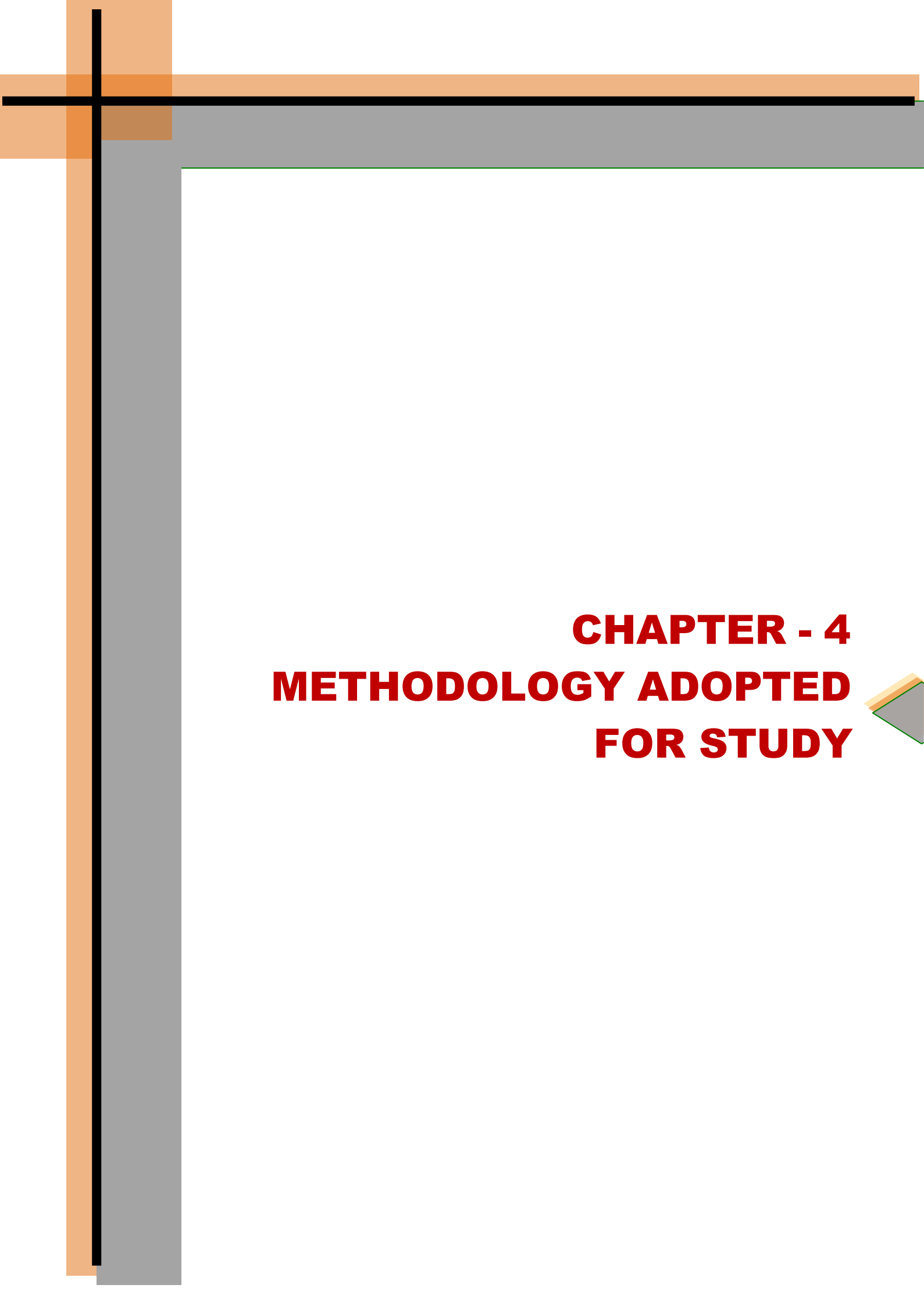
The golden temple of Sripuram is a spiritual park situated at the foot of a small range of green hills in a place known as "Malaikodi". The temple is between Vellore-Odugathur state highways, near Tirumalaikodi. The temple with gold covering has intricate work done by artisans specializing in temple art using gold.

3.7.3 Jalagandeeswarar Temple

The Jalagandeeswarar Temple inside the Vellore fort dedicated to Jalagandeeswar, is noted for its sculptures, and speaks volumes of the exquisite craftsmanship of the highly skilled artisans of that period.

3.7.4 Yelagiri Hills

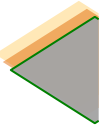
Yelagiri is a hill station of the Vaniyambadi-Tirupattur road at an altitude of 1,410.6 metres above MSL and spread across 30 Sqkm. The hill station is much unspoiled and retains a laid-back atmosphere, unlike many other hill stations of India. Near Yelagiri is a seasonal waterfall named Jallagamparai, which receives water during the rainy season.



CHAPTER - 4

METHODOLOGY ADOPTED

FOR STUDY



CHAPTER 4

METHODOLOGY ADOPTED FOR FEASIBILITY STUDY

4.1 General

The feasibility study involves carrying out economic analysis, preliminary designs, and approximate cost estimation based on surveys, inventories, investigations etc. The methodology adopted for different tasks is discussed in this Chapter. Consultant divided the consultancy services into following tasks to carry out the feasibility study:

- Review of all available reports and published information.
- Detailed reconnaissance.
- Identification of possible alternatives for stand-alone ring/bypass road, evaluation of different alternatives with comparison on techno-economic considerations.
- Traffic studies including traffic surveys.
- Inventory and condition survey of the existing roads.
- Inventory and condition survey for existing bridges and culverts.
- Detailed topographical survey using Total Station.
- Pavement investigations for existing roads.
- Sub-grade characteristics and strength of other materials for construction.
- Environmental and social impact analysis.
- Project costing and prioritization of segments.
- Preliminary engineering design

4.2 Collection and Review of Secondary Data

The secondary data required for the development of study were collected from various sources primarily from DE, NH Vellore. The secondary data includes:

- Climate
- Rainfall, Flooding information and other relevant data
- Details of sanctioned/ongoing works.
- Hydraulic and geo-technical data for existing bridges
- Accident data
- Sources of construction material
- Type of project clearances involved for implementation of project.

Information regarding several aspects of traffic engineering was also be elicited from the officials of respective departments, committees, etc, during discussions to have a complete outlook of the project area and also for an appraisal of existing traffic situation.

4.3 Reconnaissance

Reconnaissance survey was carried out to outline the procedure for the detailed investigations. It has identified the following:

- Topographic and physical features of the project and surrounding region, including land use pattern and environmental features.
- Alignment alternatives and grade separators.
- Traffic pattern.
- Locations for conducting diverse traffic surveys.
- Preliminary inventory of pavement, carriageway type, bridges and structures, intersections, urban/congested areas in existing roads.
- Requirements for conducting supplementary investigations.
- Extent of land available and additional requirements.

The project road is lined with km and 200 m pillars of radial roads of alignment crossing locations. The available topographic maps, GT sheets and satellite imageries are being studied.

4.4 Field Surveys and Investigations

The field surveys and investigations is conducted in two phases; the necessary traffic surveys to study the economic and financial viability of the project in first phase and other field surveys and investigations for detailed design of approved alignment of Bypass in second phase. The following are the field surveys and investigations for the project.

- Topographical Surveys
- Road Inventory Survey
- Inventory and Condition Survey of Bridges and Culverts
- Traffic Surveys
 - Classified Volume Count Survey
 - Origin-Destination Survey
 - Turning Movement Survey
 - Speed and Delay Survey
 - Axle Load Survey

- Pedestrian Survey
- Pavement investigations
 - Pavement Condition Survey
 - Pavement Composition and Existing Sub-grade Characteristics
 - Pavement Structural Strength (Benkelman Beam Deflection)
- Hydraulic and Hydrological Investigations
- Geo-technical Investigation
- Sub-grade Soil Characteristics for widening portion/new alignment
- Material Survey

4.4.1 Topographic Survey

The basic objective of the topographic survey is to collect the essential ground features along the alignment that is useful for the detailed design and for the computation of quantities. The topographic survey work consists of reconnaissance survey, establishing DGPS points, fixing of BM pillars, horizontal traversing, vertical traversing, levelling and detailed topographical survey to capture all details, preparation of drawing and submission of report.

Initially, the survey team has to visit the whole area to be surveyed to understand the actual ground conditions prevailing in the corridor and to assess the logistic. Based on this survey, separate survey teams is mobilised for fixing of control pillars, for traversing, levelling and for detail survey.

Instruments to be used for Topographical Survey

The Topographic survey is undertaken by Total Station and GPS to develop a Digital Terrain Model (DTM). The consultants being fully aware of the high standards aimed at for project preparation and propose the use of the following latest instruments of high accuracy.

Digital Global Positioning System

The basic plan control points (Primary Points) will be established by dual frequency GPS observation, using Leica GS08 Plus static Glonass with RTK/ Promark DGPS with static, providing a pair of primary control points along the proposed road section on permanent reference pillars.

Total Stations



Total stations of Leica TS06/ Nikon DTM 652 of 1sec accuracy and/or Nikon DTM352/ Nikon Nivo/ Leica TC705/ Topcon GTS 235N of 5sec accuracy will be deployed for topographic survey work.

Digital / Auto levels

Digital / Auto levels of Leica Sprinter/Sokkia C320 or equivalent with standard deviation of 1 mm per 1 km double run levelling using bar coded telescopic levelling staves with least count of 0.1 mm/ 0.5 mm will be deployed.

Fixing of Horizontal and Vertical Control Points

The horizontal control points shall be fixed using Global Positioning System along the alignment. Control Pillar of size 30cm x 30cm x 60cm shall be cast in RCC of grade M15 with a nail fixed in the centre of the top surface. The reference pillar shall be embedded in concrete upto a depth of 45 cm with PCC M10 (15 cm wide all around). The portion above ground shall be painted yellow. The spacing shall be 5km apart.



Bench Mark pillar of size 15cm x 15cm x 45cm shall be cast in RCC of grade M 15 with a nail fixed in the centre of the top surface. The reference pillar shall be embedded in concrete up to a depth of 30cm with CC M10 (5cm wide all around), the balance 15 cm above ground shall be painted yellow. The spacing shall be 250m apart in straight alignment and 100m in curves. The final RL (w.r.to GTS) and BM No. are marked on the reference/BM pillars with red paint.

Detailed Topographic Survey

After finalizing the X, Y and Z values based on the horizontal and vertical traverse loops, the detailed topographical survey of capturing all the existing features shall be carried out. The survey should extend a minimum 30m beyond either side of centreline of proposed carriageway or land boundary

whichever is more. The survey area should be increased at major intersection and extended to minimum of 500m along major cross roads. The work includes LS and CS details including all the existing features along the project corridor.



Longitudinal and Cross sections

Longitudinal section levels shall be taken at every 25 m interval. Cross sections at every 50 m interval in full extent of survey covering sufficient number of spot levels on existing carriageway and adjacent ground for profile correction course and earth work calculations. Cross sections shall be taken at closer interval at curves as stipulated in IRC.

Longitudinal and cross sections for major and minor streams as per recommendations contained in IRC Special Publication No. 13 and IRC:5-1998.

Collection of Topographical Features

All landside features given below, is captured, within this corridor and presented in drawings.

- Electrical Poles, Telephone Poles, Lamp Poles and any other Private/Unauthorized utility Poles with their routing network.
- Water / Sewerage / Oil / Gas Pipe Lines with diameter and material of the pipe.
- All Utility lines, both overhead and underground.
- Manholes – with their actual size and shape (ex. rectangular or square or circular)
- Trees with girth more than or equal to 0.3m - while surveying the trees, care is taken to exactly classify the trees according to its girth.
- Building lines indicating the type of buildings (shops or houses), Right of Way boundary if available at site by presence of boundary stones.
- Sufficient road center points, edge points and shoulder points are taken to define the existing layout of the roadway.
- Approach road details of 50m lengths are recorded on either side of the road. But on important junctions, length of road to be surveyed is subjected to a minimum length of 500m.
- Location of traffic islands, median, channelising islands, rotaries, police chowkis, (top and bottom levels are must for all these) with its locations, and dimensions.
- Location of bus bays / bus stops, truck - parking areas, taper length, roadway width.
- Special emphasis was laid in identifying all religious places - temples, temple mast, mosque, church, locations, boundary lines and clear dimensions of compound walls and entrances.
- Locations of roadside drain clearly identifying the type (Built-up / Earthen, Rectangular / Trapezoidal etc., and whether Open / Closed), width of drain (waterway width and wall width in case of built-up drain) including the beginning

and end of drain. All water features such as ponds, tanks, lakes, streams, canals and wells etc were mapped.

- Roadside cultivation viz., agricultural, residential, commercial, shops and business established areas etc.
- Identification of all bridges and culverts along the project road includes location (Chainage) and reference number, width of bridge / culvert (width of slab or diameter of pipe, no of pipes/spans), course of water path, skew of bridge / culvert, span arrangement.

4.4.2 Road Inventory Survey

Road inventory survey of the existing road stretches, which is utilized as part of proposed project road, are carried out. The objective of the road inventory survey is to assess the potential capacity of the road section. The information on road characteristics should be collected by physical measurement and visual evaluation. A team of enumerators shall traverse the road sections with a specified format for the purpose of recording the data. The collected data is compiled in tabular statement using Excel computer software. The database is used in developing the base year road configuration, facilitating both qualitative and quantitative evaluation of the present sufficiency of roads. The data collected include but not limited to the following:

- Type of terrain.
- Land use.
- Carriageway width and type of surfacing.
- Width and type of shoulders.
- Road intersection(s) and their details.
- Land width (ROW).
- Locations of water bodies and retaining structures
- Height of embankment and depth of cutting
- Utility services on either side of the road within the ROW.
- General drainage conditions.

4.4.3 Inventory and Condition Survey of Bridges and Culverts

Inventory of all the existing structures like bridges, culverts, etc., along the proposed alignment is carried out. The data collected include type of existing superstructure, substructure and abutment, span and dimensions of existing bridge, hydraulic particulars like HFL, scour around piers, etc., river protection works, etc.

The condition of existing bridge components and approaches is identified by visual survey. Deficiencies such as spalling of concrete, damages to the wearing coat and expansion joints, breakage of hand rails, posts and return/wing walls, disturbed protective works in the bed, quadrant pitching etc will be recorded.

The inventory and condition of existing culverts in the project road is include the identification of deficiencies like choking of pipes, channel obstruction, damages in head/return/ wing walls' spalling of concrete, etc. and the observations are recorded.

4.4.4 Traffic Surveys

The necessary traffic surveys such as classified traffic volume counts, origin-destination and commodity movement surveys, turning movement surveys, axle load survey, speed-delay surveys and pedestrian counts is carried out at the locations approved by Divisional Engineer, National Highways, Vellore, in accordance with the IRC guidelines and requirements. The detailed methodology on traffic surveys are described in succeeding paragraphs.

4.4.4.1 Classified Traffic Volume Count Survey

A manual traffic count is carried out at strategic mid-block locations. Counts carried out for 7 days, 24 hours continuously in both directions. At each identified station, both directional counts are carried out by vehicle type. i.e. cars, jeeps,

Regular Counts

These are the traffic volume data of the locations where highways department conducts periodic classified traffic volume counts. Efforts would be made to obtain the historical traffic data for a period of last five years or more.

4.4.4.2 Origin Destination Surveys

The main objective of the survey is to derive the passenger travel pattern of the road. Interviews is carried out on a random sample basis on a typical working day by stopping the vehicles (RSI – Road Side Interview method) at the selected locations (preferably at the mid block classified traffic volume count locations) on both sides of the project road for a continuous period of 24 hours. The successful completion of these surveys (a large sample) highly depends on the level of assistance available from local police to stop the vehicle for interviewing the road user. The information to be obtained from the road users during RSI includes their travel characteristics and willingness to pay toll (user fee) following the improvement to the project corridor as specified in the objective of the study. The survey is carried out through pre-planned structured questionnaires suitable for computer analysis. vans, buses, trucks, MAVs, LCV's, tractors, motorised two wheelers, three wheelers, and slow moving vehicles like cycles and carts.

All the results shall be presented in tabulated and graphical formats. The analysis of data brings out the hourly, daily, and weekly variations in traffic. Weekly average daily traffic (ADT) is calculated and using the appropriate seasonal factors Annual Average Daily Traffic (AADT) is calculated for each location.

The information collected during these surveys for passenger vehicles include the origin and destination, purpose, occupancy and frequency of the trip and occupation and income of the main passenger in the vehicle. In the case of freight vehicles the information sought would be quantity, type and value of commodity being transported, in addition to origin and destination and frequency of travel on the route. Information on the likely toll (user fee), the users would be willing to pay would be obtained by giving a set of likely toll rates (Rs. Per Km) on the proposed facility. Strip matrices shall be worked out for different vehicle type.

4.4.4.3 Turning Movement Surveys

The main objective of the survey is to establish peak hour turning movements at critical intersections in the study area. Manual turning volume counts of classified vehicles is made separately for direction-wise movements including left turning and right turning traffic at all the major intersections. The survey is carried out on a typical working day covering both morning and evening peak hours. The data generated on turning movements in respect of stream composition, direction wise and category wise vehicle volumes.

The analysis of the data would suggest the improvement proposal i.e. at-grade controlled/uncontrolled improvement or construction of grade separator, and could help in suggesting any modifications required in the at-grade junction that would making the traffic flow smooth.

4.4.4.4 Axle Load Survey

The intensity of traffic loading is an important parameter for the design of pavements. The axle load surveys will be carried out to determine the load pattern and the trend of overloading, at selected location. This survey will be carried out in both directions for one day (24 hours) on a random sample basis normally for trucks only.

Weights of individual single axles or tandem axles will be recorded. From the survey the Vehicle Damage Factor (VDF), Gross Vehicle Weight (GVW) and Single Axle Load distribution for each vehicle types will be calculated.

4.4.4.5 Speed and Delay Survey

Speed is one of the most important characteristics of traffic and its measurements are a frequent necessity in traffic engineering studies.

Journey time studies are to be conducted to evaluate congestion, its location and delays. The moving car observer method is most commonly used for measuring running speed and journey speed of the road. The survey vehicle is travelled in the stream of general traffic at similar speeds as of other traffic during different times of the normal working day and noting down the journey time. The delays and corresponding contributory factors at intersections / major activity centres, etc. are collected to identify major bottlenecks on the road.

The main objective of conducting this survey is to recommend suitable measures for segregation of local traffic, smooth flow of through traffic and traffic safety. The measures include provision of bypasses, service roads, grade separators, improvement of intersections, etc.

4.4.4.6 Pedestrian/Animal Cross Traffic Surveys

Pedestrian survey is intended to collect the data on pedestrian movement at specific locations where significant pedestrian activity is exists, with a view to identify and providing the type and extent of pedestrian facility needed at the locations. Pedestrian cross traffic surveys is carried out for a period of 8 hours (covering morning and evening peak hours) as per the standard format. The survey is carried out by direction of each pedestrian crossing the roadway/ using the side walk. The cattle cross counts also conducted at the locations where significant cattle cross movement is exists, to provide cattle underpasses and barriers to control the entry of cattle into roadway.

4.4.4.7 Accident Survey

Accident is a major social problem, due to loss of lives. Raw accident information / date is collected from the respective Police Stations and Regional Transport Office along the stretch. These data is utilised to identify the accident prone areas and draw measures to eliminate those critical zones.

4.5 Pavement Investigation

The main objective of the investigation is to identify the characteristics of the pavement and sub-grade of existing road sections which is utilized as part of project road.

4.5.1 Pavement Condition Survey

The pavement condition survey is carried out by visual observations supplemented with simple measurements using tape, straight edge etc. The following pavement damage data (as a percentage of paved Carriageway area) will be collected.

- a) Cracking
- b) Ravelling

- c) Pot Holes
- d) Rutting
- e) Patch Works

The road length divided into 200 m sections and data is recorded for each section. The rut depth is measured by a straight edge, 3 m long using a graduated wedge. The areas of cracking, pot holing and ravelling are recorded by experienced engineers. The length and width of the deficiencies are estimated. Data to be recorded is including all visual defects to pavement shoulders, embankments and drainages. The rating of the pavement condition will be assigned by walking on the road stretch by group of engineers and after group discussion.

4.5.2 Pavement Composition and Existing Sub-grade Characteristics

Existing roads have been built over the span of several years. No clear history and composition of the existing pavement may be available. In order to assess the composition of the existing pavement and to determine the strength of existing sub grade soil, trial pit investigation will be conducted on the existing road.

Test pits is taken on the existing pavement, cutting about 600 mm inside the road edge. Test pits is conducted at a staggered interval of 1km. Exact location of the test pit with respect to the existing kilometre stone are recorded. From the test pit, thickness of various pavement layers of existing crust measured and recorded.

Pits are dug up to the required depth so as to expose the top of the sub grade soil. On top of the sub grade soil the following tests is conducted.

- Field density test using sand replacement method as per IS 2720 part 28
- Moisture content test as per IS 2720 (Part 2) -1973

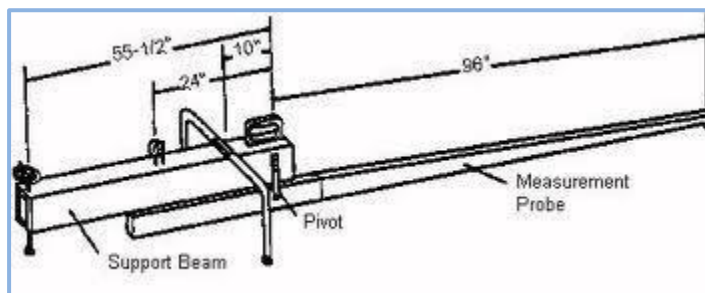
Once the tests on the top of the sub grade completed, then the pit was further dig and sub grade soil material collected for laboratory testing. On the collected sample following tests is conducted.

- Grain size- as per IS 2720 (Part 4)-1985
- Soil classification- AASHTO and IS
- Atterberg limits- as per IS 2720 (Part 5)-1985 and IS 2720(Part-6)-1972
- Proctor Compaction and optimum moisture content- as per IS 2720 (Part- 8)
- CBR (soaked & un-soaked)- as per IS 2720 (Part -16)

4.5.3 Pavement Structural Strength

For assessing the structural strength of existing pavement, the deflection is measured using Benkelman Beam in accordance with procedures laid down in IRC-81-1997. Benkelman

Beam deflection survey to be carried out according to the C.G.R.A procedure given in IRC: 81-1997 using a standard truck having a rear axle weighing 8170 kg fitted with dual tyre inflated to a pressure of 5.60 kg/cm². Before starting the deflection measurements, the Benkelman Beam shall be calibrated to ensure that the dial gauge and the beam are working correctly. The deflection measurements shall be taken on the existing roads at an interval of 100m.



In the transverse direction, the measurements point should be 0.9m from the pavement edge for two lane (2L) carriageway sections and 1.5m from the pavement edge for divided four lane carriageway sections. Additional deflection measurements should be made in a section based on the variability of the deflections. For this purpose, highest and lowest values in a section should be compared with the mean value.

4.6 Hydraulic and Hydrological Investigations

The hydrological and hydraulic studies shall be carried out in accordance with IRC Special Publication No. 13 ("Guidelines for the Design of Small Bridges and Culverts") and IRC: 5-1998 ("Standard Specifications & Code of Practice for Road Bridges, Section I General Feature of Design"). These investigations shall be carried out for all existing drainage structures along the road sections under the study and also if any new proposals.

4.7 Geotechnical Investigations for Bridges

Geo-technical investigations and sub-surface explorations for the proposed bridges/road over bridges/underpasses/flyovers etc., along high embankments and any other location as necessary for proper design of the works and conduct all relevant laboratory and field tests on soil and rock samples.

- Sub-soil investigations will be done as per IRC: 78-2000.
- The scheme for the borings locations and depth of boring shall be prepared and got approval from the Divisional Engineer, Vellore.
- The soil testing reports shall be in the format prescribed in relevant IRC Codes.
- Bore holes shall also be carried out at locations of high embankments for embankment design.

4.8 Sub-grade Soil Characteristics for New Alignment

In-order to assess the strength of the existing natural soil at the location of the additional carriageway/new alignment, test pit investigation are conducted. Test pits on the natural ground is taken on the widening side of the existing carriageway beyond the toe of the existing road embankment/along proposed new alignment.

For the widening of existing road within the ROW and for the roads along new alignment, the test pits for sub grade soil type will be taken at 3km interval or for each soil type, whichever is more. A minimum of three samples will be tested corresponding to each homogeneous segment or each soil type encountered, whichever is more.

Pits are dug up to the required depth so as to expose the top of the sub grade soil. On top of the sub grade soil the following tests is conducted.

- Field density test using sand replacement method as per IS 2720 part 28
- Moisture content test as per IS 2720 (Part 2) -1973

Once the tests on the top of the sub grade completed, then the pit was further dig and sub grade soil material collected for laboratory testing. On the collected sample following tests is conducted.

- Grain size- as per IS 2720 (Part 4)-1985
- Soil classification- AASHTO and IS
- Atterberg limits- as per IS 2720 (Part 5)-1985 and IS 2720(Part-6)-1972
- Proctor Compaction and optimum moisture content- as per IS 2720 (Part- 8)
- CBR (soaked & un-soaked)- as per IS 2720 (Part -16)

4.9 Material Survey

Material surveys are conduct for fine and coarse aggregates, collected from quarry and borrow area.

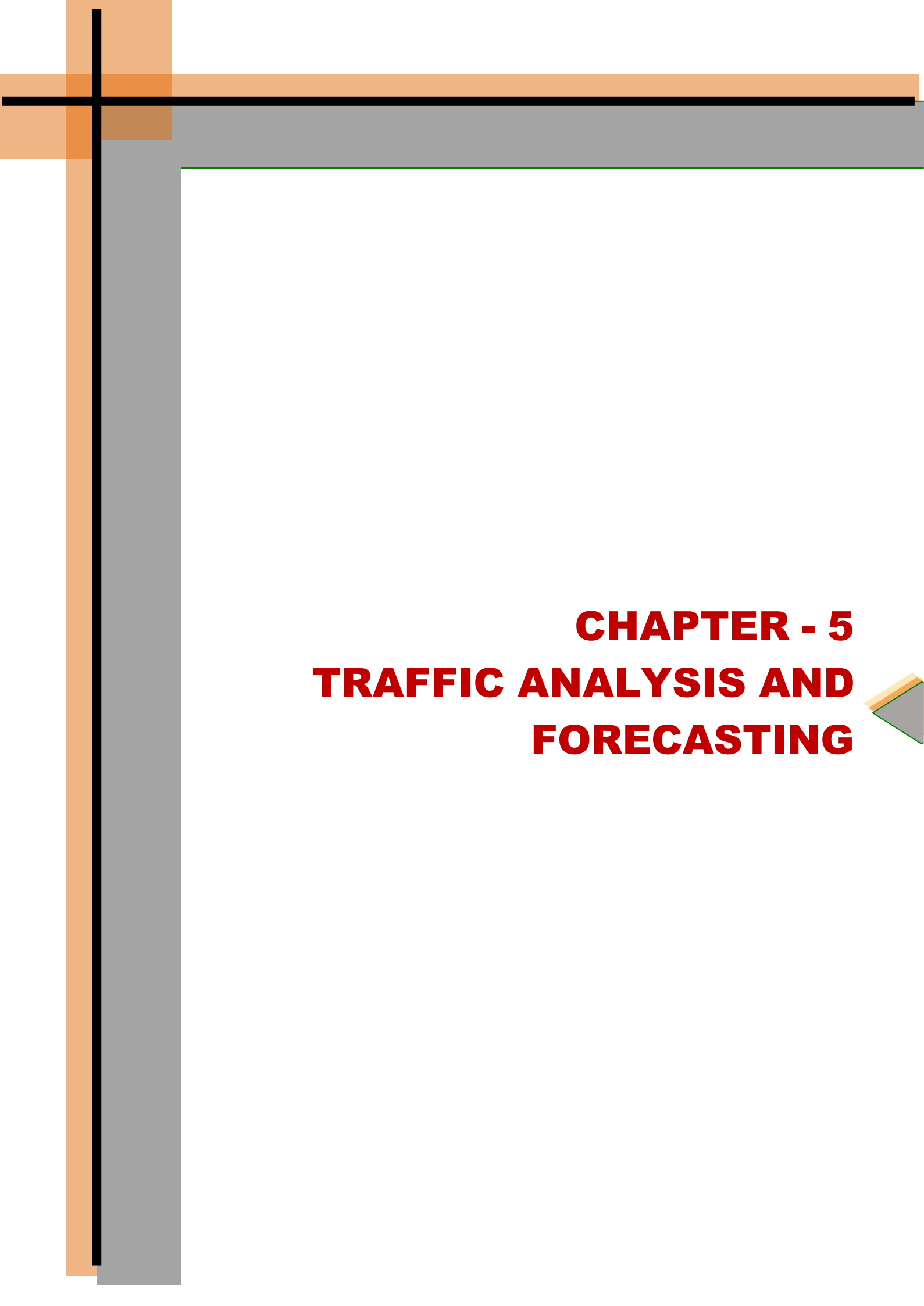
The names, addresses and contact numbers of different quarry owners with adequate yields of materials along with prevailing market rates will be collected. The quarry charts and lead charts will be obtained and mass haul diagram will be prepared.

4.10 Utility Services

During the inventory and topographical surveys, details of utility services such as water lines, telephone cables, power cables etc., running along the proposed alignment is collected for consideration during the detailed project preparation.

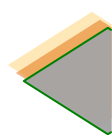
4.11 Trees

The details of existing trees (girth wise) within the proposed right of way are collected in the topographical survey for environmental impact assessment.



CHAPTER - 5

TRAFFIC ANALYSIS AND FORECASTING



CHAPTER 5

TRAFFIC ANALYSIS AND FORECASTING

5.1 General

A thorough knowledge of the travel characteristics of the traffic is essential for future traffic estimation. Hence detailed traffic surveys have been carried out to assess the baseline traffic characteristics in the project vicinities.

The study aims at obtaining the existing traffic and travel characteristics on the project corridor and forecasting the average annual daily traffic for project horizon year considering various consistent streams and for various scenarios. The results of analysis and recommendations for improvements are discussed in the following sections.

5.2 Traffic Homogeneous Sections

The Project corridor has been further divided into homogeneous sections based on the traffic generation and dispersal nodes located along the project road.

The details of traffic homogeneous sections considered for the purpose of study and analysis are presented in the Table 5.1.

Table 5.1 Details of Traffic Homogeneous sections on SH-15

Bypass Name	Section No.	Type of Terrain	Start Ch	End Ch	Length (Km)
Vellore Bypass	I	Plain	0+000	6+500	6.5
	II	Plain	6+500	20+850	14.35

5.3 Survey Locations

Traffic surveys are intended to understand the existing traffic scenario on the proposed project road and to identify the improvements required for upgrading it to have better facilities. The following primary traffic surveys are conducted on the project road and their key plan is shown in **Fig. 5.2**.

Table 5.2 Schedule of Traffic Survey and their locations

S. No	Survey	Survey Code	Chainage (km)	Survey Location
1	Classified Traffic Volume Count Surveys (7 Days-24 Hours)	CVC -1	29/8	NH-234, Kambatham
		CVC -2	81/1	NH-234, Sathumadurai
2	Origin-Destination and Surveys (24 Hours) Commodity Movement	OD-1	29/8	NH-234, K.V.Kuppam
		OD-2	81/1	NH-234, Sathumadurai
		OD-3	11/0	SH-127, Intersection with SH-88
		OD -4	19/0	SH-88, Tharanampet

5.3.1 Classified Traffic Volume Count Survey

Estimates of current classified traffic levels for the road sections under study are normally obtained from the mid block counts. These count stations are located away from the local traffic influence areas.

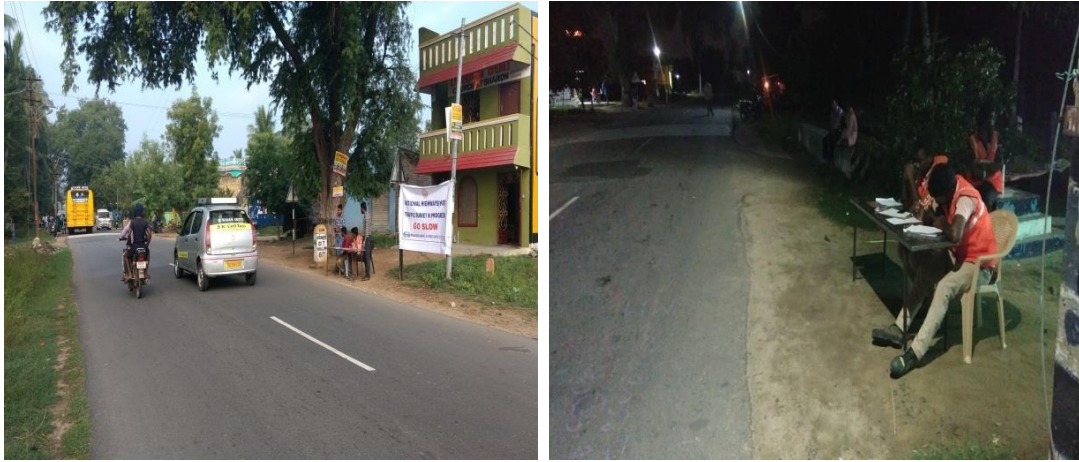
These surveys in both directions were organised for a continuous period of 7 days round the clock at the selected locations and the data was collected as per the standard data format.

At each identified station, both directional counts were carried out by vehicle type. i.e. cars, jeeps, vans, buses, trucks, MAVs, LCV's, tractors, motorized two wheelers, three wheelers, and slow moving vehicles like cycles and carts.

All the results are presented in tabulated and graphical formats. The analysis of data brings out the hourly, daily, and weekly variations in traffic. Weekly average daily traffic (ADT) is calculated for each location.

5.3.1.1 At km 29/8 near kambatham

To identify the existing traffic in NH-234, 7 days classified traffic volume count survey was conducted at km 29/8 near kambatham. The analysis of classified traffic volume count surveys are given below and the detailed data are given in **Annexure – I**.



The Average Daily Traffic (ADT) at this location is presented in **Table 5.3**.

Classified Traffic Volume Count Survey (Average Daily Traffic)																								
Project Name:Consultancy services for preparation of Detailed Project report (DPR) for capacity augmentation of various selected stretches on National Highways in the State of Tamil Nadu (Package - II).															Weather:Clear									
Section From:		Near Kambatham								Station No. TP-2														
Location Km. :		Km. 29.800								Date:		06-01-2023 to 12-01-2023												
Direction Towards : Both Direction										Hour :24 hours														
Time	Car / Jeep	Mini LCV	Tempo / LCV	FAST MOVING VEHICLE				Mini Bus	Bus	Animal Cart	Cyde	Two - Wheeler	Auto	Auto Rickshaw	Tractors Trolleys	Tractors	SUMMARY							
				2-Axle	3-Axle	4 to 6 Axle	M-Axle										Total Motorised Vehicles	Total Commercial vehicles	Total Non Motorised Vehicles	Total Tollable Vehicles	Total Vehicles			
6-1-23 UP	935	356	86	43	55	45	0	34	271	0	139	8389	0	589	1	16	10820	890	139	1825	10959			
6-1-23 DN	863	416	96	30	22	19	0	43	274	0	101	8136	0	582	1	14	10496	900	101	1763	10597			
7-1-23 UP	793	379	99	49	47	26	0	23	235	0	102	7480	0	500	1	13	9645	858	102	1651	9747			
7-1-23 DN	705	331	83	35	30	51	0	29	275	0	123	7447	0	527	3	12	9528	834	123	1539	9651			
8-1-23 UP	857	413	112	48	45	36	0	29	271	0	114	7628	0	548	2	14	10003	954	114	1811	10117			
8-1-23 DN	750	358	94	46	39	49	0	31	296	0	125	7666	0	530	4	15	9878	913	125	1663	10003			
9-1-23 UP	866	426	116	56	51	39	0	34	268	0	110	7794	0	557	3	14	10224	990	110	1856	10334			
9-1-23 DN	775	361	100	54	44	48	0	27	302	0	116	7656	0	535	5	19	9926	936	116	1711	10042			
10-1-23 UP	955	362	88	44	55	46	0	34	273	0	120	8595	0	612	6	18	11088	902	120	1857	11208			
10-1-23 DN	871	415	94	30	22	19	0	45	277	0	101	8075	0	577	7	17	10449	902	101	1773	10550			
11-1-23 UP	911	435	118	48	45	35	0	34	273	0	113	8033	0	570	2	14	10518	988	113	1899	10631			
11-1-23 DN	793	374	95	46	39	51	0	33	304	0	130	7632	0	543	4	16	9930	942	130	1735	10060			
12-1-23 UP	834	397	100	49	47	28	0	23	243	0	104	7969	0	529	5	13	10237	887	104	1721	10341			
12-1-23 DN	742	335	86	36	31	53	0	36	296	0	127	7716	0	562	5	12	9910	873	127	1615	10037			
Total Weekly Traffic	11650	5358	1367	614	572	545	0	455	3858	0	1625	110216	0	7761	49	207	142652	12769	1625	24419	144277			
ADT Number	1664	765	195	88	82	78	0	65	551	0	232	15745	0	1109	7	30	20379	1824	232	3488	20611			
ADT PCU	1664	1148	293	264	246	351	0	98	1653	0	116	7873	0	2218	32	45	15885	4053	232	5717	16001			
AADT Number	1714	796	203	92	85	81	0	68	573	0	232	16217	0	1142	7	31	21009	1695	232	3612	21241			
AADT PCU	1714	1194	305	275	256	365	0	102	1719	0	116	8109	0	2285	33	47	16404	3911	116	5930	16520			

5.3.1.2 At km 72/400 near Sathumadurai

To identify the existing traffic in NH-234, 7 days classified traffic volume count survey was conducted at km 81/1 near Sathumadurai. The analysis of classified traffic volume count surveys are given below and the detailed data are given in **Annexure – I**.



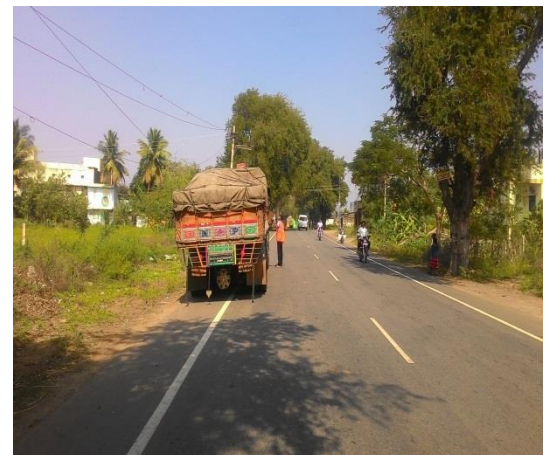
The Average Daily Traffic (ADT) at this location is presented in **Table 5.4**.

Section From:		Km 81+100							Station No. TP-2												
Location Km. :		Near Vellore							Date: 07-01-2023 to 13-01-2023												
Direction Towards : Both Direction									Hour :24 hours												
Time	FAST MOVING VEHICLE								SLOW MOVING								SUMMARY				
	Car / Jeep	Mini LCV	Tempo / LCV	Truck				Mini Bus	Bus	Animal Cart	Cycle	Two - Wheeler	Auto	Auto Rickshaw	Tractors Trolleys	Tractors	Total Motorised Vehicles	Total Commercial vehicles	Total Non Motorised Vehicles	Total Tollable Vehicles	Total Vehicles
				2-Axle	3-Axle	4 to 6 Axle	M-Axle														
7-1-23 UP	2576	350	198	109	28	73	0	136	576	0	44	7089	0	238	7	11	11391	1470	44	4046	11435
7-1-23 DN	2724	452	150	98	30	93	0	163	613	0	52	6509	0	240	7	9	11088	1599	52	4323	11140
8-1-23 UP	2706	357	203	111	31	77	0	141	585	0	46	7350	0	247	9	8	11825	1505	46	4211	11871
8-1-23 DN	2831	466	156	99	33	96	0	170	648	0	53	6768	0	257	8	12	11544	1668	53	4499	11597
9-1-23 UP	1837	422	129	118	44	54	0	159	600	0	51	6787	0	202	4	13	10369	1526	51	3363	10420
9-1-23 DN	1938	503	159	104	36	119	0	136	609	0	80	6661	0	210	1	11	10487	1666	80	3604	10567
10-1-23 UP	1901	430	129	125	51	46	0	162	610	0	52	6981	0	205	8	12	10660	1553	52	3454	10712
10-1-23 DN	1998	510	164	107	38	123	0	141	627	0	92	6765	0	217	5	11	10706	1710	92	3708	10798
11-1-23 UP	1982	500	202	128	41	71	0	187	580	0	61	6902	0	299	5	13	10910	1709	61	3691	10971
11-1-23 DN	1961	405	154	146	41	50	0	155	567	0	62	6849	0	294	7	13	10642	1518	62	3479	10704
12-1-23 UP	2042	521	204	133	34	77	0	188	587	0	63	7064	0	313	6	9	11178	1744	63	3786	11241
12-1-23 DN	1998	386	154	145	33	61	0	157	581	0	62	7013	0	298	7	11	10844	1517	62	3515	10906
13-1-23 UP	2208	469	240	118	36	95	0	179	567	0	58	6779	0	231	4	8	10934	1704	58	3912	10992
13-1-23 DN	2628	490	158	134	39	100	0	121	626	0	44	7148	0	258	5	12	11719	1668	44	4296	11763
Total Weekly Traffic	31330	6261	2400	1675	515	1135	0	2195	8376	0	820	96665	0	3509	83	153	154297	22557	820	53887	155117
ADT Number	4476	894	343	239	74	162	0	314	1197	0	117	13809	0	501	12	22	22043	3223	117	7699	22160
ADT PCU	4476	1341	515	717	222	729	0	471	3591	0	59	6905	0	1002	54	33	20056	7586	117	12062	20115
AADT Number	4610	930	357	249	77	168	0	327	1245	0	117	14223	0	516	12	23	22737	2996	117	7963	22854
AADT PCU	4610	1395	536	746	231	758	0	490	3735	0	59	7112	0	1032	56	34	20735	7355	59	12501	20794

5.3.2 Origin - Destination and Commodity Movement Surveys

The Origin – Destination survey was carried out with the primary objective of studying the travel pattern of passenger and goods traffic in the project area. The result of this survey forms a useful input for estimating the diverted traffic and planning for tolling strategy.

The O-D survey was conducted at 5 locations as mentioned in Table 2.1 as per the guidelines given in IRC: 102-1988. Roadside Interview Method was adopted for conducting the survey. The vehicles were stopped at random sample basis with the help of police and the drivers were interviewed by trained enumerators to collect the needed information/data.



During the surveys the information pertaining to origin, destination, trip length, commodity types and trip purpose as applicable for various vehicle types were recorded.

Data Checking

The collected data was entered into the computer and checked manually. Incorrect entries were corrected by cross-checking it with original field data sheets. The data was also checked for inconsistencies. The checked and corrected data were used for final analysis.

Zoning System

For analysis of O-D data collected from the field, it is required to code it for origin and destination of trip. For this purpose, a zoning system was developed for the project. In all, total 24 traffic zones were considered for the project. The list of traffic zones is presented in **Table 5.5**.

Table 5.5: Zoning System for the Project

Zone No.	Zone/(City/Town, Taluk, Dist., State)
1	Katpadi / Latheri / Nearby this Area
2	Gudiyatham / Pallikonda / K.V.Kuppam
3	Pernambut / Nearby this Area
4	Vellore
5	Ambur/Vaniyambadi
6	Chittoor / Paradarami route
7	Thiruvannamalai / Polur Near By Area
8	Kanchipuram, Chennai
9	Thiruvallur, Chennai
10	Ranipet / Arcot
11	Arani / Vandavasi / Chetpet / Cheyyar
12	Tindivanam / Gingee / Neyveli / Beyond Through Pondicherry
13	Beyond Tindivanam (South side- Trichy / Madurai / upto Kanyakumari)
14	Beyond Kaniyambadi (Salem, Krishnagiri, Coimbatore, Yelagiri, Kerala)
15	Hosur / Bangalore
16	V.Kotta & Nearby Area
17	Beyond V.Kotta through Karnataka State
18	KGF, Kolar Beyond Other Karnataka Areas
19	Palamaner / Madanapalle / Kadappa / Rayachoty
20	Tirupathi
21	Beyond Tirupathi (Andhra & Telangana)
22	Maharashtra
23	North India
24	East India Kolkata Side States

Commodity Groups

The different commodities recorded during the O-D survey have been classified in thirteen categories as presented in **Table 5.6**. Due consideration has been given to include all possible commodities and to categorize them into homogeneous groups.

Table 5.6: Classification of Commodities

Sl. No	Commodity Type
1	Empty
2	Petroleum Products
3	Consumer Items
4	Coal / Coak, Stone etc
5	Food Grains, Vegetables, Cereals
6	Industrial Materials
7	Building Materials
8	Wood, Forest Products
9	Other Miscellaneous Goods

Development of the Origin – Destination Matrices

After coding of Origin - Destination data, vehicle-wise O-D matrices are developed for each survey location and the combined O-D matrix, category-wise, formed for trip distribution based on the assigned O-D zoning system is given in **Table 5.7 to 5.15**. The analysis of O-D Matrix is useful to find out the quantity of traffic to be travel in the proposed Vellore Bypass.

Table 5.7 O-D Matrix for Light Commercial Truck (LCV)

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	233	0	0	0	3	27	0	0	0	27	0	14	0	0	0	0	0	19	0	0	0	0	0
2	70	0	12660	711	5626	71	0	4	27	4	0	0	0	7	0	0	0	4220	76	3	0	2	0	0
3	24	30	0	13	4	47	14	0	7	4	20	7	19	7	0	0	0	0	0	0	0	0	0	0
4	0	0	703	0	0	0	48	0	0	0	149	20	20	34	0	0	0	703	24	0	0	0	0	0
5	9	4	0	17	0	6	0	0	3	0	7	0	0	0	0	0	0	0	10	6	3	4	0	0
6	23	50	770	23	33	0	0	0	12	4	14	7	0	83	0	0	0	0	0	0	0	0	0	0
7	21	0	0	42	7	14	0	0	0	0	0	0	0	0	0	0	0	7	0	7	0	0	0	0
8	0	0	703	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
9	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	7	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0
11	62	21	0	118	7	14	0	14	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
12	14	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	21	0	7	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
14	7	0	0	7	0	9	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0
15	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	6	0	0	0	0
16	4	9	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	12	0	0	4	0	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	0	4	0
18	12	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0
19	18	91	703	22	0	0	7	2	2	4	7	4	0	0	0	0	0	0	0	4	0	0	0	0
20	0	0	17	0	17	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	2	17	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.8 O-D Matrix for 2-Axle Truck

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	65	4	0	0	0	28	0	0	0	28	11	0	0	0	4	2	0	14	0	0	2	0	0
2	36	0	11193	19	7835	58	7	0	12	0	4	6	0	2	0	1119	0	13431	19	2	0	2	0	0
3	18	30	0	20	2	27	6	8	7	2	4	2	2	4	0	0	0	0	0	6	0	0	0	0
4	0	9	1119	0	4	0	67	0	0	0	55	11	11	22	1119	9	2	0	22	0	0	4	2	0
5	18	21	0	16	0	14	11	0	7	0	0	4	0	0	0	0	0	0	11	3	4	5	0	0
6	14	45	9	6	13	0	18	2	0	0	7	4	20	22	4	4	0	0	0	5	2	0	0	0
7	15	4	2	37	13	11	0	0	0	0	0	0	0	0	0	2	0	2	5	2	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	2	9	4	0	4	3	0	0	0	0	0
9	0	9	0	2	0	0	0	0	0	0	0	0	7	7	4	6	0	0	33	0	0	4	0	0
10	0	0	0	0	0	0	14	0	0	0	14	0	0	0	0	2	0	2	2	0	0	0	0	0
11	37	7	2	52	4	6	0	2	0	0	2	0	0	0	0	0	0	0	13	2	0	0	0	0
12	9	0	0	9	0	0	0	0	0	0	0	0	0	0	0	4	0	0	7	0	0	0	0	0
13	2	7	0	11	4	9	0	0	0	0	0	0	0	0	0	4	0	4	5	0	0	2	0	0
14	2	0	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	0	0	0
15	2	0	0	5	0	19	4	0	2	2	0	0	0	0	0	0	0	0	0	3	2	0	0	0
16	2	9	0	8	0	0	0	2	7	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0
17	12	0	0	7	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	10	0	0	0	0	3	0	7	0	6	0	0	0	0	0	0	0	0	3	0	0	0	0	0
19	16	68	0	26	2	0	32	0	17	0	4	14	19	4	0	0	0	0	0	0	0	0	0	0
20	0	4	2	0	7	0	0	0	0	0	0	0	4	11	4	0	0	0	0	0	0	0	0	0
21	0	9	4	0	7	0	5	0	0	0	0	0	4	14	0	0	0	0	0	0	0	0	0	0
22	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
23	0	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0

Table 5.9 O-D Matrix for 3-Axle Truck

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	18	1	0	0	1	4	0	0	0	15	0	6	0	1	1	0	0	1	0	0	0	0	0
2	6	0	355	9	532	24	4	0	4	0	7	0	0	0	177	0	0	532	4	2	2	0	0	0
3	0	9	0	3	0	22	0	0	0	0	4	3	2	2	1	0	0	0	1	0	0	0	0	0
4	0	11	355	0	0	0	7	0	0	0	15	0	4	7	0	1	0	532	3	0	0	0	0	0
5	0	0	0	0	0	3	2	0	3	0	0	0	2	0	0	0	0	0	2	0	0	2	0	0
6	4	11	5	3	5	0	2	0	0	0	8	2	3	10	0	0	0	0	0	0	0	0	0	0
7	0	2	0	11	0	0	0	2	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	177	3	0	0	1	0	0
9	0	6	1	0	1	0	2	0	0	0	0	0	0	6	2	4	0	0	10	0	0	0	0	0
10	0	3	0	0	0	0	0	0	0	0	4	0	0	0	1	1	0	0	0	0	0	0	0	0
11	2	0	0	11	0	1	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0
12	2	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2	3	0	0	0	0	0
13	0	1	0	2	0	2	0	2	0	0	0	0	0	0	0	0	0	0	4	3	0	2	0	0
14	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0
15	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	3	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	3	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0
19	12	6	177	8	0	0	10	0	10	3	6	1	13	4	0	0	0	0	0	0	0	0	0	0
20	0	0	1	0	1	0	0	0	0	0	2	0	2	7	0	1	0	177	0	0	0	0	0	0
21	0	2	2	2	2	0	0	0	0	0	0	0	4	5	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	4	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
23	0	1	0	7	0	0	5	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.10 O-D Matrix for Multi - Axle Truck

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	4	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	22	0	0	30	0	0	0	0	0	0	0	0	2028	7	22	0	507	0	0
3	0	0	0	0	0	22	0	0	0	0	0	0	14	0	0	0	0	0	0	7	15	0	0	0
4	0	4	0	0	4	0	0	0	0	0	0	0	109	0	8	16	0	8	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	7	0	0	0	0	55	0	0	0	0	0	0	29	0	0	0
6	0	40	0	0	20	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	14	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	20	0	0	0	0	0	0	0	0	0	0	0	61	41	4	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	55	0	0	4	0	0	0	0	0	0	0	0
11	0	0	0	24	0	7	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0
13	0	0	0	24	0	24	0	0	0	0	0	0	0	0	0	0	0	4	71	0	7	0	0	0
14	0	0	0	0	0	15	0	0	7	0	0	0	0	0	0	0	0	0	63	22	30	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	7
16	6	0	0	6	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	7	0	11	0	0	0	0	30	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	20	0	0	0	0	0	0	0	40	81	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	20	0	0	0	0	0	0	0	55	40	20	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0
23	0	7	0	4	0	0	0	0	0	0	0	0	0	12	0	0	0	8	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0

Table 5.11 O-D Matrix for Cars/Jeeps

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	190	83	0	0	73	256	0	0	0	329	73	110	110	0	0	12	12	24	0	0	0	12	0
2	113	0	382	19	212	113	183	0	73	19	439	73	14	219	0	0	0	269	132	129	16	0	13	0
3	295	136	0	107	0	8	110	19	0	132	146	0	37	37	0	0	0	0	46	16	0	0	0	0
4	0	59	175	0	12	37	1170	0	0	0	914	219	219	560	0	36	24	50	128	0	0	0	13	0
5	116	185	0	128	0	151	37	19	40	38	37	0	0	0	0	0	0	0	19	82	8	0	13	8
6	19	435	235	0	235	0	329	0	19	0	585	0	164	400	0	0	0	0	86	0	0	0	0	0
7	404	630	214	1212	808	606	0	0	0	0	110	0	0	37	0	0	12	12	89	0	50	6	6	0
8	0	107	204	0	0	0	0	0	0	0	73	73	0	97	12	48	95	62	110	0	0	0	0	0
9	0	209	119	0	0	0	0	37	0	0	0	0	0	18	24	48	24	59	84	0	0	0	0	0
10	0	50	0	0	0	0	73	0	0	0	73	37	73	73	0	0	0	12	6	0	0	0	0	0
11	656	252	14	1111	404	335	0	0	16	0	0	0	0	0	0	101	0	50	86	32	8	26	13	0
12	0	98	36	50	0	101	0	0	50	0	0	0	0	0	0	12	12	0	65	0	0	6	19	0
13	454	98	83	404	50	202	0	101	0	0	0	0	0	0	0	86	24	36	199	50	0	26	13	0
14	89	0	0	231	0	32	0	50	16	0	0	0	0	0	0	0	0	0	142	105	8	26	6	0
15	0	0	0	86	0	16	0	85	54	0	0	37	0	0	0	0	0	0	55	57	8	0	6	0
16	57	49	0	114	0	18	0	29	38	161	0	19	0	0	0	0	0	0	13	0	0	0	0	0
17	151	0	0	0	0	0	0	132	38	38	0	19	37	0	0	0	0	0	0	0	0	0	0	0
18	29	10	0	29	0	0	73	48	0	57	110	19	37	37	0	0	0	0	130	0	0	6	0	0
19	45	244	0	163	61	0	54	19	46	0	102	160	138	145	0	0	0	14	0	0	0	0	0	0
20	0	36	18	0	0	8	0	0	0	0	0	0	0	91	0	0	0	0	8	0	0	0	0	0
21	0	18	72	0	18	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0
22	0	0	12	7	7	0	0	0	0	0	0	7	14	0	0	0	0	0	0	0	0	0	0	0
23	0	14	0	20	7	0	14	0	0	0	20	0	7	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.12 O-D Matrix for Two-Wheelers

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	6720	3162	0	687	0	0	0	0	0	583	291	0	0	0	395	0	0	514	0	0	0	0	0
2	1248	0	6233	234	959	12581	2040	0	740	0	291	0	0	0	0	479	0	0	11335	987	0	0	0	0
3	4600	8335	0	1092	0	247	0	194	247	858	583	291	0	0	0	0	0	0	385	0	0	0	0	0
4	0	791	0	0	0	0	1749	0	0	0	583	1166	0	687	395	395	0	0	1926	0	0	0	0	0
5	156	194	0	194	0	1727	1457	194	247	0	1749	0	0	0	0	0	0	0	2603	0	0	0	0	0
6	390	6552	2730	78	3003	0	874	0	0	0	583	291	837	2184	0	0	0	0	291	247	0	0	0	0
7	1658	1105	553	3316	1658	276	0	0	0	0	0	0	0	0	0	276	0	0	128	0	0	0	0	0
8	0	0	0	0	0	0	291	0	0	0	583	291	0	0	0	395	0	0	385	0	0	0	0	0
9	0	1732	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128	0	0	0	0	0
10	0	276	0	0	276	0	0	0	0	0	291	0	0	291	0	0	0	0	0	0	0	0	0	0
11	829	553	0	5251	276	1293	0	0	0	0	0	0	0	0	0	0	0	0	385	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	395	0	642	0	0	0	0	0
13	0	0	0	553	0	0	0	0	0	0	0	0	0	0	0	0	0	0	257	0	0	0	0	0
14	0	0	0	0	0	1727	0	0	0	0	0	0	0	0	0	0	0	0	514	493	0	0	0	0
15	78	0	0	0	0	1480	0	156	0	78	0	0	0	0	0	0	0	0	0	493	247	0	0	0
16	858	0	0	78	0	0	0	78	0	312	0	0	0	0	0	0	0	0	0	247	0	0	0	0
17	234	0	0	156	0	0	78	78	234	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	78	0	0	291	156	0	0	0	78	0	0	0	0	0	0	385	0	0	0	0	0
19	78	19215	1438	0	0	0	78	0	78	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	819	273	0	0	0	0	0	0	0	0	0	0	273	0	0	0	0	0	0	0	0	0	0
21	0	2184	273	0	0	291	0	0	0	0	0	0	273	546	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.13 O-D Matrix for Passengers Auto

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	374	249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	310	0	432	0	0	2692	0	0	0	0	0	0	0	0	0	0	0	0	2640	0	0	0	0	0
3	420	432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	66	2252	409	0	409	0	0	0	0	0	0	0	0	1638	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0
9	0	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	62	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	3768	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.14 O-D Matrix for Buses

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	402	201	0	0	134	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0
2	303	0	0	0	0	302	0	101	0	101	0	0	0	0	0	0	0	0	78	151	0	0	0	0
3	808	0	0	101	0	151	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	67	0	67	0	0	0	0	0	0	0	0	67	0	67	0	201	78	0	0	0	0	0
5	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	0	0	0	0	0
6	101	959	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	67	67	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0	0
8	0	134	134	0	0	0	0	0	0	0	0	0	0	0	67	67	67	0	78	0	0	0	0	0
9	0	201	201	0	0	0	0	0	0	0	0	0	0	0	0	0	134	0	78	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	157	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	134	0	0	0	151	0	0	0	0	0	0	0	0	0	67	0	0	157	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	0	0	0	0
16	202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	202	0	0	202	0	0	0	0	0	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	101	0	0	0	0	0	0	0	0	0	0	0	0
19	0	414	0	129	110	0	0	0	0	0	0	0	28	28	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.15 O-D Matrix for Maxi Cabs/Vans

O/D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	0	58	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0
2	44	0	0	29	0	751	0	29	83	0	0	15	0	0	0	0	0	0	297	125	0	0	0	0
3	59	0	0	0	0	42	0	0	42	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	19	0	0	0	228	0	0	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0	42	0	0	0	0
6	0	0	0	0	0	0	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	91	0	0	137	91	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	46	0	0	182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	65	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	83	0	0	0	0	0	0	0	0	0	0	0	0	0	83	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83	42	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

5.4 Traffic Forecasting

The traffic forecast for the project corridor is carried out by the transport demand elasticity method, which is a proven technique worldwide and is the preferred technique in India. While the forecast is considered to be reliable for a period of 10 years, the forecast beyond 10 years can only be indicative, as there are certain policy variables that could change in long run and cannot be predicted based on the past performance. The vehicle registration data has been obtained from the available State Government sources. Similar time series past data on economic and demographic variables for Tamil Nadu State such as population, state income (NSDP) at constant prices and per capita income at constant prices also collected.

5.4.1 Transport Demand Elasticity

Elasticity of traffic demand is defined as the rate at which traffic changes due to changes in the corresponding selected economic variables. The growth rate for calculating elasticity is adopted by vehicles positions in Tamil Nadu; because the growth rates observed are to be more realistic as compared to the past traffic data. Therefore, to estimate the elasticity of traffic demand, we have established the relationship between the traffic growth of a particular vehicle with the economic variables considered, such as NNP, NSDP, per capita income and population growth of Tamil Nadu. The vehicle positions data is collected from the Road Transport year book and its growth rate is calculated from Linear Regression Analysis. The growth rate of registered vehicles is given in **Table 5.16**. The growth rate of Economic Indicators at Constant Prices (2004-05) is given in **Table 5.17**. The schematic of linear regression graph of various vehicles & economic indicators is shown in below.

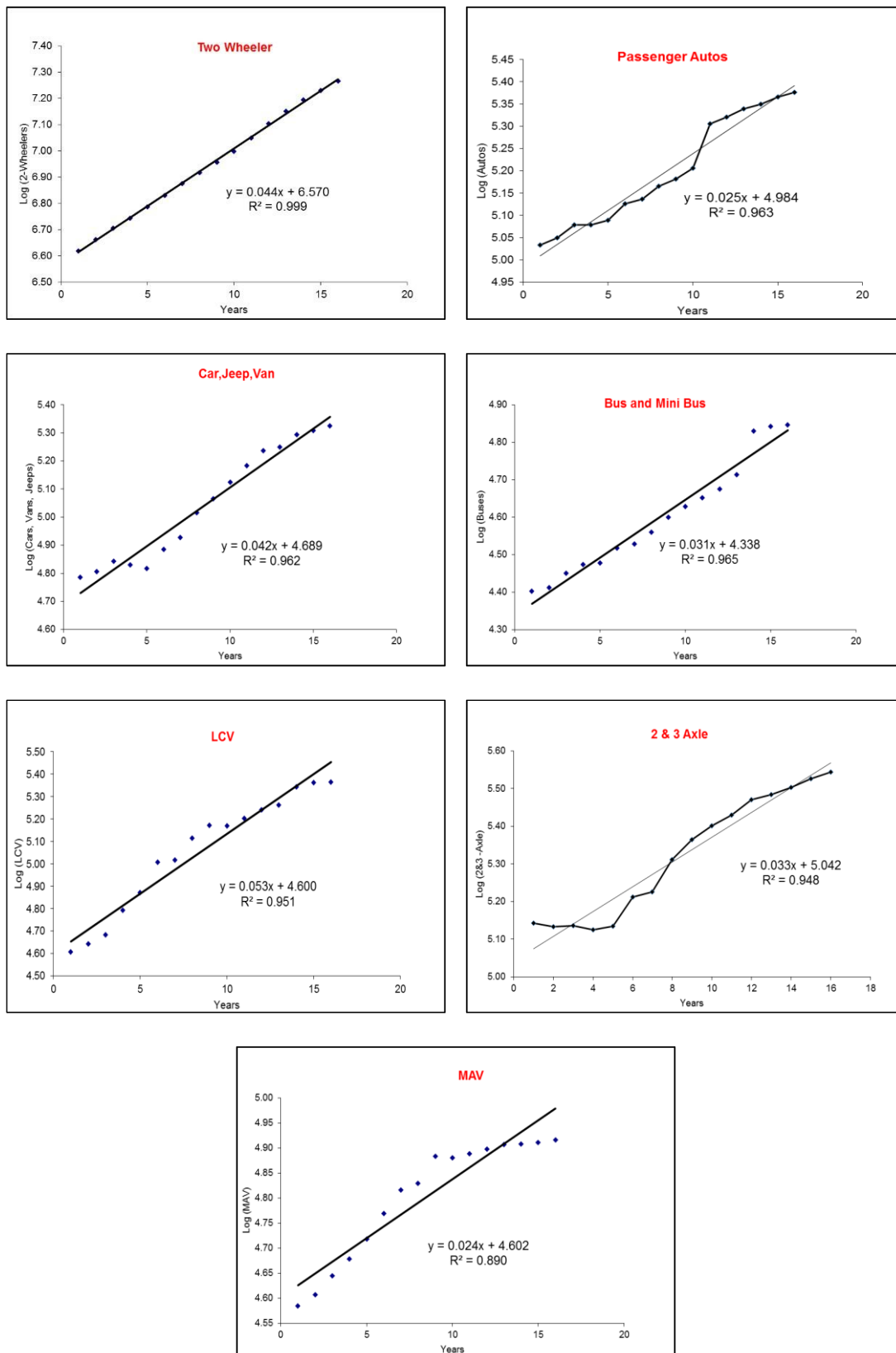
Table 5.16 Growth Rates for Registered Vehicles in Tamil Nadu

Sl. No.	Year	No. of Vehicles							Log (No. of Vehicles)						
		Two-Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV	Two-Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV
1	2000-01	4163002	108090	61032	25265	40598	139007	38431	6.62	5.03	4.79	4.40	4.61	5.14	4.58
2	2001-02	4600565	111942	64036	25805	43864	136113	40431	6.66	5.05	4.81	4.41	4.64	5.13	4.61
3	200-03	5073643	119719	69804	28158	48239	136770	44084	6.71	5.08	4.84	4.45	4.68	5.14	4.64
4	2003-04	5547755	119937	67647	29732	62240	133254	47655	6.74	5.08	4.83	4.47	4.79	5.12	4.68
5	2004-05	6106057	122832	65811	30061	74380	136440	52248	6.79	5.09	4.82	4.48	4.87	5.13	4.72
6	2005-06	6750328	133639	76990	32957	101637	162932	58706	6.83	5.13	4.89	4.52	5.01	5.21	4.77
7	2006-07	7503426	136986	84668	33767	103911	168393	65488	6.88	5.14	4.93	4.53	5.02	5.23	4.82
8	2007-08	8260019	146244	103816	36274	130659	204562	67579	6.92	5.17	5.02	4.56	5.12	5.31	4.83
9	2008-09	9036783	152072	116291	39790	148375	231493	76448	6.96	5.18	5.07	4.60	5.17	5.36	4.88
10	2009-10	9969598	160734	133055	42496	148249	251784	75931	7.00	5.21	5.12	4.63	5.17	5.40	4.88
11	2010-11	11207338	202133	152377	44867	160002	269167	77311	7.05	5.31	5.18	4.65	5.20	5.43	4.89
12	2011-12	12659928	209003	172494	47335	173857	295080	79053	7.10	5.32	5.24	4.68	5.24	5.47	4.90
13	2012-13	14150373	218329	177410	51666	183433	304523	80610	7.15	5.34	5.25	4.71	5.26	5.48	4.91
14	2013-14	15595140	223702	196651	67569	220765	318546	80857	7.19	5.35	5.29	4.83	5.34	5.50	4.91
15	2014-15	16991527	232112	203495	69600	230717	336139	81548	7.23	5.37	5.31	4.84	5.36	5.53	4.91
16	2015-16	18400635	237970	211114	70169	232309	349497	82516	7.26	5.38	5.32	4.85	5.37	5.54	4.92
Source: Govt of Tamilnadu, State Transport Authority						Const in Equation			0.044	0.025	0.042	0.031	0.053	0.033	0.024
						Growth Rate			10.66%	6.17%	10.41%	7.15%	13.76%	8.14%	5.93%

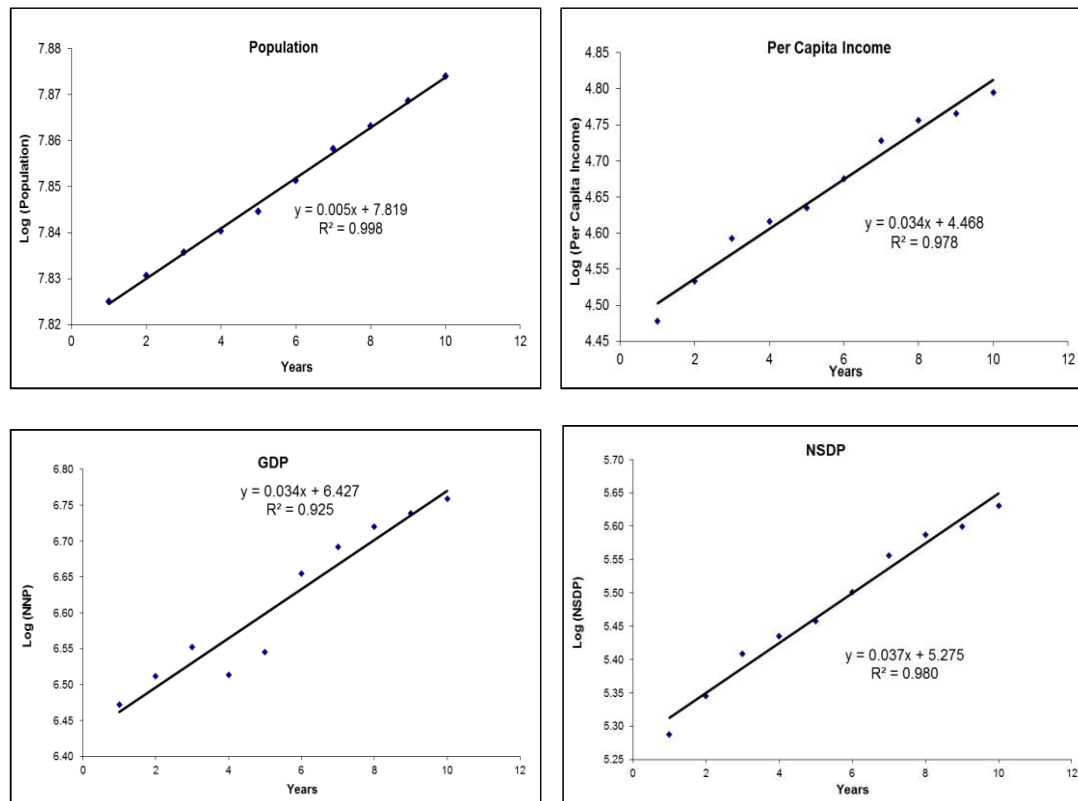
Table 5.17 Growth Rate of Socio-Economic Indicators at Constant Price

Sl. no	Year	Population	Per Capita Income	GDP	NSDP	Log			
			At Constant Prices (04-05) (in Rs)	At Constant Prices (04-05) (Rs in crore)	At Constant Prices (04-05) (Rs in Lacs)	P	PCI	NNP	NSDP
1	2004-05	66836000	30062	2967599	193645	7.83	4.48	6.47	5.29
2	2005-06	67698000	34126	3249130	221588	7.83	4.53	6.51	5.35
3	2006-07	68501000	39166	3564627	256286	7.84	4.59	6.55	5.41
4	2007-08	69251000	41314	3264011	272340	7.84	4.62	6.51	5.44
5	2008-09	69926000	43193	3506734	286744	7.84	4.64	6.54	5.46
6	2009-10	71009000	47394	4516071	316760	7.85	4.68	6.65	5.50
7	2010-11	72147039	53507	4918533	359961	7.86	4.73	6.69	5.56
8	2011-12	72980698	57093	5247530	386508	7.86	4.76	6.72	5.59
9	2012-13	73897443	58360	5482111	397471	7.87	4.77	6.74	5.60
10	2013-14	74811251	62361	5741791	427182	7.87	4.79	6.76	5.63
Const. in Equ.						0.005	0.034	0.034	0.037
Growth Rate						1.16%	8.25%	8.14%	8.99%

Source: Socio Economic Survey of Tamil Nadu 2013-14



Schematic Diagram of Linear Regression Graph of Vehicles



Schematic Diagram of Linear Regression Graph of Economic Indicators

Elasticity for passenger vehicles (Two Wheelers, Three Wheelers & Cars)

$$E = G / ((1+G_p) * (1+G_{pci}) - 1)$$

$$E = G / 9.50$$

Where

G_p = Growth Rate of Population

G_{pci} = Growth Rate of Per Capita Income

Elasticity for Buses

$$E = G / \text{growth rate of NSDP}$$

$$E = G / 8.99$$

Elasticity for Trucks and MAV

$$E = G / (\text{NSDP of States} + \text{GDP})$$

$$E = G / 17.13$$

The Comparison of Elasticity with IRC and vision 2021 is shown in **Table 5.18**

Table 5.18 Comparison of Elasticity

Source	Two Wheeler	Passenger Auto & Cab	Car/Jeep	Bus	LCV	2 & 3 Axle	MAV
Elasticity as per calculation	1.12	0.65	1.10	0.80	0.80	0.48	0.35
Elasticity as per SP-19	2.50	2.50	2.00	1.60	2.00	2.00	2.00
Elasticity as per vision 2021 (MoRT&H)	-	-	1.70	1.40	1.50	1.50	1.50

Based on the elasticity, the consultant have divided the growth rate into three scenarios i.e. Most likely, Optimistic and Pessimistic scenario. In the most likely scenario the consultant have adopted the minimum elasticity obtained from the different sources as mentioned in the **Table 5.18** above. For the Optimistic Scenario, the consultant adopted maximum elasticity. But elasticity is too much higher for the first five year i.e. year 2013 to 2018 and development goes fast after the construction of the highway. Therefore the optimistic scenario, the consultant has adopted the same elasticity for first five year i.e. 2013 to 2018 as in the most likely. For the pessimistic scenario it is assume that if nothing is to be happen in the future regarding developments, growth will be minimum 5% for all vehicle category. The elasticity adopted in the base year, further reduce by 10% in the five years slab as per IRC SP: 19 2001. Elasticity of Mostly like Scenario and Optimistic Scenario in different year as shown in the **Table 5.19 & 20** respectively.

Table 5.19 Elasticity in Different Years (Most Likely Scenario)

Year	Two Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV
2004-2016	1.12	0.65	1.10	0.80	0.80	0.48	0.35
2016-2020	1.01	0.58	0.99	0.72	0.72	0.43	0.31
2020-2025	0.91	0.53	0.89	0.64	0.65	0.38	0.28
2025-2030	0.82	0.47	0.80	0.58	0.59	0.35	0.25
2030-2035	0.74	0.43	0.72	0.52	0.53	0.31	0.23
2035-2040	0.66	0.38	0.65	0.47	0.47	0.28	0.20
2040-2045	0.60	0.35	0.58	0.42	0.43	0.25	0.18

Table 5.20 Elasticity in Different Years (Optimistic Scenario)

Year	Two Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV
2004-2016	1.12	0.65	1.10	0.80	0.80	0.48	0.35
2016-2020	1.07	0.62	1.04	0.76	0.76	0.45	0.33
2020-2025	1.01	0.59	0.99	0.72	0.72	0.43	0.31
2025-2030	0.96	0.56	0.94	0.68	0.69	0.41	0.30
2030-2035	0.91	0.53	0.89	0.65	0.65	0.39	0.28
2035-2040	0.87	0.50	0.85	0.62	0.62	0.37	0.27
2040-2045	0.82	0.48	0.81	0.58	0.59	0.35	0.25

Based on elasticity adopted, econometric model run for each case separately and find out the growth rate. The growth rate of corresponding scenario in different year is shown in the Table 5.21, 22 & 23 respectively.

Table 5.21 Growth Rate of Most Likely Scenario

Year	Two Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV
2016-2020	9.59%	5.55%	9.37%	6.44%	12.38%	7.33%	5.34%
2020-2025	8.63%	5.00%	8.43%	5.79%	11.15%	6.59%	5.00%
2025-2030	7.77%	5.00%	7.59%	5.21%	10.03%	5.93%	5.00%
2030-2035	6.99%	5.00%	6.83%	5.00%	9.03%	5.34%	5.00%
2035-2040	6.29%	5.00%	6.15%	5.00%	8.13%	5.00%	5.00%
2040-2045	5.67%	5.00%	5.53%	5.00%	7.31%	5.00%	5.00%

Table 5.22 Growth Rate of Optimistic Scenario

Year	Two Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV
2015-2020	10.13%	5.86%	9.89%	6.79%	13.07%	7.73%	5.63%
2020-2025	9.62%	5.57%	9.40%	6.45%	12.42%	7.35%	5.35%
2025-2030	9.14%	5.29%	8.93%	6.13%	11.80%	6.98%	5.08%
2030-2035	8.68%	5.03%	8.48%	5.82%	11.21%	6.63%	5.00%
2035-2040	8.25%	5.00%	8.06%	5.53%	10.65%	6.30%	5.00%
2040-2045	7.84%	5.00%	7.65%	5.26%	10.11%	5.98%	5.00%

Table 5.23 Growth Rate of Pessimistic Scenario

Year	Two Wheeler	Passenger Auto	Car/Jeep	Bus	LCV	2 & 3 Axle Trucks	MAV
2015-2020	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
2020-2025	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
2025-2030	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
2030-2035	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
2035-2040	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
2040-2045	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%

5.5 Traffic Projections

Traffic projections were made by applying the mode-wise growth rates as discussed above to the base year (2023) traffic. Mode-wise projections are undertaken upto horizon year of 2040. The projected traffic in AADT (PCU) for Pessimistic case from different point location of project corridor is illustrated in **Table 5.24** respectively.

Table 5.24 Projected Traffic in AADT (PCU) for Most Likely Case

Year	Vellore Bypass
2023	14528
2024	15254
2025	16017
2026	16818
2027	17659
2028	18542
2029	19469
2030	20442
2031	21464
2032	22538
2033	23665
2034	24848
2035	26090
2036	27395
2037	28764
2038	30203
2039	31713
2040	33298
2041	34963
2042	36712
2043	38547
2044	40474
2045	42498
2046	44623
2047	46854
2048	49197
2049	51657
2050	54240
2051	56952
2052	59799
2053	62789
2054	65929

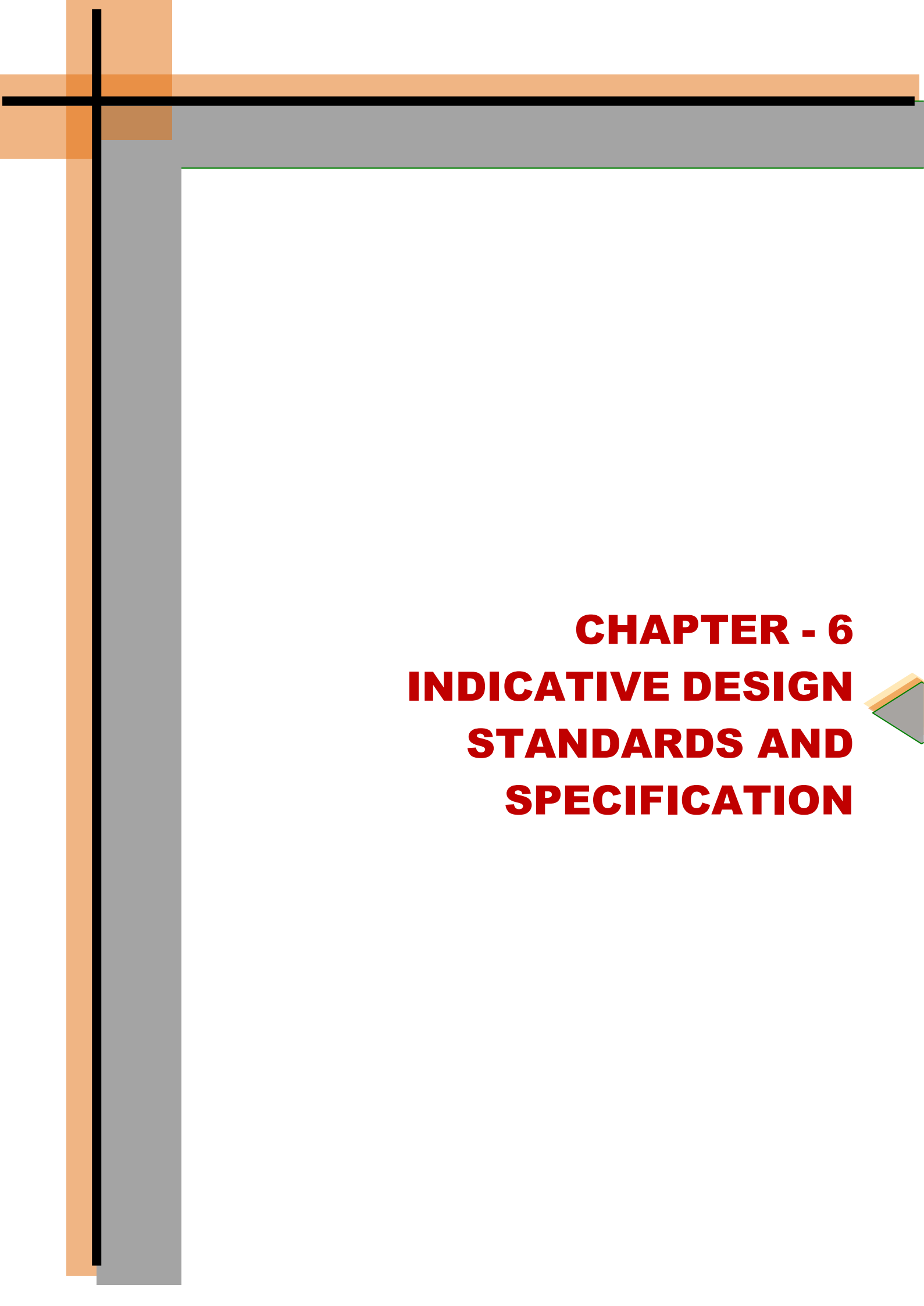


- Warrant for Four lane Capacity
- Warrant for Six lane Capacity

5.6 Capacity Analysis

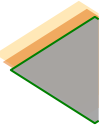
Capacity analysis for the project corridor is carried out in order to assess the Level of Service (LOS) offered by road sections under prevailing roadway and traffic conditions. Capacity and Design Service Volumes (DSV) specified in **IRC-64-1990**, Capacity of Roads in Rural Areas have been adopted for determining the Level of Service offered by road sections during study period. Based on the average rise & fall observed from the field surveys, the project corridor runs through Plain terrain only. The projected sectional traffic is compared with Design Service Volume (DSV) to assess the up-gradation requirement for the corridor under prevailing roadway conditions. Capacity augmentation is generally warranted for roads that cater to traffic volumes in excess of the DSV at LOS B.

As it is seen from the above table that the Vellore Bypass is sustain with four lane with Paved Shoulder configuration upto design period of 18th year (2044) respectively. Therefore, the proposed bypass is developed as four lane with Paved Shoulder.



CHAPTER - 6

INDICATIVE DESIGN STANDARDS AND SPECIFICATION



CHAPTER 6

INDICATIVE DESIGN STANDARDS AND SPECIFICATIONS

6.1 General

The basic objective of good functional road design is to arrange the physical elements of the highway to meet traffic volume capacity, safety and vehicle operating cost requirements of drivers and vehicles. The criteria of safety and economy are often in conflict and the application of design standards to a specific project often have to provide a “trade-off”, i.e. to provide an appropriate and acceptable compromise between engineering and economic constraints.

6.2 Design Standards

The stretch of the stand alone bypass of Vellore Town, under the scope of study, runs predominantly through plain terrain. The alignment passes through many villages along the road which are densely populated. Sound geometric design results in economical operation of vehicles and ensures safety. This section describes the standards and principles based on which the various designs will be carried out. The proposed standards are consistent with the parameters recommended in the relevant standards of the Indian Roads Congress (IRC) publications, MORT&H circulars and relevant recommendations from NH, Vellore. The design standards as stated would be ensured with a realistic compatibility within the proposed ROW.

The proposed road as a partially access controlled highway with undivided carriageway. The geometric design of roadways deals with the portioning of the physical elements of the roadway according to standards and constraints. The basic objective in geometric design is to provide a smooth-flowing, crash-free facility. Geometric roadway design can be broken into two main parts: Horizontal geometry and Vertical geometry. Combined, vertical and horizontal geometry provide a three-dimensional layout for a roadway. The design principles of the good geometry of the road can be set out in the following paragraphs:

- The designed geometry shall not become obsolescent before the design year. As such, both horizontal and vertical geometry should be accorded due importance and shall be designed with care as the deficiencies are costly and sometimes impossible to rectify later on due to the subsequent roadside development.

- Uniformity of design standards shall be maintained throughout the length of the project stretch. In case of any change, it shall be affected in a gradual manner.
- Design shall be consistent and coherent. The standards followed for different elements shall be compatible with one another.
- The design shall cover all geometric aspects of road and more emphasis shall be given to Road Safety of the road users.
- The design shall be carried out aiming at minimizing the vehicle operating cost including initial cost, cost of maintenance etc and maximizing the road safety.
- The design shall take into consideration the environmental, aesthetic and landscaping aspects of the project road.
- The vertical alignment should provide for a smooth longitudinal profile consistent with category of the road and lay of the terrain.
- Safety should form an integral part of the design elements.
- “Ruling” standards should be followed as a matter of routine. “Minimum” standards should be followed only where serious restrictions are imposed by technical or economic considerations.

Design Standards set out in following codes have been followed:

IRC: 32 - 1969	Standard for Vertical and Horizontal Clearances of Overhead electric Power and Telecommunications Lines as Related to Roads
IRC: 54 - 1974	Lateral and Vertical Clearances at Underpasses for Vehicular Traffic
IRC: 64 - 1990	Guidelines for Capacity of Roads in Rural Areas
IRC: 62 - 1976	Guidelines for control of Access of Highways
IRC: 66 - 1976	Recommended Practice for Sight Distance on Rural Highways
IRC: 73 - 1980	Geometric Design Standards for Rural (Non-Urban) Highways

The proposed design standards have been developed after a careful review of above available design guidelines and the requirements of the project road. These design standards have been discussed in the following sections:

6.3 Terrain Classification

The Project road under study passes mostly through a plain and rolling terrain. Geometric design of a highway is influenced significantly by terrain conditions. Geometric standards relevant to plain terrain as given in **IRC: 73-1980** and **IRC: SP: 84-2019** have been taken into consideration while setting out the design standards.

6.4 Design Speed

The design speed is a selected speed used to determine the various geometric design features of the roadway. There are a number of factors involved in determining the design speed of a particular road, including its functional classification, its geometric design, the actual operating speed of the road, the maximum speed limit permissible by law, and the traffic volume of the road. As a principle, it is desirable that the proposed design speed be consistent with general topography and adjacent land use. The speed selected for design should also be suitable to travel needs and habits of nearly all road users. **For National Highways the desirable (ruling) design speeds as per IRC: 73-1980 is 100 km/h for plain/rolling terrain and have been adopted for the Project highway.**

6.5 Level of Service (Los)

The Level of Service (LOS) characterizes the operating conditions on the roadway in terms of traffic performance measures related to speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience. The levels of service range from level-of-service A (least congested) to level of service F (most congested). The Highways Capacity Manual (HCM) provides the following levels of services in **Table 6.1**.

Table 6.1 Level of Service

Level of Service (LOS)	General Operating Conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Capacity analysis is carried out to identify the present and future level of services at various sections of project road. **IRC 64: 1990** recommends Level of Service (LOS)-B for rural roads. Thus it will be identified whether LOS-B is being maintained during the designed period of the project. IRC has recommended the following design service volumes in **Table 6.2**.

Table 6.2 Design Service Volumes @ “B”

Carriage Width	Terrain	Curvature (degree/km)	Design Service Volume (PCU/Day)
Four lane	Plain		35000 (earthen shoulder) 40000 (paved shoulder)

These values of Design Service Volume have been kept in view while considering improvement proposals for the project road.

6.6 Right-of-Way (RoW)

The **IRC: 73-1980** design standards specify a range of 30 m to 60 m (normal 50 m) Right-of-Way width for Access Controlled National highways in the plain / rolling terrain.

6.7 Cross-Sectional Elements

6.7.1 Lane Width

The standard lane width as per IRC: SP: 84-2019 of a basic traffic lane is taken to be 3.5 m. Thus, for 2-lane and 3-lane carriageways, the carriageway widths will be 7.0 m and 10.5 m, respectively.

6.7.2 Shoulders

A roadside shoulder is a reserved area by the verge of a road or motorway. Generally it is kept clear of all traffic. In the event of an emergency or breakdown, a motorist can pull into the hard/paved shoulder to get out of the flow of traffic and obtain an element of safety. Shoulders are a critical element of the roadway cross section. A paved shoulder also allows some extra flexibility should a motorist need to take evasive action, as it is a buffer area between the main thoroughfare and the edge of the road. Shoulders provide recovery area for errant vehicles; a refuge for stopped or disabled vehicles; and access for emergency and maintenance vehicles. Shoulders can also provide an opportunity to improve sight distance through large cut sections. The shoulder width on the outer side as given in IRC: SP: 84-2019 is 3.0 m wide (1.5 m paved and 1.5 m earthen) for open country with isolated built up areas.

6.8 Horizontal Alignment

6.8.1 Radii of Horizontal Curves

The Radius required for horizontal curves shall be calculated from the following formulae:

$$R = \frac{V^2}{127(e + f)}$$

Where, R = Radius in meters

V = Vehicle speed in km/hour

e = Super-elevation ratio in meter/meter

f = Coefficient of side friction between vehicle tyres and the pavement
(taken as 0.15)

Based on the above equation and the maximum permissible values of super elevation taken as 7.0%, for a speed of 100 km/h, minimum radius is 400m. According to the **IRC: 73-1980** design standards, the desirable (ruling) radii of horizontal curves are 360m and 230m, for plain/rolling terrains, corresponding to design speeds of 100km/h and 80km/h. On new roads, horizontal curves should be designed to have the largest practical radius generally more than the above values corresponding to design speed. The Consultants recommend providing higher radii for smooth curvatures to accommodate possibility of higher speeds in future. This is because improvements in horizontal geometry are likely to prove very costly if taken up in future. Hence the radii proposed are as follows which also correspond to the maximum super-elevation values of 5.0%.

6.8.2 Transition (Spiral) Curves

A transition curve, transition spiral, or spiral easement, is a mathematically calculated Euler spiral fitted between a straight and a circular curve on a section of highway. In plan (i.e., the horizontal curve) the start of the transition is at infinite radius and at the end of the transition it has the same radius of curvature as the adjoining circular curve, thus forming a very broad spiral. At the same time in the vertical plane, the outside of the curve is gradually raised until the full super elevation is reached. A spiral easement is used to smooth the change in centripetal acceleration experienced by a road vehicle and the users approaching the horizontal circular curve and to prevent abrupt forces and discomfort. Without such an easement the centripetal force would change abruptly, with very undesirable results, at the tangent point where the straight track meets the curve. Minimum length of the transition curve will be determined from the following considerations and the largest of the three values

will be adopted for design.

1. Rate of change of centrifugal acceleration, the length of transition curve is

given by: $L_s = 0.0215V^3 / CR$

Where, L_s = Length of transition in meters

V = Speed in km/hr

R = Radius of circular curve in meters

C = $80/(75+V)$ (Subject to a maximum of 0.8 and minimum of 0.5)

2. Rate of change of super-elevation, the minimum length of transition is given

by: $L_s = e N W$

Where, L_s = Length of transition in meters

W = width of carriageway

N = Rate of change of super elevation (Not steeper than 1 in 150 for roads in plain & rolling terrain)

e = super elevation ratio in meter/ meter

3. Based on Empirical Formula, the minimum length of transition is given

by: $L_s = 2.7 V^2 / R$

The **IRC: 73-1980** design standards suggest 130 m and 90 m transition curve lengths for circular curves of radii 360 m and 230 m (design speeds of 100 km/h and 80 km/h). The Consultants propose maximum transition curve lengths of 115 m and 90 m for design speeds of 100 km/h and 80 km/h respectively. No transition curve will be required for a horizontal radius of 2000m or more for a design speed of 100 km/h.

6.8.3 Super-Elevation

Super elevation is tilting the roadway to help offset centripetal forces developed as the vehicle goes around a curve along with friction that keep a vehicle from going off the road. Super-elevation required on horizontal curves shall be calculated from the following formulae:

$$e = V^2 / 225R$$

Where, e = super-elevation in meter/meter

V = speed in km/hr

R = Radius in meters

The **IRC: 73-1980** design standards propose a maximum super-elevation rate of 7% for plain and rolling terrains, and 7% to 10% for the mountainous terrain. However, it has been experienced that high super-elevation causes the reduction in sight distance especially at junctions and in hill sections. Also, as mixed traffic is expected and high value of super elevation tends to generate high speeds, there are more chances of accident at curves. To enhance the safety aspects, the Consultant's propose 5.0% maximum super-elevation rate for the project road. The radii of curves which do not require super-elevation are as under:

- (a) For design speed of 100 km/h: 2000 m
- (b) For design speed of 80 km/h: 1400 m

6.8.4 Pavement Camber or Cross fall

According to **IRC:73-1980**, the crossfall on straight sections of road carriageway, paved shoulders shall be 2.5% for bituminous surface and 2.0% for cement concrete surface. Cross fall for granular shoulders on straight portions shall be at least 0.5% steeper than the slope of the pavement and subject to a minimum of 3 percent.

6.8.5 Sight Distances

Sight distance, in the context of road design, is how far a road user (usually a vehicle driver) can see before the line of sight is blocked by a hill crest, or an obstacle on the inside of a horizontal curve or intersection. Insufficient sight distance can have implications for the safety or operations of a roadway or intersection. The ability to see ahead is of critical importance in the safe and efficient operation of a vehicle. Sight distances are a direct function of the design speed, perception-reaction time, driver eye height, object height and the coefficient of pavement friction.

6.8.5.1 Stopping Sight Distance

Stopping sight distance is the distance traveled while the vehicle driver perceives a situation requiring a stop, realizes that stopping is necessary, applies the brake, and comes to a stop. Actual stopping distances are also affected by road conditions, the mass of the vehicle, the incline of the road, and numerous other factors. For design, a conservative distance is needed to allow a vehicle traveling at design speed to stop before reaching a stationary object in its path. Typically the design sight distance allows a below-average driver to stop in time to avoid a collision. The stopping sight distance is a sum of two distances –the distance traversed by the vehicle from the instance the driver sights an object necessitating a stop to

the instant the brakes are applied and the distance required to bring the vehicle to a complete stop from the instant brake are applied. Desirable stopping sight distances as per **IRC: 73-1980** design standards are 180 m, 130 m for design speeds of 100 km/h, 80 km/h respectively.

6.9 Vertical Alignment

6.9.1 Gradients

The vertical alignment should provide for a smooth longitudinal profile. Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile. Guidelines given in IRC: 73-1980 shall be followed.

6.9.2 Maximum Grades

The IRC: SP-73:2015 geometric design standards propose ruling vertical grades of 2.5% and limiting gradient to 3.3% for plain and rolling terrains. The consultants propose a maximum 3.3% vertical grade for plain and rolling terrains.

6.9.3 Minimum Grades

To ensure adequate drainage, roadways typically have a minimum longitudinal grade of 0.5% to 0.6%, depending on the terrain. A minimum longitudinal gradient of 0.3% is considered adequate in most conditions to secure satisfactory drainage as per **IRC: SP: 42**. Hence the consultants propose a minimum 0.3% vertical grade. The minimum longitudinal grades as per **IRC: 73-1980** design standards are 0.5% for lined side ditches and 1.0% for unlined side ditches.

6.9.4 Vertical Curves

Vertical Curves are the second of the two important transition elements in geometric design for highways, the first being Horizontal Curves. A vertical curve provides a transition between two sloped roadways, allowing a vehicle to negotiate the elevation rate change at a gradual rate rather than a sharp cut. The design of the curve is dependent on the intended design speed for the roadway, as well as other factors including drainage, slope, acceptable rate of change, and friction. These curves are parabolic and are assigned stationing based on a horizontal axis. Vertical curves should be provided at all grade changes exceeding 0.5%. Vertical curves will be designed to provide for visibility at least corresponding to the safe

stopping sight distance. More liberal values will be adopted wherever this is economically feasible. As per **IRC: 73-1980** design standards, the minimum lengths of vertical curves are 60 m and 50m for design speeds of 100 km/h and 80 km/h respectively.

6.9.5 Summit or Crest Curves

Summit or Crest Curves are designed for safe stopping sight distance. The Consultants propose minimum summit curve K values of 75 and 33 for design speeds of 100 km/h and 80 km/h respectively as mentioned in **IRC: SP 23-1983**.

6.9.6 Valley or Sag Curves

Valley or Sag Curves are designed for headlight sight distance. The Consultant propose minimum K values for valley or sag curves recommended by **IRC: SP 23-1983** as 42 and 26 for design speeds of 100 km/h and 80 km/h respectively.

For a good vertical design generally:

- At locations of grade break of 0.5%, vertical curves will be provided.
- The length of vertical curve will be not less than 0.6V (kmph).
- At locations of sight deficiency, at least Stopping Sight Distance (SSD) will be provided

6.10 Drainage System

Adequate drainage is a primary requirement for maintaining the structural soundness and functional efficiency of a road. Pavement structure including sub-grade must be protected from any ingress of water, otherwise over a period of time it may weaken the sub-grade by saturating it and cause distress in the pavement structure. In the drainage design, rapid dispersal of water from pavement and sub-grade shall be the basic consideration.

Alignment of the road can have a vital bearing on provision of proper drainage. Therefore, while fixing the alignment care shall be exercised to allow proper drainage of rain water from the road surface.

The proposed bypass road is passing through plain and rolling terrain. At locations where there are no service roads, that is, un-kerbed road sections, near level longitudinal gradient shall be adopted. Road sections with kerbs on the sides of the pavement shall be given a minimum gradient of 0.1% for effective drainage.

Rain water falling on the road surface shall be taken off quickly by providing a camber to the road surface. Following rates of camber shall be applied for various surfaces:

Bituminous pavement for Carriageways and Paved shoulders (Main carriageway & Service Road)	- 2.5%
Concrete pavement for Carriageways and Paved shoulders	- 2.0%
Earthen shoulders	- 3.0%

6.10.1 Sub-Surface Drainage

Drainage of the pavement layers across the earthen shoulders has an important bearing on the performance of the pavement. In order to effect proper drainage, bottom layer of Granular Sub Base shall be extended for the full width of formation, when the road formation is in filling. At locations, where the road is in cutting or at locations of service road, where the road retained by lined drains, the bottom of the drains shall be fixed at least 125 mm below the Granular Sub Base layer bottom. When lined drain abuts the main road or service road, weeps holes shall be provided on the side wall of the drains for sub surface drainage.

6.10.2 Side Drains

Rural sections without service roads shall be provided with side ditches of required cross section on both sides. The sides of the side ditches shall be turfed to prevent erosion.

Side ditches shall be given a trapezoidal shape with a flat bottom of 0.6 m width and side slope 1 vertical to 2 horizontal. Side ditches shall be given a gradient between the minimum value of 0.1 % and a maximum value of 3.0% so as to restrict the flow velocity within 1.5 m/sec. Side ditches shall be connected to the nearest culvert/rain water harvesting pits.

At the location where foot paths are provided at the end of service roads, closed lined drains shall be provided below the foot paths. The capacity of the drains shall be sufficient to carry the discharge from the main carriageway and the service roads. Invert level of the drain shall be fixed at least 125 mm below the lowest level of the Granular Sub Base layer. Lined drains shall be given a gradient between the minimum value of 0.1% and a maximum value of 1 % so as to restrict the flow velocity within 3 m/sec.

Lined drains shall be covered and man holes and silt chamber shall be provided at appropriate intervals. Lined drain shall be properly connected to the nearest culvert/side ditch/rain water harvesting pits.

6.10.3 Shoulder Drains and Chute Drains

For locations having embankment height above 3 m, chute drains shall be provided on the sides of the embankment to avoid rain cuts to the embankment. Chutes shall be of pre-cast concrete section protected on either side with stone pitching. Chute drains shall be provided at 10 m interval on the embankment slope.

In order to direct the water from the pavement surface to the chute drain, shoulder drain between the paved shoulder and the earthen shoulder shall be provided. This shall be connected to the chute drain through the pre-cast channel provided across the earthen shoulder. Energy dissipation basin shall be provided at the end of each chute drain. This shall be connected to the ground level drainage system.

6.10.4 Cross Drainage

Adequacy of the cross drainage system shall be reviewed through local enquiry. Flood marks and high flood levels available for the minor bridges and cross drainage structure shall be collected.

Cross drainage adequacy and the hydraulic design shall be carried out as per IRC: SP:13. At the location of cross roads, Hume pipe culverts shall be provided to convey the drainage water along the project highway or other appropriate drainage measures shall be designed to clear the run off water.

6.10.5 Rain Water Harvesting System

Rain water harvesting system is to be provided all along the project highway as per provisions of IRC SP 50:1999.

6.11 Intersections/ Junctions

Road junction/intersection is a key element of highway design. The efficiency, safety, speed, cost of operation and capacity of road system depends very much on the intersection design. The choice between an at-grade and grade separated junctions at a particular site depends upon various factors such as traffic, economy, safety, aesthetic delay etc. Grade separated junctions generally are more expensive initially and are justified in certain situations.

The main objective of intersection design is to reduce the severity of potential conflicts between motor vehicles, buses, trucks, bicycles, pedestrians and facilities while facilitating

the convenience, ease and comfort of people traversing the intersections. The design should be fitted closely to the natural transitional paths and operating characteristics of the users.

Design of a safe intersection depends on many factors as given below:

- Human factors
- Traffic considerations (mainly design hour turning movements, type of movement and vehicle speeds)
- Road and environmental considerations (sight distance, conflict area, geometric features)
- Economic factors.

Generally intersections can be classified in to the following categories depending on the traffic conditions.

- Uncontrolled intersections at-grade;
- Intersections with Priority Control;
- Time separated / signalized intersection at-grade;
- Space separated intersections/Grade separated intersections

A signalized intersection besides other warrants is justified if the major street has a traffic volume of 650 to 800 vehicles per hour (both directions) and Minor Street has 200 to 250 vehicles per hour in one direction only. The detailed warrants for signalized intersection are laid down as per IRC: 93-1985. A grade separator shall be designed for all National Highway and State Highway crossings as per IRC: SP: 84-2014.

Each junction on the project road is carefully designed with due regard to physical conditions of the site, extent and cost of land, cost of construction and the effect of proposal on the neighborhood. Allowances will be made for space needed for traffic signs, lighting columns, drainage, public utilities etc. Various design parameters to be used for intersection design are discussed in the following paragraphs.

As per IRC, all intersections are designed for minimum turning radius of 18m to accommodate the tractor. A curve radius of 15 to 30 m is adopted depending on site conditions. To ensure large vehicles turn right / left without difficulty on to or from a major road, a radius of 15-20 m control circles tangential both to the centre line of the major road and the side of the central verge away from the minor road is used. A minimum width of 5.5m has been provided for turning lanes at the intersections.

Three types of auxiliary lanes have been considered at intersections. These are storage / right turning lane, acceleration lane and deceleration lane. The last two together are also called speed change lanes. Provision of auxiliary lanes increases the capacity of intersection and improves safety. The length of these lanes depends on the volume of traffic entering from or leaving onto the cross road. The standards proposed in IRC SP: 41 “Guidelines for the Design of At-Grade Intersection in Rural and Urban Areas” is applied.

To permit easy right turning of large vehicles, the gap in central reserve of intersection is extended to 2.5 m beyond the assumed extension of kerb line of minor road and the shape is determined by 15 m to 20 m radius control circles tangential both in the centre line of minor road and the major road. A gap of 25 m in central median at intersections has been proposed for easy right turn from major cross roads. It is desirable to provide kerbs at the intersections for more positive traffic delineation and collection of storm drainage. The kerb of mountable type should be provided at the intersections.

Control of Access

Cross roads at very close intervals impede the safe movement of traffic and give rise to ribbon development. Control of access is one of the effective ways of checking ribbon development.

On rural sections of important routes, it is desirable to exercise limited access control. This is especially necessary in the case of highways in the urban fringe. In order to counteract, parallel service roads (frontage roads) are provided, connections from these should not be closer than 750 meters.

Traffic Control Devices

The design of road traffic signs, road marking and guidelines on design and installation of road traffic signals shall be done according to the IRC standards.

Cautionary, mandatory and informatory signs will be provided depending on the situation and function they perform in accordance with the IRC: 67-2012 guidelines for Road Signs. The design, location, materials, definitions plate, route marker assembly at junctions, colour of back sign of post and inscription shall be done as per IRC-31- 1969.

The main functions of traffic signs are:-

- Timely warning of hazardous situations when not self-evident.
- Regulation of traffic by imparting message to the drivers about the need to stop, give way, limit the speed.
- Information to highway routes, directions and point to interest.

In view of above, they are an integral part of traffic control of a high-speed highway such as this project road. To be effective, a road sign should meet five basic requirements:

- Fulfill a need
- Command
- Convey a clear and simple meaning
- Command respect from road user and
- Give adequate time for response

Design, placement, operation, maintenance, and uniformity are aspects that should be carefully considered in order to maximize the ability of road sign to meet five basic requirements.

Based on functions as explained in above section, the types of signs are

- Danger signs also denoted as warnings or cautionary signs.
- Instruction signs also known as regulatory signs.
 - (i) Prohibitory signs and
 - (ii) Mandatory signs.
- Information signs
 - i. Indication signs,
 - ii. Advance /Direction sign
 - iii. Route and identification sign.,

IRC codes of practice for road sign (IRC 67-2021) confirm to the stipulations stated above and hence it has been following

Mandatory or Regulation Sign (MS)

Warning & Cautionary Sign (WS)

Informatory sign (IS)

Mandatory Signs: Mandatory / prohibitory signs are to indicate the prohibition upon certain kind of vehicle manoeuvre and vehicle type like overtaking prohibited, parking prohibited etc., and the purpose is to every positive instruction to the motorists.

The mandatory signs are in circular shape in general except two important signs (I) STOP and (ii) GIVE WAY which are in octagonal and triangular in shape respectively.

Stop Sign in our project road shall be used at intersection points of less important roads and shall not be used on through project road and for speed control on it. IRC standard for this sign post is octagon with white border, red back ground the standard size of the octagon 900mm and minimum 600mm.

Give Way sign is used to assign right of way to traffic on certain approaches to an intersection. As for example on a minor road to assign right of way to the major road but where stop is not necessary at all times. IRC Standards suggests downward pointing equilateral triangle of 900mm standard 600mm minimum with red border white back ground.

Prohibitory Signs for

- Movement prohibition
- Waiting restrictions
- Restriction on directions, light or speed of the vehicle

They are circular in shape & of dia. 600mm, standard with red border on white back ground.

Warning signs or cautionary signs: Used to necessarily warn the traffic about existing or potentially hazardous condition on or adjacent to the highway or connecting street or road. These are provided, a few examples being at cross road, irregular intersection, school, hospital, gap in median etc. They shall be provided as per IRC standards.

Informatory Sign: The same signifies the purpose in routes, destinations near rivers, parks, forest, towns, villages, historical sites to help the traffic in the direct manner possible. The letters and numerical of the sign shall be provided as per IRC-30-1968.

Over Head Signs: They have been proposed at entry/exit of bypasses, major junctions, toll plazas, etc. The vertical clearance as per IRC shall be 5.5m. The size of the letters shall be 25 – 30 cm and length of Panel about 7m.

Chevron Signs: At the curved alignment of the roadway, the chevron signs are used to inform the drivers about the sharpness of curve on outer edge of curve. The spacing and location details of Chevron signs are as under:

Table 6. 3 Criteria and Spacing Details of Chevron Signs

Sl. No.	Radius of Horizontal Curve in (m)	Distance between Single Chevron (m)	
		On Curve	Before Curve
1	50	15	30
2	100	20	40
3	200	30	60
4	300	45	90
5	400	60	120
6	500	70	140
7	500-100	80	150

Design and Siting:

The road signs shall be of retro-reflective type and made of high intensity grade with encapsulated lens type reflecting sheeting fixed over aluminum sheets. The sign pastes shall be aluminum alloy post or steel post of hollow section of cast or sheet metal.

Location of the sign posts shall be left side and shall be carried out on the right side. As per IRC (Code of practice for Road Signs, Indian Road Congress, New Delhi), on all roads with or without kerb and with or without shoulder , the extreme edge of the ground mounted sign adjacent to the roadway shall be at a distance of 600mm to 3m from the carriageway or paved shoulder depending upon the local conditions.

On kerbed roads, the bottom edge of lowest sign shall not be less than 2.1m and not more than 2.5m above kerb. On roads without kerbs, the bottom edge of the lowest sign shall not be less than 2m and not more than 2.5m above crown of the pavement. To improve the visibility of the signs on multilane roads, the minimum height of lower edge of the sign should be kept as 2.5m above the highest point of carriageway.

Care shall be taken in selecting the locations particularly in urban stretches, that sign post is not lost. Adjust other sign posts or advertising posts and the siting distance shall be adjusted for better visibility.

Pavement Markings

Road markings perform the important function of guiding and controlling traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. The location and type of marking lines, material and colour is followed as per IRC: 35-1997, Code of Practice for Road Markings. The road markings were carefully planned on carriageways, intersections, toll plazas and bridge locations.

Road markings are used as a means of controlling and guiding traffic. Types of markings are:-

- Center line
- Traffic lane basis
- No overtaking zone markings
- Pavement edge lanes
- Carriageway width reduction transition markings
- Obstruction approach markings
- Stop lines
- Pedestrian crossing
- Cyclists
- Route direction / arrows
- Parking space limits
- Bus stops.

Object markings:-

- Object within the carriageway
- kerb marking for visibility
- kerb marking for parking restrictions
- Object adjacent to the carriageway

Criteria for marking:-

- Solid lines are restrictions in nature it is an offense to cross such a line
- Broken lines are restrictive in nature/ character and vehicles can cross such line if done with safety.

- When a combination of solid and broken line used, the vehicle shall not cross the solid line and right to broken line.
- Double lines indicate maximum restrictions.

Commonly used colour is white and yellow. Ordinary paints for road markings are as per IS 164-1981. But these paints do not have good degree of brightness. Hence hot applied thermoplastic paints shall be used in the project road. Besides, improved night visibility shall be obtained by the use of minutes glass beads incorporated in the marking to produce retro-reflective surface.

Code of practice for road markings (with paints) IRC 35-1997 shall be the guide for marking center lines, traffic lane lines, no overtaking zone marking, obstruction approach markings, slope line, pedestrian crossings, cyclists crossings, route friction arrows, marking at approaches to intersection route direction arrows etc.

Kilometre, 200 m and Road Boundary Stones

Both ordinary kilometre stones and 200 m stones will be provided as per IRC 8 and IRC 26 standards respectively and on both sides of the project Highway. The design, materials, script and sequence of inscription; size, shape and spacing of letters / numerals, colour, background, inscription and placement of 200m Stone as per IRC- 26 and kilometre stone shall be done as per IRC:8 – 1980. The inscription on the stones shall be the numerals 2, 4, 6 and 8 marked in an ascending order in the direction of increasing chainage away from the starting station.

The road boundary stones (RBS) shall be provided on either side of road at the boundary and at a spacing of 50m c/c. In addition these shall be fixed at all angular points of the boundary. The details of boundary stones shall conform to IRC: 25- 1967.

Delineators and Object Markers

Roadway delineators are intended to mark the edges of the roadway so as to guide drivers on the alignment ahead. Object markers will be used to indicate hazards and obstructions within the vehicle flow path, for example, channelling islands close to the intersections.

Road side delineators are provided to help visual aids to drivers crossing the alignment of the road, especially at night. They are effective at locations where horizontal and vertical

geometry change and during severe conditions such as rain or fog. Generally delineators are reflectorised for better visibility at night.

Delineators will be provided as per the details given in the drawings and will be in accordance with the provisions of IRC: 79-1981. They are basically driving aids and should not be regarded as substitutes for warning signs, road markings or barriers. Delineators will be provided for all curves of radius less than 1000m. They are not provided at locations where Chevron sign boards are provided.

Road way delineators are generally in the form of guide posts of metal or concrete in rectangular or triangular conical cross section. The side facing the traffic should have dimension not less than 100mm. They should be 800-1000mm high. As an alternative empty drums usually painted in boards of black and white and red orange yellow reflectors 7.5 cm. Dia, placed 80° to traffic direction about 120 to 150 mm from top.

Delineators shall be provided:

- On horizontal curves of radius less than 1000m
- Vertical curves of inadequate visibility if any
- Road section where visibility become poor due to mist, fog etc.
- Reaches where the alignment appears uncertain to the driver i.e. pavement with transitions, temporary road diversions etc.
- Road sections subject to frequent submergence and ponding due to storm water
- Approaches to narrow bridges and culverts
- Road embankment exceeding 3m in height
- Approaches to important intersections
- Special problem points such as causeway and tunnels

Hazard markers:

Hazard markers should be put wherever there are objects close to road as to constitute an accident hazard, e.g. bridge abutments, guard rails etc., They are also to be provided in conjunction with a guard rail on a bridge approaches.

Object markers:

Object markers shall be provided at the following locations:

- i) Traffic islands at approaches to intersections
- ii) Around periphery of rotary islands
- iii) Median openings
- iv) Facing approaching traffic at islands forming left infiltration lanes
- v) On median / islands on far side of the intersection
- vi) At points where traffic divides into different directions e.g. down ramps of a grade separated intersections
- vii) On far side of T-junctions and street dead ends

Raised Pavement Markers (Cat's Eyes/Road Studs)

The cat's eye or road studs shall be provided to improve the visibility in the night time and wet-weather conditions. Those shall be prismatic retro reflective type two way markers conforming to ASTM D 4280.

Attenuator

Attenuators shall be provided at hazard markers locations given in IRC: 79, structural columns of large direction signs, illumination lamp posts and at approaching traffic inlands of toll plaza. It shall take repeated impacts without any additional recovery procedures and with minimal or no repairs. The attenuators modules shall be moulded from HDPE plastic. The design, size, number of modules, etc. of attenuators shall be as per International Standards and location specific duly considering the likely impact.

Guard Post and Crash Barrier

Guard posts are proposed on embankments of height more than 1.0m to less than 3.0m, bridge approaches and horizontal curves of radius greater than 170m. The spacing of guard post shall be 2.0m c/c in these areas. Typical Guard post consists of precast (M20) post of size 200mm x 200mm and a height of 600mm above ground level. They are encased in M15 cement concrete for a depth of 450mm below ground level. Guard posts are painted with alternate black and white reflective paint of 150mm wide bands.

As per IRC, road side safety barriers are basically meant to shield two types of road side hazards i.e. embankments and road side obstacles and also preventing the vehicles veering off

the sharp curves. The barrier is not warranted for embankment having a fill slope of 3:1 or flatter. In view of the above, the following guidelines have been followed for installation of road side barrier:

- a) Metal Beam Crash Barrier is proposed at locations where the embankment height is more than 3.0m.
- b) At horizontal curves of radius less than 450m for complete length of curves including transition curves and 20 m further before and after the curve
- c) At major bridge/culverts approaches.

The specifications, design aspects, end treatments, and placement of metal beam crash barrier shall conform to IRC.

Road Humps and Rumble Strips

The Road Humps are formed by providing a rounded hump of 3.7m width (17m radius) and 0.10m height for the preferred advisory crossing speed of 25kmph for general traffic as per the IRC: 99-1988 guidelines. The basic material for construction is bituminous concrete formed to required shape. Road humps are located at T-intersections and cross road intersections on minor roads or perpendicular arms about 25m away from the inner edge of the carriageway. Proper signs boards and markings are provided to advise the drivers in advance of the situation. Road humps are extended across carriageway up to the edge of paved shoulder.

Rumble Strips are formed by a sequence of transverse strips laid across a carriageway. Maximum permitted height of 20mm provided no vertical face exceeds 6mm. These rumble device produce audible and vibratory effects to alert drivers to take greater care and do not normally reduce traffic speeds in themselves. The typical design details of rumble strips proposed are transverse strips of Bituminous Concrete 500mm wide and overall thickness 20mm laid across a carriageway up to the end of paved shoulder. There will be 6 such transverse strips spaced at 1.0m c/c. Rumble strips are proposed in advance of sharp curves with radius less than 170m, transition zones (speed limit zones) and village approaches.

Proper sign boards and marking are proposed to advise the drivers in advance of the feature on the road.

Pedestrian Guard Rail

These will be made of structural steel angles squares. These are proposed for heavily trafficked urban areas to safeguard against stray pedestrians moving into heavily trafficked areas. These will be provided at all the built-up location at inner edge of footpath connected with service road if proposed.

Concrete Guard rails shall be provided in the approaches to Bridge in a length upto which protection work shall be provided and shall be flushed with inner edge of L-shape drain in flank. Beyond that, the Guard post shall be placed at interval of 1.5m.

Highway Illumination:

Street lighting is primarily intended to enable the road users such as motorists, cyclists, and pedestrians to see accurately and easily the carriageway and immediate surroundings in darkness. During the night it is facilitated by the head lights but it is not possible to depend on headlights and consequently a large proportion of accidents occur in night. Hence it has been proposed lighting of the project road in built-up sections, congested locations, major junctions and bus bays/stops. It is needless to emphasize that improved visibility by means of artificial lightening shall loosen the strain on the driver, the speed shall improve and consequently the traffic flow condition shall also improve and shall help in maintaining the LOS.

Landscaping & Tree Plantation:

The plant trees and shrubs of required number and type at the appropriate locations within the ROW and in the land earmarked by the client for afforestation as per IRC Guide lines on Landscaping and Tree Plantation.

Tree plantation shall be taken up at the locations where the Government lands available, in pockets of realignment locations, at location as per local forest department.

Aesthetic of areas surrounding the roadways are a prime consideration in the design of roads. This must be in the line with road safety considerations. Landscaping of the environment in the vicinity of roads contributes in a number of ways like:

- Control of soil erosion
- Noise abatement

- Safety barrier
- Glare reduction at night from on coming traffic
- Visual barrier where ever required
- Indicative guide for direction of traffic movement
- Scenic beauty – psychological comfort

It is recommended that local / regional varieties of trees, plants and shrubs should primarily be used. Amongst the considerations for selection would be tolerance to pollution, as well as cyclones, particularly in the case of trees in proximity to the edge of the roadway. While the latter is normally discouraged, but the shade provided by the trees would be of great advantage given to the hot climate of the area.

Trees could also be layered in a pattern of increasing height. Undulating berms covered with local grasses, are of great aesthetic value.

The spacing of avenue trees will depend on the type and growth characteristics of trees, requirement of maintenance, penetration of distant views etc., a range of 10-15 m would meet the requirement for most varieties. A spacing of 10m can be adopted in this project.

Utilities:

Two metre wide strip of land at the extreme edge of the ROW is kept for accommodating utilities, both over as well as underground.

In major built-up / urban areas, provision of 3 rows of 450mm dia NP4 RCC pipes shall be provided across main carriageway at every 500m intervals for the purpose of crossing underground utilities. Each pipe in 3 rows might be used for communication, power and other services which shall be decided by the local concerned authorities. A Chamber shall be provided on either end of such crossings.

In rural areas, 1 single row of 450mm dia NP4 RCC pipe shall be provided across main road at an interval of every 1 kms.

The cover shall be minimum of 600mm shall be provided from the road top.

However, the actual location of crossings shall be decided by the competent authority at the time of execution of the project road.

All the design standards discussed above and which are integral part of the design are summarized in **table 6.5** below:

Table 6.5 Design Standards adopted for Project Road

Design Specification	Unit	Proposed Design Standards Plain & Rolling Terrain
Design Speed	km/hr	100/80
ROW in Open areas	m	50/70
Carriageway Width for Four lane with Paved Shoulder in rural areas	m	9.0 (0.5 shyness + 7.0 Carriageway + 1.5 Paved Shoulder)
Width of Service Road (min)	m	5.5
Paved Shoulder in Rural Areas	m	1.5
Un-paved Shoulder in Rural Areas	m	1.0
Width of Parapet	m	0.5
Longitudinal Gradient		
a) Ruling	%	2.5
b) Limiting	%	3.3
Cross Fall		
I. Flexible Pavement		
a) Main carriageway/ Service road	%	2.5
b) Paved Shoulder	%	2.5
c) Un-paved Shoulder	%	3.0
Super-elevation (Maximum)	%	5
Minimum Radius of Curvature		
Desirable Minimum	m	400
Absolute Minimum	m	250
Sight Distance		
SSD	m	180
Minimum Vertical Curve Length	m	60
Clearance from Road		
a) ROB	m	6.55

Design Specification	Unit	Proposed Design Standards Plain & Rolling Terrain
b) Flyover	m	5.5
c) Vehicle Underpass	m	5.5

6.12 Structural Design

Design standards is clearly identified and enumerated for evolving a comprehensive design philosophy, which cover all aspects of design for various parts of the bridges/structures viz. superstructure, substructure, foundations, protection works and repair and rehabilitation. The design philosophy is primarily based on relevant IRC codes of practice (prescribed for design, execution, maintenance and safety during construction and service), IRC specifications, latest guidelines and circulars of NH and relevant Bureau of Indian Standards (BIS). For aspects not covered by IRC and BIS Standards, relevant recommendations of the International Standards or sound engineering practices are followed. The design philosophy depends on the following:

- Materials – concrete, steel etc.
- Live loads
- Width of carriageway and number of lanes
- Design speed
- Requirement of footpaths
- Temperature gradient and climatic data
- Wind effect
- Seismic effect
- Safe bearing capacity and soil parameters
- Differential settlement
- Methodology for analysis and design
- Bearings, expansion joints and wearing coat
- Construction techniques
- Protection works
- Repair / rehabilitation techniques

6.12.1 Carriageway Width

The 4 lane carriageway with paved shoulder, the overall configuration of the deck of the new / reconstructed culverts/bridges will be 22.5m (without footpath) & 29.5m (with footpath) as per latest codes. For new or reconstructed or widened culverts, the overall width as per Two Laning manual of specification issued by Indian Road congress (IRC: SP-84:2019).

6.12.2 Span Arrangement

The structural arrangement of the new four lane bridge is decided based on hydrology of the channel and sub-soil investigation report for the site. From the data available, a few structural alternatives may be feasible but the basic objective to select such a form which is ensure provision of longer spans with lesser expansion joints and meet other functional, structural and economic requirements and also blend with environment of the surrounding area. The form selected is most innovative and cost effective and suitable for construction by locally available technology.

Based on preliminary design, GADs for bridges and other structures shall be prepared. GADs show salient features of the structures such as overall length, span arrangement, carriageway width, deck level, foundation level, type of superstructure, substructure and foundations; bearings, expansion joints, return walls, ground levels, HFL, LWL, vertical clearance, design loading, cross and longitudinal profile etc. and submitted to the authorities for approval. Detail design of bridges and structures has been carried out based on hydraulic and geo-technical studies, following the standards and code of practices. In evolving the structural framework, aspects like ease of construction and cost effectiveness will be kept in view.

6.12.3 Design Standard & Codes of Practices

6.12.3.1 Design Standards

Summary of various Design Standards finalized and adopted for designing different structural components are:

Table 6.6: Summary of various Design Standards

(a)	Width of Carriageway, (i) For Minor & Major Bridges (for New/ Reconstruction) 2-Lane Structures (ii) For Minor & Major Bridges (for Retain / Widening) 2-Lane Structures (iii) Culverts & other Structures	For all bridges without footpath (Rural Area) – 14.0 metre overall width (0.5m Crash barrier & 0.75m Safety Kerbs on either edge with 11.5m carriageway including shyness in between). For all bridges with footpath (Urban Area) – 16.0 metre overall width (0.5m Handrail, 1.5m Footpath & 0.5m Crash barrier on either edge with 11.0m carriageway including shyness in between). If structure is in sound condition & carriageway is $\geq$ 10.5m, the bridge is retained as it is, otherwise, widened to width as for new bridges. Width equal to the roadway width of the approaches
(b)	Design Loading: Dead Loads, Footpath Live Loads, Live Loads, other Forces/ Loads, Temp Variation etc.	As per IRC 6-2014.
(c)	Seismic Loading Project Road : Zone II	As per IRC:6, the seismic effect has been considered as per the following criteria: Culverts and Minor Bridges up to 10m span are not designed for seismic effect Bridges satisfying both limits of total length not exceeding 60m and spans not exceeding 15m are not designed for seismic effect All other bridges have been designed for seismic effects.
(d)	Wearing Coat	50mm thick wearing coat
(e)	Expansion Joints	Filler Type/ Strip seal Type depending upon span length of structure
(f)	Drainage Cross Fall, Drainage Spouts	As per design requirements
(g)	Approach Slabs	RCC approach slabs of 3.50 metre length over the full width of the bridge
(h)	Bearings	Tar paper or Elastomeric bearings for Bridges
(i)	Superstructure	Minor & Major Bridges: Span up to 8.0m - RCC Box; Span from 8.0m to 12.0m - RCC Solid Slab; Span from 18.0m to 36.0m - RCC/PSC T-Beam; Culverts: Solid Slab or RCC Box (as the case may be)
(j)	Substructure Piers Abutments Wing walls	RCC Wall. RCC Cantilever Type. RCC Cantilever Type Retaining Wall

(k)	Foundations:	Raft/ Open Foundation for bridges
(l)	Materials Specifications: Steel: Un-tensioned steel Prestressing steel Concrete Piers/ Abutments, Open foundation RCC/PSC Superstructure	Fe-500D Grade shall be used with reference to IS: 1786. Pre stressing steel as per IRC: 112 – 2011 specifications. As per IRC: 78-2014 and IRC 112

6.12.3.2 Codes of Practices and standards

The structural design is conform to the latest revision of codes and recommendation of MOST specifications and sound engineering practice.

For manufactured items, the recommendations of manufacturer regarding the use, design criteria, installation instructions and properties will be considered for the design of structures.

The following are the various design codes that shall be followed for the structural design of various components of the project road. These shall be supplemented, wherever required, by guidelines from various international codes:

- IRC: 5 – 1998 Standard Specifications and Code of Practice for Road Bridges.
Section I – General Features of Design
- IRC: 6 – 2014 Standard Specifications and Code of Practice for Road Bridges.
Section II – Loads and Stresses
- IRC: 45 – 1972 Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges.
- IRC: 78 – 2014 Standard Specifications and Code of Practice for Road Bridges.
Section VII – Foundation and Substructure
- IRC: 83 – 1987 Standard Specifications and Code of Practice for Road Bridges.
Section IX – Bearings (Part II: Elastomeric bearings)
- IRC: 89 – 1997 Guidelines for Design and Construction of River Training and Control Works for Road Bridges.
- IRC: 112 – 2011 Code of Practice for Concrete Road Bridges.
- Other IRC Special Publications for Bridges:
- IRC: SP – 13 Guidelines for the Design of Small Bridges and Culverts

- IRC: SP – 33 Guidelines on Supplemental Measures for Design, Detailing and Durability of Important Bridge Structures.
- IRC: SP – 35 Guidelines on Inspection and Maintenance of Bridges
- IRC: SP – 40 Guidelines on Techniques for Strengthening and Rehabilitation of Bridges
- IRC: SP – 69 Guidelines and Specifications for Expansion Joints
- IRC: SP – 73 Manual of Standards & Specifications for Two-Laning of State Highways on BOT Basis
- Ministry of Surface Transport circular number RW/NH/34041/44/91-S&R dated 14.03.2000 for use of fusion bonded epoxy coated reinforcement in bridges on National Highways to be constructed in marine environment susceptible to severe corrosion.

The specifications of latest MOST, IS, BS, AASHTO codes, in that order, will be followed for items outside the purview of the foregoing standards.

6.12.3.3 Loads & Load Combinations

Dead Loads

The following unit weights shall be considered in the design:

PSC/Reinforced Concrete	25 kN/m ³
Plain Concrete	25 kN/m ³
Structural Steel	78 kN/m ³
Wearing Coat	23.6 kN/m ³
Soil	20 kN/m ³

Superimposed Dead Loads

A) Wearing Coat: 65mm thick layer of bituminous course.

B) Crash barrier/ railing:

The concrete crash barrier shall be proposed adjacent to the carriageway on either side.

C) Safety Kerbs:

750mm wide safety kerbs shall be proposed on the bridges in the rural areas.

Carriageway Live Loads

The bridges shall be designed for the worst effects of the following live loads:

- Two lane of IRC Class A loading in each lane; or.
- One lane of IRC Class 70R loading (wheeled / tracked) in 2 lanes, with Class A in each remaining lane.

Typically, 3 load combinations are analysed:

- 1 x Class 70R-L over two lanes
- 1 x Class 70R-L over two lanes and 1 lane Class A
- 3 lanes of Class A

Note that for new 4Lane bridges, the live loads is considered on carriageway only between crash barrier/safety kerbs.

Table 6.7: Detailed lane reduction factors

Number of lanes	Reduction in longitudinal effect
For two lanes	No reduction
For three lanes	10% reduction
For four lanes	20% reduction
For five or more lanes	20% reduction

This table is applicable for individually supported superstructure of multi-laned carriageway. However as per IRC-6, it shall be ensured that the reduced longitudinal effects are not less severe than the longitudinal effect, resulting from simultaneous loads on two adjacent lanes. Longitudinal effects mentioned above are bending moments, shear force and torsion in longitudinal direction.

The Impact Factor (IF) shall be considered as per Clause 208 of IRC: 6-2014. The IF calculated for different spans are as table given below:

Table 6.8: IF for different Spans

Span (m)	RCC Bridges	Steel bridges
19	0.180	0.277
20	0.173	0.269
22	0.161	0.254
24	0.150	0.240

Span (m)	RCC Bridges	Steel bridges
25	0.145	0.234
28	0.132	0.217
30	0.125	0.207
36	0.107	0.182
40	0.098	0.168

Pedestrian Live Loads

The pedestrian live loads are considered over footpath as per IRC: 6-2014.

Longitudinal forces due to Bearing Friction

The longitudinal forces due to bearing effects shall be considered as per IRC: 6-2014.

Horizontal Forces due to Water Currents

The water current forces shall be considered as per IRC: 6- 2014.

Earth Pressure

Soil parameters proposed to be taken for the backfill material behind abutments are:

$$\begin{aligned}\phi &= 30^\circ, \\ \delta &= 20^\circ, \\ \gamma_d &= 20 \text{ kN/m}^3,\end{aligned}$$

For the design of foundations for the bridges, soil characteristics shall be reviewed on a case to case basis, following the results obtained from actual borings to be carried out at site.

Seismic Loading

Seismic loading applicable to the zone where the bridges are located shall be considered.

Wind Loading

The wind loads shall be considered as per IRC: 6 -2014.

Temperature Loading

The bridge superstructure / components i.e. bearings and expansion joints shall be designed for temperature loading as per IRC: 6 – 2014.

Load Combination

All structural members shall be designed to sustain safely the most critical combination of various loads and forces that co-exist.

Exposure Condition

The various exposure conditions are detailed below for the various elements. The recommended concrete grades (as required for structural design and/or durability) and corresponding concrete covers are specified below.

Table 6.9: Exposure Condition and Cover Requirements

Item	Exposure Condition	Concrete Grade	Concrete Cover to Outermost Bar
Foundation	Severe	M35	75mm
Abutment	Severe	M35	75mm in contact with soil; 40mm elsewhere
Box Structures Bridges	Severe	M35	75mm in contact with soil; 40mm elsewhere
Culvert	Severe	M30	75mm in contact with soil; 40mm elsewhere
Approach slab	Severe	M30	75mm in contact with soil; 40mm elsewhere
Pier	Severe	M35	75mm in contact with soil; 40mm elsewhere
Precast PSC/RCC beams	Moderate	M50 - PSC M35 - RCC	40mm
Deck slab	Moderate	M35	40mm to upper surface 30mm to soffit where protected by precast beam or permanent formwork
Crash barrier	Moderate	M40	40 mm

Maximum Steel Stress

While checking SLS, the crack width has been restricted to the value given in Table 12.1 of IRC: 112. Accordingly maximum Steel stresses have been restricted to the values given

below. Note that for IRC 6 Annexure B Clause 7.0 and 7.2 (for PSC and RCC) specify lower live load factors i.e. 0.75 x live load effect shall be considered

Table 6.10: Recommended Values of W_{max}

Condition of Exposure ⁽¹⁾ As per Clause 14.3.1	Reinforced members and prestressed members with un-bonded tendons	Prestressed members with bonded tendons
	Quasi-permanent load combination ⁽²⁾ (mm)	Frequent load combination (mm)
Moderate	0.3 ⁽²⁾	0.2
Severe	0.3	0.2 ⁽³⁾
Very Severe and Extreme	0.2	0.2 ⁽⁴⁾ and decompression

Table 6.11: Steel Stress Limits: Maximum Bar Diameters Φ for Crack Control

Steel stress [MPa]	Maximum bar size [mm]	
	$w_k = 0.3 \text{ mm}$	$w_k = 0.2 \text{ mm}$
160	32	25
200	25	16
240	16	12
280	12	-
320	10	-

Table 6.12: Maximum Bar Spacing for Crack Control

Steel stress [MPa]	Maximum Bar Spacing [mm]	
	$w_k = 0.3 \text{ mm}$	$w_k = 0.2 \text{ mm}$
160	300	200
200	250	150
240	200	100
280	150	50
320	100	-

Bed Protection Works

Proper approach/ slope protection is to be provided as per IRC 89.

CHAPTER - 7

IMPROVEMENT PROPOSALS



CHAPTER 7

IMPROVEMENT PROPOSALS

7.1 General

A proper design would play a vital role in ensuring the proper functioning of the project. Every element of the road shall be designed in such a manner that it is cost effective and increases road user comfort and safety.

This section describes the improvement proposals for the project. The proposed designs are consistent with the parameters recommended in the relevant standards of the Indian Roads Congress (IRC) and MoRTH circulars. The proposed road is a access controlled highway with divided carriageway and service roads. For the design of the project road, the following are taken into consideration:

1. The designed facility shall not become obsolescent before the designed life.
2. Design shall be consistent, and the standards followed for different elements shall be compatible with one another.
3. The design shall cover all geometric aspects of road including signages, grade separated structures, etc.
4. The design will be done aiming at minimizing the vehicle operating cost
5. The design will take into consideration the environmental, aesthetic and landscaping aspects of the project road.

7.2 Proposed Cross Sections

The width and layout of project road cross-section depend on many factors, the chief amongst them being the classification of road, design speed and the volume of traffic expected. Other considerations are the requirements of parking lanes, bus-bays, loading-unloading bays, occurrence of access points, volume of pedestrians and cyclists, width of drains, location of sewer lines, electricity cables and other public utility services.

7.2.1 Lane Width

The standard lane width as per IRC: SP: 84-2019 of a basic traffic lane is taken to be 3.5 m. Thus, for 2-lane and 3-lane carriageways, the carriageway widths will be 7.0 m and 10.5 m, respectively. The bypasses for Vellore Town are proposed for four lane with 1.5m Paved Shoulder on either side in main carriageway and 7.25m service road on either side in Approach Portions.

7.2.2 Shoulders

The shoulder width on the outer side as given in IRC: SP: 84-2019 is minimum 2.5 m wide (1.5 m paved and 1.0 m earthen) for open country with isolated built-up areas. A 2.0 m wide paved shoulder is recommended in Built up areas with no provision for earthen shoulder.

A camber of 2.5% for paved section and 3.0% for unpaved section sloping away from the crown would be provided. Super-elevation would be provided at the horizontal curves conforming to IRC code requirements.

The details of cross section are given in fig. 7.1 to 7.6 and their schedule of cross section is given in **Table 7.1**.

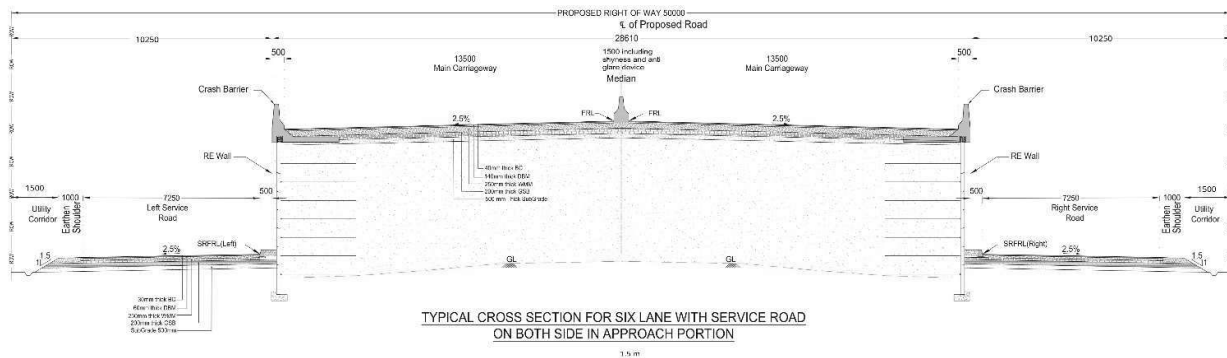
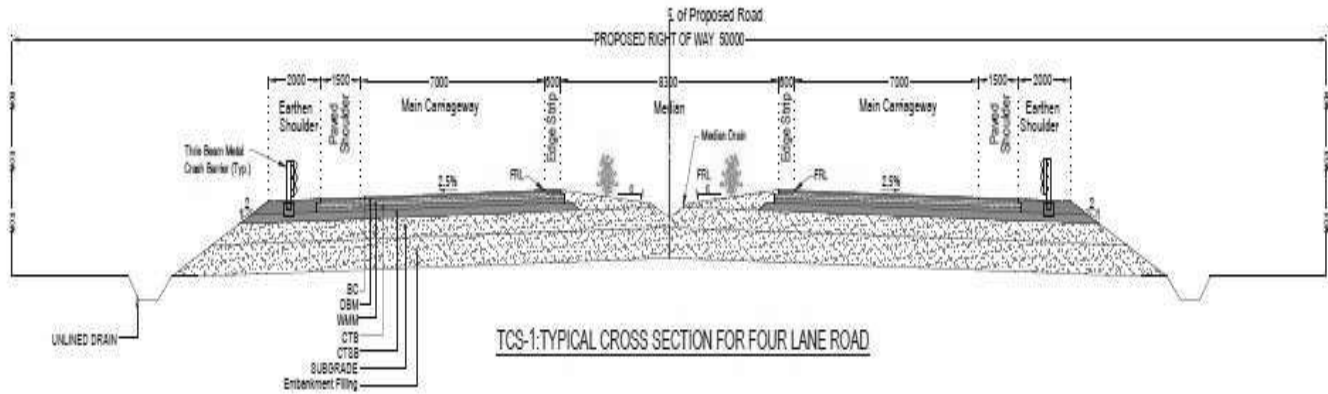
Table 7.1 Schedule of Cross Sections

TCS SCHEDULE					
SL.NO	DESIGN CHAINAGE		TCS TYPE	LENGTH	REMARKS
	FROM	TO			
1	0	0+358	-	-	Not part of the project
2	0+358	0+463.696	TCS - Elevated rotary	105.696	Elevated rotary at starting and approach with existing NH-75
3	0+463.696	0+650	ROB Span	186.304	
4	0+650	1+180	TCS-2	530.000	Six Lane with Service Road in Approach Portion on BHS
5	1+180	1+300	TAPER	120.000	
6	1+300	3+955	TCS-1	2655.000	Four Lane with Paved Shoulder
7	3+955	4+035	MAJOR BRIDGE	80.000	
8	4+035	5+319	TCS-1	1284.000	Four Lane with Paved Shoulder
9	5+319	5+519	MAJOR BRIDGE	200.000	
10	5+519	5+740	TCS-1	221.000	Four Lane with Paved Shoulder
11	5+740	5+860	TAPER	120.000	
12	5+860	6+860	TCS-2	1000.000	Six Lane with Service Road in Approach Portion on BHS
13	6+860	7+380	TCS-3	520.000	Four Lane with Atgrade Service Road on BHS
14	7+380	8+500	TCS-2	1120.000	Six Lane with Service Road in Approach Portion on BHS
15	8+500	9+150	TCS-3	650.000	Four Lane with Atgrade Service Road on BHS
16	9+150	9+270	TAPER	120.000	
17	9+270	10+360	TCS-1	1090.000	Four Lane with Paved Shoulder
18	10+360	10+480	TAPER	120.000	
19	10+480	11+500	TCS-2	1020.000	Six Lane with Service Road in Approach Portion on

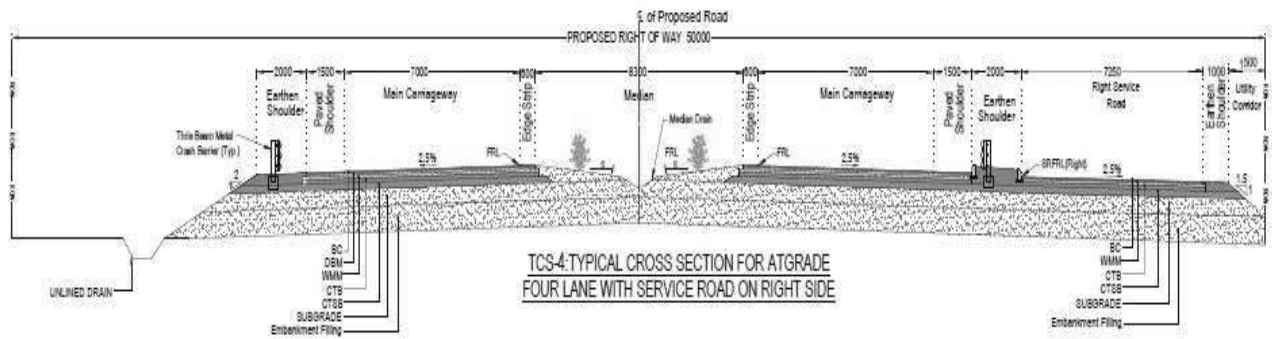
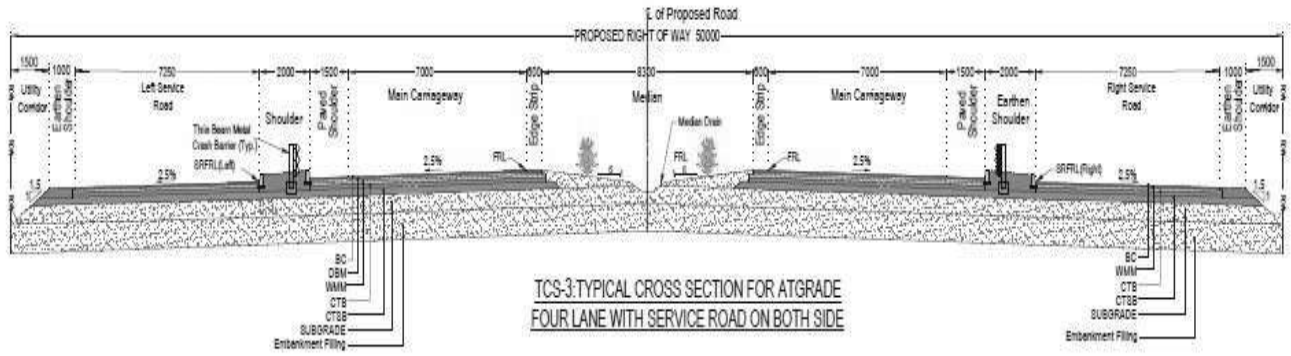
					BHS
20	11+500	11+820	TCS-3	320.000	Four Lane with Atgrade Service Road on BHS
21	11+820	11+940	TAPER	120.000	
22	11+940	12+780	TCS-1	840.000	Four Lane with Paved Shoulder
23	12+780	12+900	TAPER	120.000	
24	12+900	13+350	TCS-4	450.000	Four Lane with Atgrade Service Road on RHS
25	13+350	14+300	TCS-2	950.000	Six Lane with Service Road in Approach Portion on BHS
26	14+300	14+420	TAPER	120.000	
27	14+420	15+640	TCS-1	1220.000	Four Lane with Paved Shoulder
28	15+640	15+760	TAPER	120.000	
29	15+760	16+640	TCS-2	880.000	Six Lane with Service Road in Approach Portion on BHS
30	16+640	16+760	TAPER	120.000	
31	16+760	17+290	TCS-1	530.000	Four Lane with Paved Shoulder
32	17+290	17+410	TAPER	120.000	
33	17+410	18+360	TCS-2	950.000	Six Lane with Service Road in Approach Portion on BHS
34	18+360	18+500	TCS-3	140.000	Four Lane with Atgrade Service Road on BHS
35	18+500	18+620	TAPER	120.000	
36	18+620	19+150	TCS-1	530.000	Four Lane with Paved Shoulder
37	19+150	19+270	TAPER	120.000	
38	19+270	20+068	TCS-2	798.000	Six Lane with Service Road in Approach Portion on BHS
39	20+068	20+114	ROB Span	46.000	
40	20+114	20+600	TCS-2	486.000	Six Lane with Service Road in Approach Portion on BHS
41	20+600	20+850	TAPER	250.000	
	TOTAL LENGTH (m)			20492	

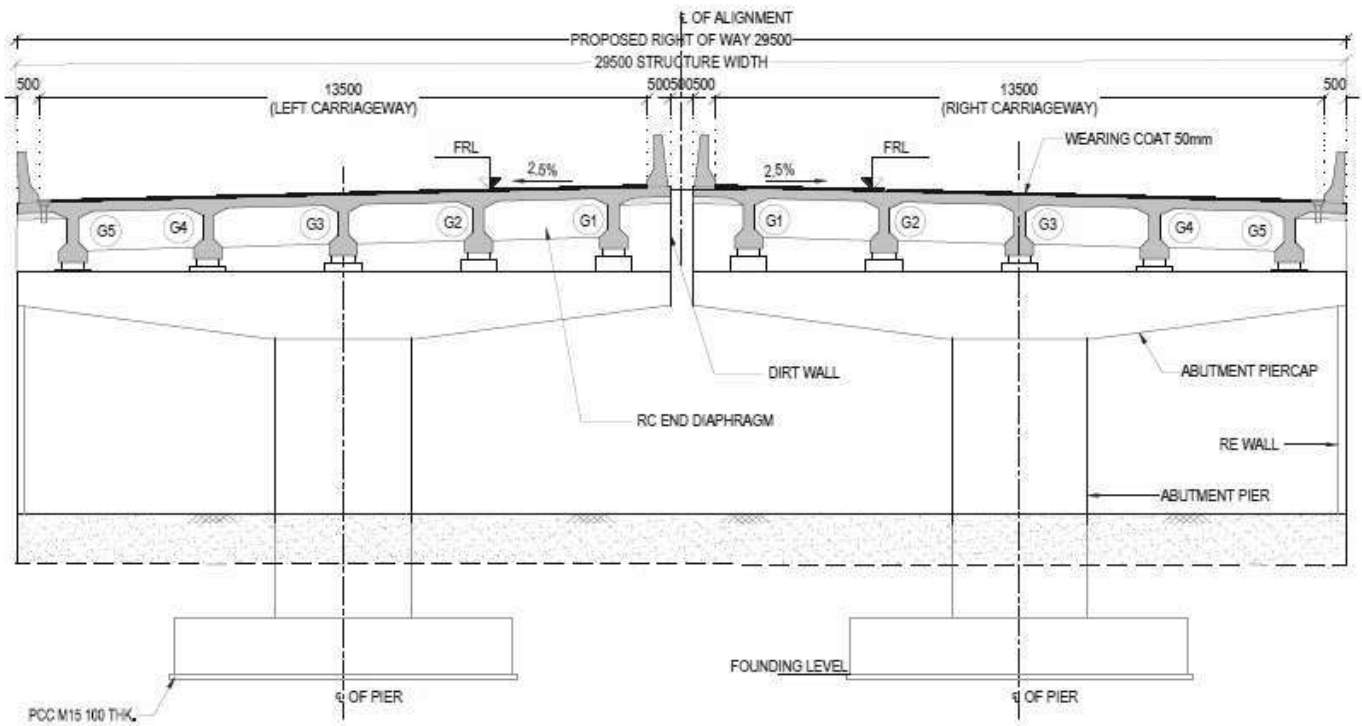
Appendix – B1

Typical Cross section

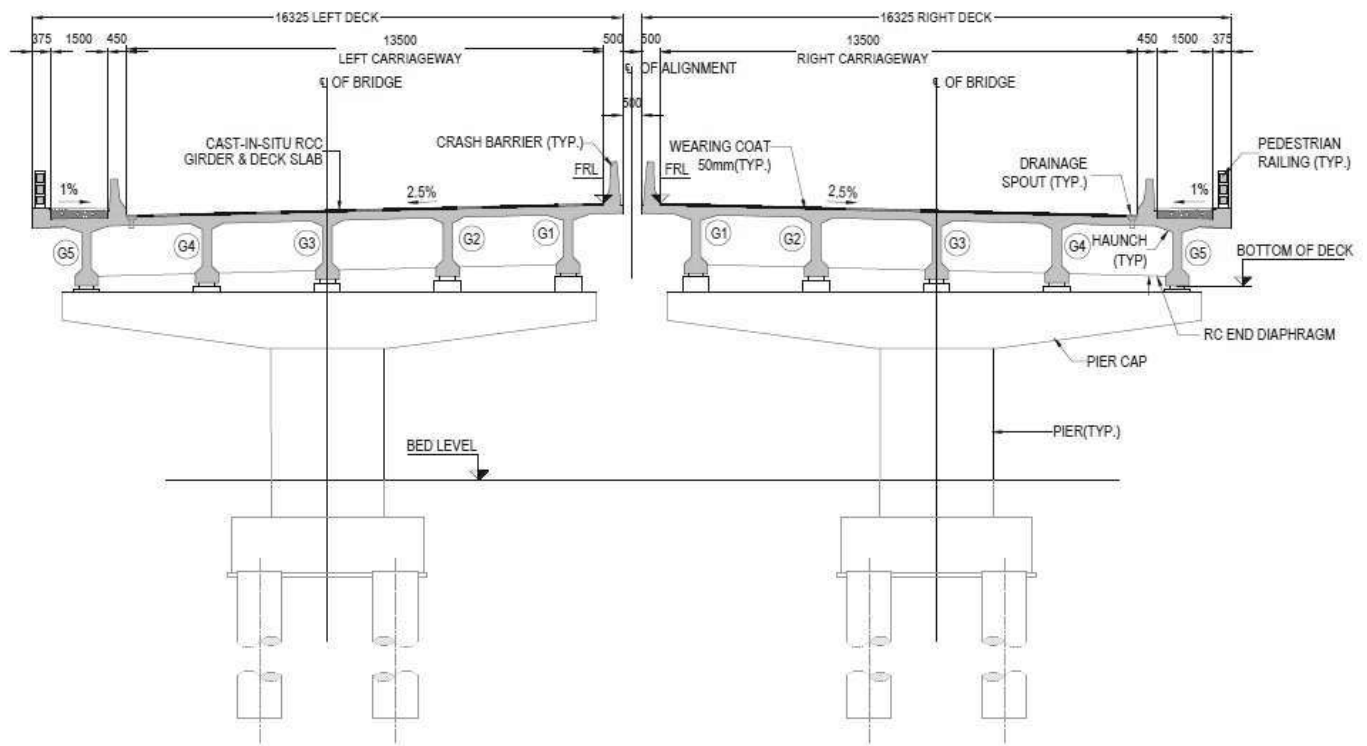


TCS -2

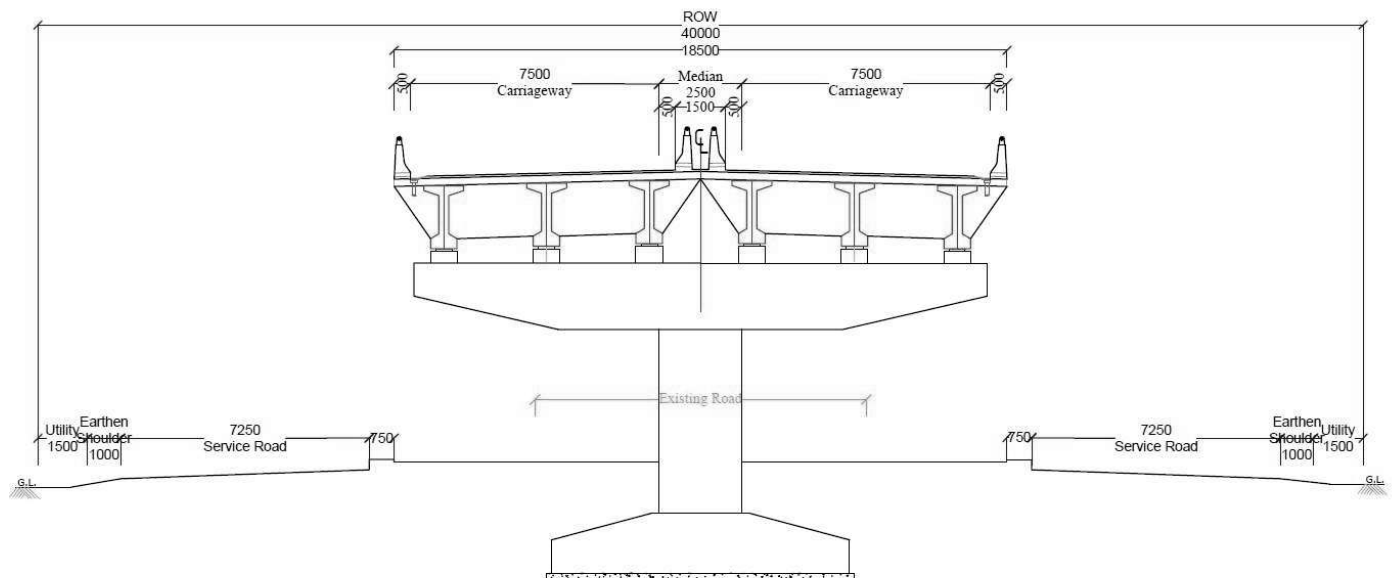




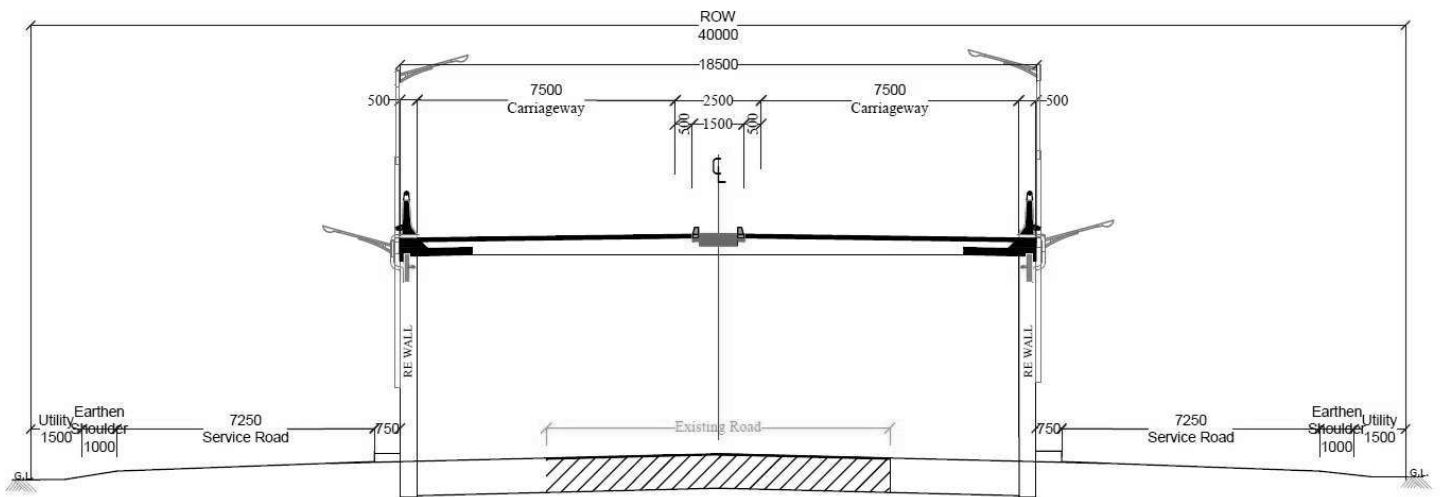
TYPICAL CROSS SECTION FOR SIX LANE IN STRUCTURE PORTION



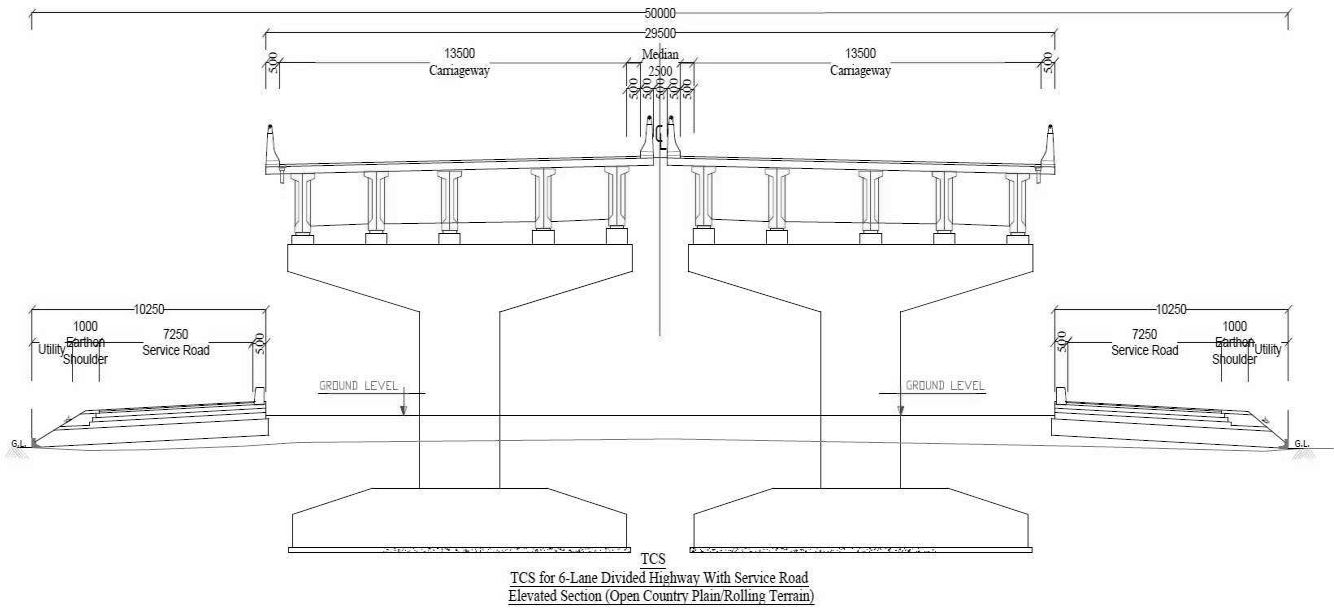
TYPICAL CROSS SECTION FOR SIX LANE MAJOR AND MINOR BRIDGE



TCS
TCS for 4-Lane Divided Highway Without Paved Shoulder
And With Service Road Elevated Section (Open Country Plain/Rolling Terrain)



TCS
TCS for 4-Lane Divided Highway Without Paved Shoulder
And With Service Road Approach Section (Open Country Plain/Rolling Terrain)



7.3 Geometric Design

Geometric design shall confirm to IRC: 73-1980, IRC: SP: 84-2019, IRC: SP: 87-2019, IRC: SP: 99-2013 and IRC: SP:23.

7.3.1 Horizontal Alignment

The Detailed Horizontal alignment has to be fluent and blend well with the topography. We are following here the designs a line, which conforms to natural contours, is aesthetically preferable to one with long tangents slashing through the terrain. The horizontal alignment should be coordinate carefully with the longitudinal profile. Under IRC guidelines, the desirable design speed for a National Highway is 100 Kmph with a minimum design speed of 80 Kmph in plain terrain. In rolling terrain, it varies from 80 Kmph to 65 Kmph.

In general, horizontal curves consist of circular portion of the curve followed by spiral transitions on both sides. Design speed, super-elevation and coefficient of friction affect the design of curve. The consultant adopted the minimum radius of 300m, and maximum super-elevation is adopted for project road is 5%. The details of proposed horizontal alignment are given in **Table 7.2**.

Table 7.2 Horizontal Alignment Details of Project Road

HIP No.	HIP Chainage	Radius	Transition Length	Delta	Lc	Dc	Shift(S)	Theta(s)	Es	k	Ts(m)	Speed	e
	m	m	m	Decimal	m	Decimal	m	Degree	m	m	m	kmph	%
1	1065.693	1000	50	43.836	715.092	40.972	0.104	1.432	78.02467	24.999	427.4032	100	2.80%
2	4103.614	500	95	28.468	153.43	17.582	0.752	5.443	16.6122	47.486	174.512	100	5.00%
3	4705.652	500	95	59.402	423.382	48.516	0.752	5.443	76.48954	47.486	333.1215	100	5.00%
4	5881.383	1000	50	17.043	247.475	14.179	0.104	1.432	11.26807	24.999	174.8492	100	4.40%
5	6936.395	1800	30	23.982	723.449	23.028	0.021	0.477	40.17312	15	397.3108	100	NC
6	7584.043	1200	40	14.462	262.89	12.552	0.056	0.955	9.676869	20	172.262	100	3.70%
7	8776.503	1100	45	11.962	184.655	9.618	0.077	1.172	6.098041	22.5	137.7539	100	4.40%
8	10866.53	700	70	24.894	234.138	19.164	0.292	2.865	17.14799	34.997	189.5685	100	5.00%
9	11706.54	2000		12.147	424.016	12.147			11.2894		212.8028	100	NC
10	12886.57	400	115	48.8	225.69	32.328	1.377	8.236	40.74251	57.46	239.5327	100	5.00%
11	13786.29	450	100	52.91	315.554	40.178	0.926	6.366	53.66781	49.979	274.3604	100	5.00%
12	15057.9	2000		14.549	507.85	14.549			16.22884		255.3012	100	NC
13	15562.16	500	95	28.449	153.266	17.563	0.752	5.443	16.59047	47.486	174.4236	100	5.00%
14	16192.19	500	95	46.882	314.126	35.996	0.752	5.443	45.79648	47.486	264.6063	100	5.00%
15	17218.94	1800	30	34.228	1045.323	33.274	0.021	0.477	83.41654	15	569.2403	100	NC
16	18012.44	2000		4.97	173.486	4.97			1.882557		86.79729	100	NC
17	19599.67	5000		0.434	37.897	0.434			0.035861		18.93691	100	NC
18	20683.31	360	60	47.354	237.53	37.804	0.417	4.775	33.54401	29.993	188.0325	100	3.20%

7.3.2 Vertical Alignment:

The vertical alignment should provide for a smooth longitudinal profile. Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile. Guidelines given in IRC: SP-23 shall be followed.

Summit curves have been designed to satisfy the criteria for Stop Sighting Distance (SSD). Intermediate Sight Distance (ISD) was also met in some straight stretches. Designing summit curves for ISD necessitates major changes in the vertical grade, which considerably increases the construction costs due to substantial increase in the volume of cutting and filling. The minimum curve lengths for suitable design speed and criteria for maximum grade changes, as per the IRC guidelines, have been followed when designing the vertical curves. At bridges with spans $\leq 30\text{m}$, flanking sections of bridges have been combined into a single vertical curve. All the valley curves are checked for the minimum required length to satisfy as per IRC 73 – 1980 for Head light sight distances at design speed of 80 Kmph or 100 Kmph. Minimum length of summit curve adopted is 73.6A and for valley curves it is 41.5A considering SSD criteria for 100Kmph design speed, where ‘A’ being the algebraic difference in grades (expressed in percentage). The details of proposed Vertical alignment are given in **Table 7.3**.

Table 7.3 Vertical Alignment details of Project Road

Sl.No.	PVI Station(m)	PVI Elevation(m)	Grade In	Grade Out	Profile Curve Length(m)	K Value
1	670.795	241.5	0.00%	-1.76%	130	73.753
2	1153.025	233	-1.76%	-2.50%	60	81.372
3	1340.642	228.31	-2.50%	-0.57%	100	51.812
4	2060.01	224.21	-0.57%	0.68%	100	80.237
5	2324.7	226	0.68%	-1.47%	160	74.7
6	2610	221.819	-1.47%	1.00%	200	81.085
7	2957.753	225.3	1.00%	-1.51%	340	135.619
8	3230	221.2	-1.51%	0.80%	200	86.598
9	3495.448	223.333	0.80%	0.30%	75	148.945
10	3761.567	224.131	0.30%	2.00%	75	44.118
11	3880	226.5	2.00%	0.00%	150	75
12	4110	226.5	0.00%	-1.93%	150	77.639
13	4291.157	223	-1.93%	0.33%	200	88.419
14	5048.92	225.5	0.33%	0.00%	60	181.863
15	5583.253	225.5	0.00%	0.05%	60	1251.179
16	5920.468	225.662	0.05%	2.50%	120	48.939
17	6500	240.15	2.50%	-2.50%	370	74

18	6804.268	232.543	-2.50%	-0.10%	100	41.731
19	7109.343	232.227	-0.10%	-0.53%	60	141.05
20	7450.816	230.42	-0.53%	2.50%	130	42.918
21	7974	243.5	2.50%	-2.50%	370	74
22	8434.433	231.989	-2.50%	0.92%	150	43.828
23	8810	235.454	0.92%	-0.85%	135	76.277
24	8930	234.437	-0.85%	1.55%	100	41.674
25	9140.214	237.7	1.55%	-2.50%	300	74.033
26	9394.842	231.334	-2.50%	0.88%	150	44.363
27	9766.525	234.61	0.88%	0.13%	150	199.019
28	10175.82	235.131	0.13%	0.62%	60	123.173
29	10685.575	238.264	0.62%	2.50%	80	42.432
30	11015	246.5	2.50%	-2.50%	368	73.6
31	11270.142	240.121	-2.50%	-0.32%	100	45.955
32	11527.748	239.287	-0.32%	0.30%	60	96.365
33	11800	240.1	0.30%	-0.05%	60	173.24
34	12625.587	239.706	-0.05%	2.51%	110	42.972
35	12900	246.6	2.51%	-2.25%	370	77.747
36	13142.02	241.162	-2.25%	0.30%	110	43.191
37	13402.769	241.944	0.30%	2.50%	100	45.454
38	13705	249.5	2.50%	-2.50%	370	74
39	14247.274	235.943	-2.50%	-0.69%	100	55.301
40	14933.983	231.193	-0.69%	-0.28%	60	145.969
41	15823.817	228.695	-0.28%	2.50%	120	43.155
42	16200	238.1	2.50%	-2.50%	370	74
43	16571.961	228.801	-2.50%	0.39%	120	41.502
44	17184.881	231.2	0.39%	0.73%	60	178.886
45	18179.025	238.426	0.00727	0.025	80	45.117
46	18450	245.2	0.025	-0.025	370	74
47	18706.095	238.798	-0.025	0.008	140	42.425
48	19308.725	243.618	0.008	0.025	75	44.115
49	20090	263.15	0.025	-0.033	430	74.138
50	20520.59	248.941	-0.033	0.00252	150	42.226

7.4 Intersections/ Junctions

Road junction/intersection is a key element of highway design. The efficiency, safety, speed, cost of operation and capacity of road system depends very much on the intersection design. The choice between an at-grade and grade separated junctions at a particular site depends upon various factors such as traffic, economy, safety, aesthetic delay etc. Grade separated junctions generally are more expensive initially and are justified in certain situations. The Vellore bypass has 2Nos. of Grade Separator at Start of Vellore Bypass & NH-48 crossing, 5 Nos. VUP @ SH-122,SH-207,MDR-1028, and also 2 Nos.of At-grade Junctions at ch:12+900 and End of Vellore Bypass). The list of Major Junction of project road is illustrated below in Table 7.5.

7.5 Pavement Design

The flexible pavements are usually referred to as a layered structure comprising generally bituminous surface like Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM), Wet Mix Macadam (WMM) base and Granular Sub-Base (GSB) course of finite thickness, resting on sub-grade of minimum thickness of 500 mm.

The thickness design of these layers is principally depended on the sub-grade CBR and the traffic loads that the pavement has to carry during its design life. Ideally, the flexible pavement is built to such a depth that stresses on any given layer will not cause unwarranted rutting, fatigue, shoving, or other differential movements which may result in an uneven wearing surface.

The chief function of the surfacing course is to provide a smooth wearing surface, resistant to traffic. Base courses are usually layers of aggregates that must possess high resistance to deformation in order to withstand the higher pressures imposed by wheel loads. High – quality processed aggregates are usually required, which also provide good internal drainage. Sub bases are generally made up of locally available aggregates.

7.5.1 Design of New Flexible Pavement

IRC: 37-2018 method is adopted for the design which is based on the empirical – analytical approach as mentioned above. The design inputs required for pavement design are explained in the following paragraphs.

7.5.2 Design Traffic

Future traffic over the design period can be estimated by applying appropriate growth factors to the present traffic. The design traffic is considered in terms of cumulative number of standard axles to be carried during the design life of the pavement. Design traffic is computed using the following equation:

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

Where

N = Cumulative number of standard axles to be catered for the design life terms of msa.

r = Annual growth rate of commercial vehicles

n = Design Period in years

A = Initial traffic in the year of completion of construction in terms of number of commercial vehicles per day

D = Lane distribution factor

F = Vehicle Damage Factor

Various Traffic surveys have been conducted in the month of Jan 2023. The Classified Traffic Volume Count Surveys (7 Days 24 Hours) conducted at 2 locations (Annexure I), Origin-Destination and Surveys (24 Hours) at 2 location and Axle Load Surveys (24 Hours) at 1 location. Based on the surveys conducted the entire project length has been designed for various sections.

7.5.3 Growth Rate

Pavements are designed to serve the traffic needs adequately over a period of years. Traffic growth must therefore be anticipated when determining structural requirements of the pavement. The traffic growth rates for different categories of the commercial vehicle are provided as per IRC: 37-2018. In clause 4.2.2 Traffic growth rates shall be established for each category of commercial vehicles. In the absence of data for estimation of the annual growth rate of commercial vehicles or when the estimated growth rate is less than 5 per cent, a minimum annual growth rate of 5 per cent should be used for commercial vehicles for estimating the design traffic.

7.5.4 Lane Distribution Factor

As per IRC: 37-2018 Clause 4.5.1.3 the design should be based on 75% of the total number of commercial vehicles in each directions.

TRAFFIC DETAILS:

As per traffic survey conducted on January 2023, CVPD and PCU observed that 3353 & 20794 respectively. It is informed that 70% of thro' traffic will use this bypass. So, 2348 CVPD is considered for main carriageway pavement design purpose.

Census Point	Stretches influenced (NH 234)	Month & Year of census	CVPD (70 % of 3353)	PCU (70% of 20794)	Msa for 20 years
Km 80/1	Km 47/4-73/250	January 2023	2348	14556	90 MSA

The slip /service road is considered for 20msa traffic.

EMBANKMENT

The alignment lies in a green field and it crosses 47 field channels. Hence, box culverts are provided almost at 500m intervals, further 1 River bridge, 6 Minor bridges, 1 No RoB cum Grade Separator, 1 No RoB, 1 No Grade separator & 2 VUPs with their approaches are also provided in this 20.85 km stretch. To provide travel comfort to the road users, the vertical geometry is levered with average 1.5m - 2.5m height of embankment.

PROPOSED CRUST

The flexible pavement is designed as three layer system as per IRC-37-2018. The bituminous layer is designed as 50 mm thick BC CRMB-55 60mm thick DBM with VG40 bitumen. The granular layer designed as 100 mm thick AIL(WMM), 110 mm thick CTB and 200 mm thick CTSB for a design period of 20 yrs.

1.	No. of Traffic Lane	Four lanes
2.	Type of Carriage – way (Single / Divided)	Divided

3.	Terrain (Hilly / Plain)	Plain
4.	Number of commercial Vehicle per day as per last count (both directions) (P)	2348 CV / Day
5.	Year of census (Last count)	2023
6.	Year of preparation of Design	2024
7.	No of Years between last count and year of completion of Construction (x)	2 year
8.	Traffic growth rate per annum (r)	5.00 %
9.	Initial Traffic in the year of completion of construction	$A = P (1 + r)^x = 1359$
10.	Lane distribution	0.75
11.	Vehicle damage factor	5.00

Pavement Layers with Engineering Properties as per Design Requirements

Sl. No	Pavement Layer	As per IRC 37: 2018, Thickness (mm)	Elastic Modulus (MPa)	Poisson Ratio
		Main Carriageway (MC)		
1	Bituminous Concrete (BC with Modified Binders)	50	3000	0.35
2	Dense Bituminous Macadam (DBM)	60		
3	Granular interlayer (WMM)	100	450	0.35
4	Cement Treated Base (CTB)	110	5000	0.25
5	Cement Treated Sub-Base (CTSB)	200	600	0.25
6	Effective Subgrade (CBR ~ >10%)	500	76.83	0.35

Resilient modulus (M):

$$M_{\text{Subgrade}} = 17.6 \times (10)^{0.64} = 76.83 \text{ Mpa}$$

7.6 Design Check

Pavement compositions are given in Table 5. As per clause 6.1, IRC:37-2018, the pavement composition should be checked for stress and strains at critical locations below the pavement. Further, stress / strain equations are given w.r.t grade of bitumen. VG-40 grade bitumen is proposed for the Main Carriageway. Pavement is checked for the following critical conditions:

- Maximum tensile strain at the bottom of the bituminous layer for Main Carriageway as per equation 3.4, IRC:37-2018 at 90% reliability and VG-40 grade bitumen using the equation

$$N_f = 0.5161 \cdot C \cdot 10^{-04} \times [1/v_t]^{3.89} \cdot [1/M_R]^{0.854} \text{ (90\% reliability)}$$

$$C = 10^M, \text{ and } M = 4.84 \left(\frac{V_b}{V_a + V_b} - 0.69 \right)$$

- Where, N_f - fatigue life in number of standard axles
 v_t - Maximum tensile strain at the bottom of bituminous layer
 M_R - Resilient modulus of bituminous layer
 V_a - Volume of air voids ~ 3.5% (MC)
 V_b - Volume of Bitumen ~ 11.5% (MC)

By substituting above values in equation, maximum tensile strain at the bottom of bituminous layer is determined.

$$\begin{aligned} 90 \cdot 10^6 &= 0.5161 \cdot 2.35 \cdot 10^{-04} \times [1/v_t]^{3.89} \cdot [1/3000]^{0.854} \\ v_t &= 1.531 \times 10^{-4} \end{aligned}$$

- Maximum vertical strain at top of subgrade as per 3.2 equation of IRC:37-2018 is given by,

$$N = 1.41 \cdot 10^{-08} [1/\epsilon_v]^{4.5337} \text{ (90\% Reliability)}$$

Where, N is number of cumulative standard axles

ϵ_t is vertical strain in subgrade

$$\begin{aligned} 90 \cdot 10^6 &= 1.41 \cdot 10^{-08} \times [1/\epsilon_t]^{4.5337} \\ \epsilon_t &= 3.265 \times 10^{-4} \end{aligned}$$

- In the case of Pavements with CTB layer, fatigue Performance check for the CTB layer should be carried out as per equ. 3.5, 3.6 & 3.7 of IRC:37-2018.

$$N = RF \left[\frac{\left(\frac{113000}{E^{0.804}} + 191 \right)}{\epsilon_t} \right]^{12}$$

Where, N is number of cumulative standard axles

ϵ_t is Tensile strain at the bottom of CTB layer

RF is Reliability factor (1 for Expressway/National Highways)

E is Elastic Modulus

$$\epsilon_t = (11300/5000^{0.804}) + 191 / (90 \times 10^6)^{1/12}$$

$$\epsilon_t = 67.59 \times 10^{-6}$$

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No. of layers	5								
E values (MPa)	3000.00	450.00	5000.00	600.00	76.83				
Mu values	0.350.350.250.250.35								
thicknesses (mm)	110.00	100.00	110.00	200.00					
single wheel load (N)	20000.00								
tyre pressure (MPa)	0.80								
Dual Wheel									
Z	R	SigmaZ	SigmaT	SigmaR	TaoRZ	DispZ	epZ	epT	epR
110.00	0.00-0.2649E+00	0.5090E+00	0.4211E+00-0.1843E-01	0.2799E+00-0.1968E-03	0.1515E-03	0.1119E-03			
110.00L	0.00-0.2649E+00-0.4489E-01	-0.5807E-01-0.1843E-01	0.2799E+00-0.5086E-03	0.1514E-03	0.1119E-03				
110.00	155.00-0.1657E+00	0.2147E+00-0.2117E+00-0.8349E-01	0.2737E+00-0.5558E-04	0.1156E-03-0.7628E-04					
110.00L	155.00-0.1657E+00-0.4363E-01	-0.1076E+00-0.8349E-01	0.2737E+00-0.2506E-03	0.1156E-03-0.7628E-04					
320.00	0.00-0.5143E-01	0.2992E+00	0.2315E+00-0.1692E-01	0.2419E+00-0.3682E-04	0.5084E-04	0.3391E-04			
320.00L	0.00-0.5143E-01	0.2082E-01	0.1269E-01-0.1692E-01	0.2419E+00-0.9968E-04	0.5085E-04	0.3389E-04			
320.00	155.00-0.5613E-01	0.3224E+00	0.2509E+00-0.3359E-01	0.2484E+00-0.3989E-04	0.5475E-04	0.3687E-04			
320.00L	155.00-0.5613E-01	0.2223E-01	0.1365E-01-0.3359E-01	0.2484E+00-0.1085E-03	0.5475E-04	0.3687E-04			
520.00	0.00-0.1616E-01	0.6093E-01	0.5154E-01-0.2553E-02	0.2265E+00-0.7380E-04	0.8681E-04	0.6725E-04			
520.00L	0.00-0.1620E-01	0.9428E-03-0.1630E-03	-0.2553E-02	0.2265E+00-0.2144E-03	0.8681E-04	0.6738E-04			
520.00	155.00-0.1734E-01	0.6518E-01	0.5845E-01-0.3678E-02	0.2316E+00-0.8041E-04	0.9150E-04	0.7749E-04			
520.00L	155.00-0.1734E-01	0.1051E-02	0.2530E-03-0.3678E-02	0.2316E+00-0.2316E-03	0.9150E-04	0.7749E-04			

The computed values of critical stress and strains are compared with allowable values and the summary is given in **Table**.

Table7.5: Design Check Summary

Layers	Main Carriageway – 90 MSA	
	Allowable Limits (x10 ⁶)	Computed Value (x10 ⁶)
Bituminous Tensile Strain	153.1	151.4
Tensile Strain at the bottom of Cementitious base	67.59	54.75
Subgrade compressive Strain	326.5	231.6

Checking for Construction Traffic

50 trips for 500m

$500 \times 0.1 \times 9 = 450 \text{ m}^3 = 450/20 = 22.5 \text{ trips} \sim 25 \text{ trips}$

- Allowable flexural stress for $25 \times 2 = 50$ repetitions of a single axle of 80 kN ($160/2$) from Equation 3.6 = 0.832 MPa as per IRC:37-2018 It can be verified that a CTB layer thickness of 110 mm will be required. Analyzing this as a Three-layer system with CTB (110 mm), CTSB (200 mm) and subgrade, the maximum tensile stress at the bottom of CTB layer due to 80 kN single axle works out to 0.808 MPa, which is lower than the computed value. Hence, the thickness of 110mm CTB is Sufficient & safe for construction of Granular Interlayer over CTB.

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No. of layers	3								
E values (MPa)	5000.00	600.00	76.83						
Mu values	0.250.250.35								
thicknesses (mm)	110.00	200.00							
single wheel load (N)	20000.00								
tyre pressure (MPa)	0.80								
Dual Wheel									
Z	R	SigmaZ	SigmaT	SigmaR	TaoRZ	DispZ	epZ	epT	epR
110.00	0.00-0.2002E+00	0.8081E+00	0.6542E+00-0.3198E-01	0.3805E+00-0.1131E-03	0.1389E-03	0.1004E-03			
110.00L	0.00-0.2002E+00	0.3825E-01	0.1978E-01-0.3198E-01	0.3805E+00-0.3578E-03	0.1389E-03	0.1004E-03			
110.00	155.00-0.1151E+00	0.5803E+00	0.4681E-01-0.1222E+00	0.3859E+00-0.5438E-04	0.1195E-03-0.1390E-04				
110.00L	155.00-0.1151E+00	0.3586E-01-0.2815E-01-0.1222E+00	0.3859E+00-0.1951E-03	0.1195E-03-0.1390E-04					

Proposed Pavement Compositions for New Formation (Main Carriageway)

Bypass	Section	Design MSA	Design CBR	Pavement Layer Thickness (mm)					Total (mm)
				BC	DBM	WMM	CTB	CTSB	
Vellore Bypass	Entire Length	61.51	10%	50	60	100	110	200	510

PAVEMENT DESIGN FOR SERVICE ROAD

Final suggested pavement thickness for Service Road pavement (10 MSA) as per IRC SP -84 with their properties is given below in **Table**.

Pavement Layers with Engineering Properties as per Design Requirements

Sl. No	Pavement Layer	As per IRC 37: 2018, Thickness (mm)	Elastic Modulus (MPa)	Poisson Ratio
		Service Road		
1	Bituminous Concrete (BC with Modified Binders)	50	3000	0.35
2	Granular interlayer (WMM)	100	450	0.35
3	Cement treated Base (CTB)	110	5000	0.25
4	Cement treated Sub-Base (CTSB)	200	600	0.25
5	Effective Subgrade (CBR ~ >10%)	500	76.83	0.35

VIEW RESULTS

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No. of layers	5									
E values (MPa)	3000.00	450.00	5000.00	600.00	76.83					
Mu values	0.350	0.350	0.250	0.250	0.35					
thicknesses (mm)	50.00	100.00	110.00	200.00						
single wheel load (N)	20000.00									
tyre pressure (MPa)	0.80									
Dual Wheel										
Z	R	SigmaZ	SigmaT	SigmaR	TaoRZ	DispZ	epZ	epT	epR	
50.00	0.00	-0.5623E+00	0.6972E+00	0.6660E+00	-0.1153E-01	0.3586E+00	-0.3465E-03	0.2203E-03	0.2063E-03	
50.00L	0.00	-0.5623E+00	-0.1528E+00	-0.1575E+00	-0.1153E-01	0.3586E+00	-0.1008E-02	0.2203E-03	0.2063E-03	
50.00	155.00	-0.1295E+00	-0.6075E-01	-0.8333E+00	-0.8478E-01	0.3079E+00	0.6115E-04	0.9207E-04	-0.2556E-03	
50.00L	155.00	-0.1295E+00	-0.6837E-01	-0.1843E+00	-0.8478E-01	0.3079E+00	-0.9122E-04	0.9207E-04	-0.2556E-03	
260.00	0.00	-0.7751E-01	0.4085E+00	0.3054E+00	-0.2168E-01	0.2805E+00	-0.5120E-04	0.7031E-04	0.4453E-04	
260.00L	0.00	-0.7751E-01	0.2629E-01	0.1391E-01	-0.2168E-01	0.2805E+00	-0.1459E-03	0.7031E-04	0.4453E-04	
260.00	155.00	-0.7692E-01	0.4238E+00	0.2705E+00	-0.5576E-01	0.2885E+00	-0.5010E-04	0.7508E-04	0.3676E-04	
260.00L	155.00	-0.7692E-01	0.2829E-01	0.9899E-02	-0.5576E-01	0.2885E+00	-0.1441E-03	0.7508E-04	0.3676E-04	
460.00	0.00	-0.2064E-01	0.7841E-01	0.6476E-01	-0.3367E-02	0.2599E+00	-0.9405E-04	0.1123E-03	0.8387E-04	
460.00L	0.00	-0.2063E-01	0.1294E-02	-0.3258E-03	-0.3367E-02	0.2599E+00	-0.2729E-03	0.1123E-03	0.8384E-04	
460.00	155.00	-0.2216E-01	0.8433E-01	0.7332E-01	-0.5298E-02	0.2667E+00	-0.1026E-03	0.1192E-03	0.9629E-04	
460.00L	155.00	-0.2216E-01	0.1459E-02	0.1533E-03	-0.5302E-02	0.2667E+00	-0.2958E-03	0.1192E-03	0.9629E-04	

The computed values of critical stress and strains are compared with allowable values and the summary is given in **Table**.

Table 7.6: Design Check Summary

Layers	Main Carriageway – 20 MSA	
	Allowable Limits (x10 ⁶)	Computed Value (x10 ⁶)
Bituminous Tensile Strain	225.4	220.3
Tensile Strain at the bottom of Cementitious base	76.61	75.08
Subgrade compressive Strain	454.9	295.8

Proposed Pavement Compositions for New Formation (Service Road)

Bypass	Section	Design MSA	Design CBR	Pavement Layer Thickness (mm)				Total (mm)
				BC	WMM (ALL)	CTB	CTSB	
Vellore Bypass	Entire Length	20	10%	50	100	110	200	460

7.7 Road Furniture's and Other features

Introduction

The road furniture, traffic safety features and other facilities to be included in the design are:

- Road Markings
- Road Studs
- Kilometer Stone Details
- Delineators and Object Markers
- Thrie-Beam Crash Barrier
- Road Humps and Rumble Strips

Road Markings

Road markings perform the important function of guiding and controlling traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. The Code of Practice for Road Markings, IRC: 35-2015 has been used in the study as the design basis.

For the road sections with Two lane with Paved Shoulder configurations, on each carriageway, edge line 150 mm wide shall be provided. Lane marking shall be made between the two edge lines dividing the carriageway into two 3.5 m lanes and shall be 100 mm wide. Other pavement markings such as stop lines, give way lines, diagonal/chevron markings, directional arrows, zebra crossings, markings at parking areas and bus stops, etc. shall be designed as per the requirement.

The road markings will be carefully planned on intersections and bridge locations during the final stage.

Cautionary, Mandatory and Informatory Signs

Cautionary, mandatory and informatory signs will be provided depending on the situation and function they perform in accordance with the IRC: 67-2012 guidelines for Road Signs.

Road Studs

Generally, road studs shall be provided at location of median openings, curves, urban stretches and at major intersections.

Nineteen degree (19°) tilted one-way reflective road studs with anchor and with 1x43 glass elements etc. complete shall be provided at 1 m c/c on pedestrian crossing with red reflective panel as per EN 1463 and BS873 part IV (1987).

Road studs shall also be provided at 9 m c/c on edge lanes and lane lines for a length of at least 130 m on, the approaching side of the intersection (on the project road), both sides of curves and median openings with white reflective panels as per BS873 part IV (1987) replaced partly with BS EN 1463-1: 1998. The road studs shall be provided on the urban stretches also considering the safety.

Kilometer Stone Details

The details of kilometer stones are in accordance with IRC: 8-1980 guidelines. Both ordinary and fifth kilometer stones will be provided. Kilometer stones shall be fixed at right angles to the centre line of the carriageway.

Delineators and Object Markers

Roadway delineators are intended to mark the edges of the roadway so as to guide drivers on the alignment ahead. Object markers will be used to indicate hazards and obstructions within the vehicle flow path, for example, channeling islands close to intersections.

Delineators and object markers will be provided as per the details given in the drawings and will be in accordance with the provisions of IRC: 79. They are basically driving aids and should not be regarded as substitutes for warning signs, road markings or barriers. Delineators will be provided for all curves of radius less than 1000m.

Thrie - beam Crash Barrier

Thrie Beam Crash Barrier is proposed at locations where the embankment height is more than 3.0m, at sharp curves where deflection angle is high and at major/minor bridge approaches.

The beam elements shall have nominal width of 483 mm. Post consists of formed channels of size 150 x 75 x 5, 785 mm long and space consists of formed channel of size 150 x 75 x 5, 330 mm long. All members of the system should be hot dipped galvanized to have a minimum coating of 550 g/sqm, each face in compliance to relevant MORT&H Specification (Cl. 810).

The spacing of posts should be 2.0 m c/c. Crash barrier system absorbs impact of vehicle and laterally restrains a vehicle from veering off. This ensures minimum damage to the vehicle and passengers.

Speed Breakers

Speed breakers in the form of humps shall be provided on all side roads intersecting the project road at grade. Speed breakers shall be provided with proper hazard markers.

Highway Lighting

Following are the lighting requirements specified in Schedule B:

- Non-conventional energy lighting system shall be provided at all major intersections
- High mast lightings shall be provided at all Major Intersections
- Highway lighting system shall be provided for VUP/Grade separator/ROB.

Non-Conventional Sources of lighting system shall be provided at all At-grade Intersections. High mast lighting shall be adopted for lighting of Major Intersections. The layout of masts, their height and spacing shall be fixed properly so that the minimum illumination level prescribed above is achieved. The night-time illumination in the areas used by pedestrian shall not be less than 10 lux. In urban areas, it is recommended that semi-cut-off luminaries shall be provided. Arrangement of lighting installations shall be staggered except at curves.

7.8 Structural Design of Bridges & culverts

The proposed Bypass starts at NH234 @ km 47+200, where Roundabout cum Grade separator is proposed with 18.5m (Existing NH Portion) & 29.5m wide in Bypass Portion overall width includes median, crash barrier & dual Two lane Carriageway, then crosses National Highways (NH-48) at Ch. 6+500, where another Grade Separator is proposed and state Highway (SH-122) & SH-207, where Vehicular underpass is proposed with 29.5m overall width. There are two Railway level crossings at Ch. 0+596 and Ch.20+087, where Six lane ROB is proposed respectively.

The proposed bypass crosses Palar River at Ch. 3+995 & Ch. 5+419 , where Major High-level Bridge is proposed. There are 5 Nos. of minor bridges & 48 Nos. of Culverts is proposed, where the river/stream crossing locations of alignment. The list of structure is illustrated in Table 7.26 to 7.34.

Table 7.6: Reconstruction of Slab culverts to Box culverts

S.No.	Existing Chainage	Design Chainage	Existing Structure Type	Existing Arrangement	Proposed Structure Type	Proposed Arrangement
1	4+791 (MDR-1028)	15+059	Slab	1 x 5.0m	Box	2 x 3.0
2	4+448 (MDR-1028)	15+453	Slab	1 x 1.0 m	Box	1 x 2.0
3	4+055 (MDR-1028)	15+883	Slab	1 x 1.0 m	Box	1 x 2.0

Table 7.7: Reconstruction of Pipe culverts to Box culverts

S.No.	Existing Chainage	Design Chainage	Existing Structure Type	Existing Arrangement	Proposed Structure Type	Proposed Arrangement
1	6+549 (MDR-1028)	13+394	Pipe	1 x 0.9m dia	Box	1 x 2.0
2	4+216 (MDR-1028)	15+660	Pipe	1 x1.0m dia	Box	1 x 2.0

Table 7.8: Proposed Box Culvert Locations

S.NO	Proposed Chainage	Proposed Treatment	Proposed Structure Type	Existing Structure Type	Existing arrangement	Proposed Arrangement				Width of structure (m)
						No. of Cells	Span / Diameter(m)	Vent(m)	Skew (Deg)	
1.	0+700	New Construction	Box Culvert	-	-	1	2	2	-	48
2.	1+310	New Construction	Box Culvert	-	-	1	2	2	-	29.5
3.	1+550	New Construction	Box Culvert	-	-	1	2	2	-	29.5
4.	1+800	New Construction	Box Culvert	-	-	1	2	2	-	29.5

5.	2+00 5	New Construction	Box Culvert	-	-	2	3	2	45	29.5
6.	2+48 0	New Construction	Box Culvert	-	-	2	3	2	-	29.5
7.	2+74 0	New Construction	Box Culvert	-	-	1	2	2	-	29.5
8.	3+40 0	New Construction	Box Culvert	-	-	1	2	2	-	29.5
9.	3+50 0	New Construction	Box Culvert	-	-	1	2	2	-	29.5
10.	3+66 8	New Construction	Box Culvert	-	-	1	3	2	-	29.5
11.	4+57 0	New Construction	Box Culvert	-	-	1	2	2	-	29.5
12.	4+85 0	New Construction	Box Culvert	-	-	1	3	2	-	29.5
13.	5+10 0	New Construction	Box Culvert	-	-	1	2	2	-	29.5
14.	6+20 0	New Construction	Box Culvert	-	-	1	2	2	-	48
15.	7+15 0	New Construction	Box Culvert	-	-	1	2	2	-	48
16.	7+44 0	New Construction	Box Culvert	-	-	1	2	2	-	48
17.	8+05 0	New Construction	Box Culvert	-	-	2	3	2	-	48
18.	8+57 0	New Construction	Box Culvert	-	-	1	2	2	-	48
19.	9+17 0	New Construction	Box Culvert	-	-	1	2	2	-	48
20.	9+70 0	New Construction	Box Culvert	-	-	1	2	2	-	29.5
21.	10+1 73	New Construction	Box Culvert	-	-	2	3	2	45	29.5
22.	10+4 50	New Construction	Box Culvert	-	-	1	2	2	-	48
23.	11+4 50	New Construction	Box Culvert	-	-	2	3	2	45	48
24.	11+7 84	New Construction	Box Culvert	-	-	2	3	2	-	48
25.	12+1 50	New Construction	Box Culvert	-	-	1	3	2	-	29.5
26.	12+3 00	New Construction	Box Culvert	-	-	1	3	2	-	29.5
27.	12+5 00	New Construction	Box Culvert	-	-	1	2	2	-	29.5
28.	12+7 92	New Construction	Box Culvert	-	-	2	3	2	14	48
29.	13+7 82	New Construction	Box Culvert	-	-	1	2	2	-	48
30.	13+945	New Construction	Box Culvert	-	-	1	2	2	-	48
31.	14+5 20	New Construction	Box Culvert	-	-	1	2	2	-	29.5
32.	14+8 80	New Construction	Box Culvert	-	-	1	2	2	-	29.5
33.	15+2 00	New Construction	Box Culvert	-	-	1	2	2	-	29.5
34.	16+3 50	New Construction	Box Culvert	-	-	1	2	2	-	48

35.	16+800	New Construction	Box Culvert	-	-	1	2	2	-	29.5
36.	17+070	New Construction	Box Culvert	-	-	1	2	2	-	29.5
37.	17+470	New Construction	Box Culvert	-	-	1	2	2	-	48
38.	17+735	New Construction	Box Culvert	-	-	1	2	2	-	48
39.	18+125	New Construction	Box Culvert	-	-	1	2	2	-	48
40.	18+480	New Construction	Box Culvert	-	-	1	2	2	-	48
41.	18+730	New Construction	Box Culvert	-	-	1	2	2	-	29.5
42.	19+100	New Construction	Box Culvert	-	-	1	2	2	-	29.5
43	19+422	New Construction	Box Culvert	-	-	2	3	2	25	48

Table 7.9: Proposed Minor Bridge Locations

S.NO	Proposed Chainage	Proposed Structure Type	Proposed Arrangement
1	3+238	Slab Bridge	3 X 10
2	5+586	Slab Bridge	1 X 8
3	5+828	Slab Bridge	2 X 8
4	6+852	Slab Bridge	2 X 8
5	10+714	Slab Bridge	2 X 8

Table 7.10: Proposed Grade Separator Locations

S.NO	Proposed Chainage	Proposed Structure Type	Proposed Arrangement	Remarks
1	0+463.696	Grade Separator (with ROB)	2x30+1x30.2+1x76.104 (ROB)+1x20 on LHS 2x30+1x23.2+1x76.104 (ROB) +1x27 on RHS	At Km:47+490 of NH-234
2	6+500	Grade Separator	20+2x30+20	Km: 109/750 of NH-48

Table 7.11: Proposed Vehicular Underpass Locations

S.NO	Proposed Chainage	Proposed Treatment	Proposed Structure Type	Proposed Arrangement				Width of structure (m)
				No. of Cells	Span / Diameter	Vent	Skew (Deg)	
1	7+974	New Construction	VUP	1	1x15+1x30+1x15	5.5	17	14.5+0.5+14.5
2	11+015	New Construction	VUP	1	20	5.5	27	14.5+0.5+14.5
3	13+740	New Construction	VUP	1	1x15+1x30+1x15	5.5	-	14.5+0.5+14.5
4	16+200	New Construction	VUP	1	1x15+1x30+1x15	5.5	-	14.5+0.5+14.5
5	18+000	New Construction	VUP	1	20	5.5	-	14.5+0.5+14.5

Table 7.12: Proposed Railway over Bridge Locations

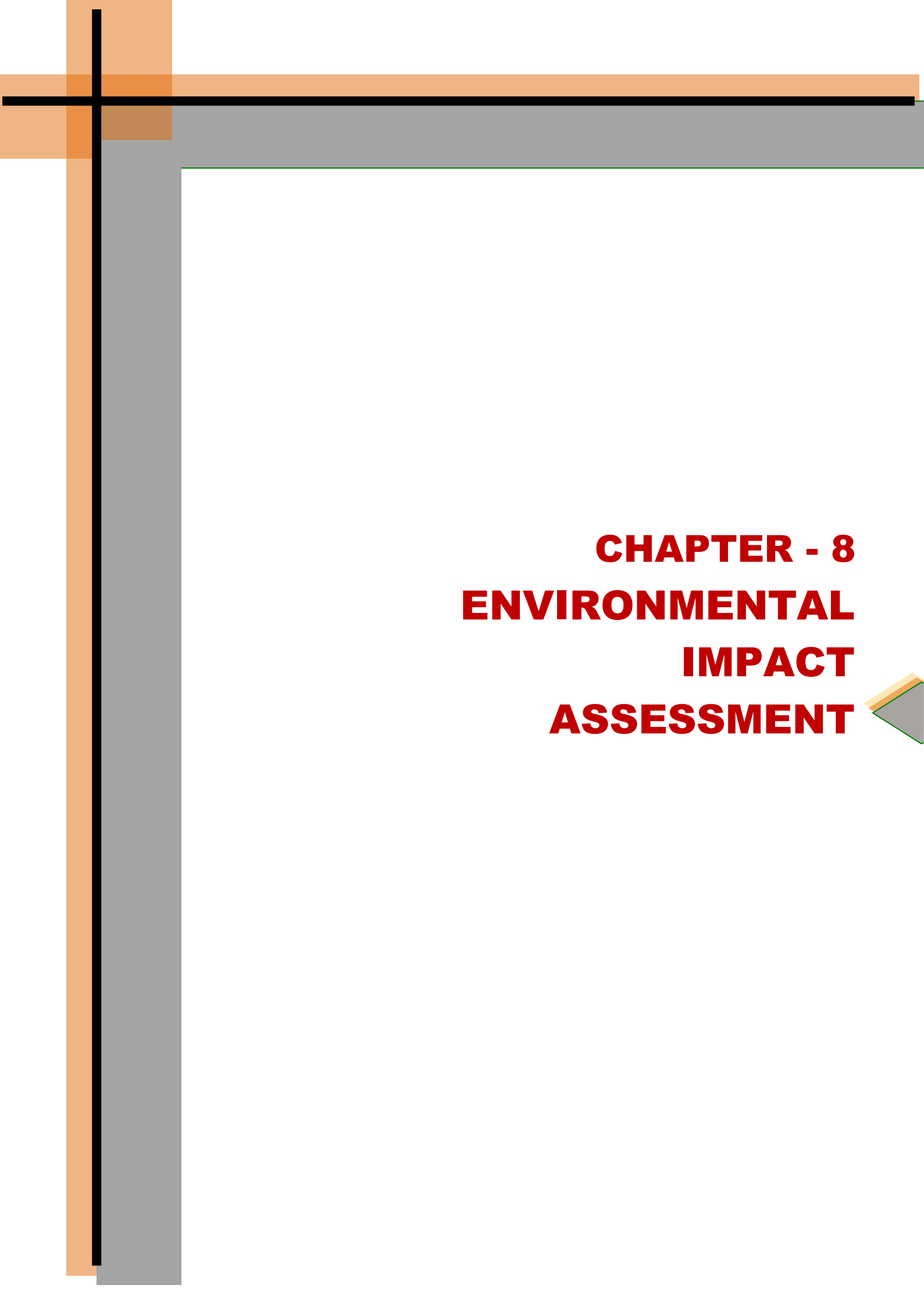
S.NO	Proposed Chainage	Proposed Structure Type	Proposed Arrangement	Remarks
1	0+596	ROB	1x76.104 m	Km: 137/600 to 137/700 of Railways
2	20+087	ROB	1X20+1X46.0(ROB)+1X20 on	Km: 140/800 to 140/900 of Railways

Table 7.13 Grade Separated Rotary:

S.No.	Proposed Chainage	Diameter of Rotary (m)		Number of Pier on Rotary		Approach Span (m)				Remarks
		Inner	Outer	Inner	Outer	To KV Kuppam	To Vellore town	To Kuppam Bypass	To Vellore Bypass	
1	0+358	36	77	4	8	2x30.0 + 1x18	2x30.0 + 1x18	1x18	1x18	Elevated Rotary at starting of Vellore Bypass.

Table 7.14: Proposed Major Bridge Location

S.NO	Proposed Chainage	Proposed Structure Type	Proposed Arrangement
1	3+995	Major Bridge	4x20
2	5+419	Major Bridge	10 X 20

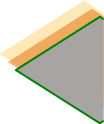


CHAPTER - 8

ENVIRONMENTAL

IMPACT

ASSESSMENT



CHAPTER 8

ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Introduction

Ministry of Road Transport & Highways (MoRT&H), Government of India has decided to take up the construction of Vellore and Gudiyatham Bypasses under EPC Mode, for better connectivity catering future traffic, efficient commercial transportation, decongestion traffic in the city areas which will reduce pollution and travel time. National Highways, Government of Tamil Nadu, has been entrusted with the task of implementation of these projects.

8.2 Need of the study

Development of highway projects is generally intended to improve the economic and social welfare of the people. At the same time, it may also create adverse impact on the surrounding environment.

People and properties may be in the direct path of road works are affected. The environmental impact of highway projects include damage to sensitive eco-systems, soil erosion, changes to drainage pattern and thereby ground water, interference with wild life movement, loss of productive agricultural lands, resettlement of people, disruption of local economic activities, demographic changes and accelerated urbanization. Highway development and operation therefore, be planned with careful consideration of the environmental impact. To minimize these adverse effects that may be created by the highway development projects, the techniques of Environmental Impact Assessment (EIA) become necessary.

8.3 Scope of Environmental Assessment (EA)

Environmental assessment is a detailed process, which starts from the conception of the project and continues till the operation phases. The steps for environmental assessment are, therefore, different in different phases. The first steps for environmental assessment are known as scoping and screening. It is a preliminary Environmental Impact Assessment study for identifying major environmental issues and their broad mitigation measures. The findings of preliminary study guide to undertake more focused Environmental Impact Assessment Study.

The basic aim of the present study is to assess the magnitude of actual and potential environmental concerns due to improvement of the connectivity between the regional

highways, presently the through traffic also required to pass through the City centre which increases travel time and travel cost of those vehicles besides causing congestion to the flow of heavy traffic. Under NH wing of GOTN, proposes to form a bypass for Vellore for better connectivity around the city catering future traffic, efficient commercial transportation, decongestion of traffic in the cities and to reduce pollution and travel time. This is also to ensure that the environmental considerations are given due weight-age, in the design of proposed improvements being studied. Environmental Screening of the study area has the following major objectives:

- To generate baseline environmental condition of the proposed project areas including Ambient Air Quality, Noise level, Water Quality (surface & ground) and Soil Quality etc.
- To classify the type of environmental assessment required.
- To delineate the major environmental issues and identify the potential hotspots, which requires further study i.e. scope for Environmental Impact Assessment (EIA).
- To recognize the potential environmental concerns.
- To determine the magnitude of potential impacts and ensure that environmental considerations are given due weight-age while selecting and designing proposed highway improvements.

8.4 Policy Legal and Administrative Frame work

Review of the existing legislation, institutions and policies relevant to the Environmental Impact Assessment at the National and State levels has been done and clearance requirements for the project at various stages of the project have been identified.

Environmental Clearance

In terms of the provision of Ministry of Environment and Forests 2006 notification and its amendment dated 1st December 2009; this project will be classified as a category 'A' project because of the following features of the road:

- *New National Highway (Bypass). The proposed stand-alone by-pass involves substantial acquisition of land, but MOEF notification on 22nd August 2013, Item 7, in column (3), for the entry (ii) classifies the Expansion of National Highways greater than 100 km involving additional right of way or land acquisition greater than 40m on Existing Alignment and 60m on Re-alignment or by-passes as category 'A'.*

Therefore, the project will not require environment clearance for execution, but prepare EIA & EMP report on the basis of model TOR specified by MOEF;

The requirement of obtaining the clearances from authorities at the state level for the project are indicated in **Table 8.1**

Table 8.1: Clearance Requirement for the Present Project

Sl. No	Activity	Statutory Authority	Relevant Statute
1	Setting of hot mix plants, crushers and batching plants	Tamilnadu State Pollution Control Board	Air (Prevention and Control of Pollution) Act, 1981 and the Noise Pollution (Regulation and Control) Rules, 2000.
2	Establishment of workers camp, equipment and storage yards	Tamilnadu State Pollution Control Board	Environment Protection Act, 1986 and Manufacturing, Storage and Import of Hazardous Chemicals Rules, 1989
3	Storage, handling and transport of hazardous materials	Tamilnadu State Pollution Control Board	Hazardous Waste (Management and handling) Rules, 1989 and Manufacturing, storage and Import of Hazardous chemical Rules, 1989
4	Waste water discharge from labour camps	Tamilnadu State Pollution Control Board	Water (Prevention and Control of Pollution) Act, 1974
5	Disposal of bituminous wastes	Local Civil Body to identify solid waste disposal sites	Hazardous Waste (Management and Handling) Rules, 1989
6	Opening up new quarries	Commerce and Industries, Govt. of Tamilnadu	Mines and Minerals (Regulation and development) Act, 1957 as amended in 1972

Sl. No	Activity	Statutory Authority	Relevant Statute
7	Conservation of forests. Under the Act, no state government or other authority shall pass, except with the approval of the central government, any order (a) De-reserving any reserved forest or part of it, (b) allowing any forest land for nonforest purpose, (d) allowing falling trees.	Department of Forest (Tamilnadu)	The Forest (Conservation) Act, 1980
8	Tree felling and removal from non forest areas (Forest Tree: 2050 Nos & Horticulture: 1662 Nos) to be removed for development of Project Highway	District Level Committee constituted by the State Govt. and chaired by the District Collector	Procedural Guidelines developed by the Department of Environment, under the orders of the Hon'ble High Court; Tree removal will be guided as per state government rules.

8.5 Project Road

The approved alignment of Vellore Bypass alignment starts at the Mangalore - Villupuram Road (at km 47/200 of NH-234), crosses the railway track between (Latheri & Virinchipuram station) crosses the Palar River and then reach NH-48 (Krishnagiri – Ranipet Road) at km 109/750 near poigai. Then alignment crosses the SH-122 at km 1/800 near Poigai mottur village, crosses the ODR-97 near Sekkanur, reaches the MDR -1028 (Nelvoy Pallikonda Road) at km 7/000, travels in existing road for the length 3200m, it takes right and runs parallel to the existing road to cross the railway track between (Pennathur to Kaniyambadi station) and then reaches the NH-234 at km 73/250. The total length of proposed bypass is 20.85 km. The proposed alignment avoids the reserved forest.

8.5.1 Project Benefits

The construction of Vellore bypass with Four lane with paved shoulders will have the following direct benefits:

- Will form a bypass for the town.
- Based on detailed traffic studies, about 60 to 72% of the through traffic will use this route, resulting in decongestion of City.
- Improved quality of life for the population in the project area.
- Economic boost to the local population because of improvement in quality of connectivity to the people with other region of state. This will ease transportation of materials and will also provide better connectivity for Indian cities.
- Provides employment facility for the local population.
- Improvement in accessibility to tourist/religious centres of Vellore, AP/KA states.
- Development of agricultural and lignite based industries.

8.6 Inventory of Environmental Features

8.6.1 Secondary Data

Secondary information on various environmental components such as physiographic, soil, geology, drainage, forest, ambient air quality, land-use, demography etc. was collected from various published sources to examine the baseline status of the environmental features in the project influence area.

In addition to the secondary data collected and the inventory information obtained, discussions with the stakeholders including the local people and government officials were held so as to provide a realistic assessment of any significant/specific socio-environmental concerns due to proposed project. These discussions helped in incorporating the views of the stakeholders.

8.6.2 Preliminary Environmental Assessment

The baseline environmental status of the project influence area is based on the field survey within proposed ROW and within the Corridor of Influence (COI). It will help in assessing the magnitude of potential impacts both beneficial as well as adverse due to the proposed project activities on the environment. The Environmental Impact Assessment (EIA) is aimed at determining the environmental impacts due to the construction and operation of the 4 lane

with paved shoulders of the Vellore bypass. The major environmental disciplines in this study would include topography and land use, soil & agriculture, geology & Seismicity, hydrology, climate and meteorology, air quality, water quality, noise level, terrestrial & aquatic ecology and sensitive receptors. In order to meet the broad aims and objectives of the study as discussed, a rational methodology and approach have been adopted.

8.6.2.1 Physical Resources

Right of Way and Terrain

The major portion of the project highway passes through plain and rolling terrain and the land acquisition is 45m ROW throughout the bypass stretch.

Climate and Meteorology

The vellore district has a semi-arid climate with high temperatures throughout the year and relatively low rainfall. The topography is almost plain with slopes from west to east. There are no notable mineral resources. Black loam soil is found in parts of Vellore Taluk. The other type of soil in the vellore district is chiefly gravelly, stony and sandy of the red variety.

Vellore district experiences hot and dry weather throughout the year. The temperature ranges from a maximum of 43.5°C to a minimum of 18.4°C. April to June are the hottest months and December to January are the coldest. Vellore receives 996.7 mm of rainfall every year. The southwest monsoon, with an onset in June and lasting up to August, brings scanty rainfall. The bulk of the rainfall is received during the northeast monsoon in October, November and December. The humidity ranges from 40%–63% during summer and 67%–86% during winter.

Water Quality

Existing quality of both the surface and ground water are required for the EIA study. Quality of water both surface and ground will be collected from concerned public work department or else sample of water is collected and tested in the laboratory by using APHA standards. Different parameter of the water will be compared with WHO and IS standards.

Air Quality

It has been observed that the CO and HC levels are below detection level (BDL) when compared to CPCB norms. It is also seen that the levels of SPM, RPM, SO₂ and NO_x are within the specified limits as specified for residential and other areas.

Noise Level

Existing scenario of the Noise quality of the contiguous region will be collected from the SPCB or else quality of noise will be measured using NLM (Noise Level Meter) to establish the base line status of the quality of noise of the contiguous region of the proposed alignment. Quality will be compared against the standards prescribed by CPCB.

8.7 Environmental Impact Assessment, Mitigation, Avoidance and Enhancement

8.7.1 Air Environment

The monitoring of the ambient air quality (AAQ) for the various land uses along the project corridor was carried out along the first row of potential receptors, so as to establish the baseline concentrations.

A comparison of levels with the respective standards for the various locations, reveal that all the parameters of Air Quality i.e. PM₁₀, PM_{2.5}, NO_x, and Sox are within the permissible limit.

8.7.2 Potential Impacts

Adverse impacts will be on air quality due to the movement of construction machinery as well as haulage of construction material, site clearance, earth filling, etc, in construction stage. Proper precaution are measures like sprinkling of water during construction phase on unpaved or haul roads, masks for labors, etc., should be adopted to avoid any adverse effects on the human health.

The negative impact on air quality during construction: sources such as large construction equipment, trucks and asphalt producing and paving equipment would be responsible for short-term impact. Site leveling, clearing of trees, laying of asphalt, construction of bridges, operation of quarry and borrow areas and hot mix plant emissions are also likely to degrade air quality. The following impacts can be identified during construction phase:

- **Generation of Dust**

Dust generation due to procurement and transport of raw materials from quarries and borrow pits, site clearance, use of heavy vehicles, machinery/ equipment, stone crushing handling and storage of aggregates and generation of fine particulate matter (smoke) in asphalt processing will be responsible for short-term and localized degradation of air quality.

- **Generation of Exhaust Gases**

Hot mix plants contribute substantially to the deterioration of air quality due to emissions of oxides of sulphur, hydrocarbons and particulate matter. During operation phase, due to the increased speed and volumes of vehicular traffic on the project corridor, marginal increase in the air pollutant levels, is expected but it may not be significant.

Mitigation Measures

Various mitigation measures have been adopted during the design stage to minimize air pollution and improve air quality.

The asphalt plants, crushers and the batching plants will be sited at least 1 km in the downwind direction from the nearest human settlement. All precautions to reduce the level of dust emissions from the hot mix plants, crushers and batching plants will be taken up. The hot mix plant will be fitted with dust extraction units. To control emissions from the stack, an adequate cyclone/scrubber will need to be provided in the event of the emissions exceeding the SPCB norms.

A vehicle management schedule prepared by the contractor and approved by the Supervision consultant shall be adhered to. Water will be sprayed in the lime/cement and earth mixing sites, asphalt mixing site and temporary service and access roads. After compacting the earthwork, water will be sprayed on regularly to prevent dust. To avoid dust emissions likely to result from transporting crushed rock and earth, the vehicles delivering construction material will be covered.

Pollution resistance species, which can grow in high pollutant concentrations or even absorb pollutants, can be planted along the roadside.

Monitoring of air pollution levels at sensitive locations shall be carried out all through the operation stage to check that the pollution levels are within standards prescribed by CPCB. A monitoring plan to the effect will be prepared for proposed project and will be submitted in EIA/EMP Report.

8.7.3 Noise Environment

The noise level prevailing at a particular location in the outdoor environment is contributed by all kinds of sources at various distances around that location. Continuous, temporal and spatial variations occur in ambient noise levels depending on the type of surrounding activities. The impact of noise on the health of individual depends on physical dose of noise viz. noise level, frequency, intermittency etc. and human factors viz. sex, age, health status, type of activity, occupational exposure etc. The major noise sources contributing to ambient noise levels in the region are vehicular traffic, existing industrial activities and construction activities.

Potential Impacts

Due to the various construction activities, there will -be temporary noise impacts in the immediate vicinity of the project corridor. The construction activities will include the excavation for foundations and grading of the site and the construction of structures and facilities. Crushing plants, asphalt production plants, movement of heavy vehicles, loading, transportation and unloading of construction materials produces significant noise during construction stage. However, these increased noise levels will prevail only for a short duration during the pre construction and construction stage.

Mitigation Measures

Enforcement Measures: Noise standards will be strictly enforced for all vehicles, plants, equipment, and construction machinery. All construction equipment used for an 8-hour shift should conform to a standard of less than 90 dB(A). If required, machinery producing high noise as concrete mixers, generators etc, shall be provided with noise shields.

Workers to wear earplugs, helmets and be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 90dB (A) per 8 hour shift. Construction sites shall not be located within 300 m from settlement areas. No hot mix, batching and aggregate crushing plants shall be located within 200 m of sensitive land uses as schools, hospitals etc.

Noise Barriers:

The shielding of the noise from the highway will result in design of barriers for the attenuation for the entire length of the settlements. Either the sound waves can be controlled near the source or the receptor can be shielded. Since safety of road using vehicles. Is of paramount importance, a specific clear distance needs to be maintained from the pavement. Hence, the only viable option is to provide a shield around the receptor.

- The noise attenuation should be worked out by the adoption of the following types of noise barriers
- Physical barriers in the form of walls, screens etc.
- Structural modifications at the receptor locations, in the form of provision of double-glazing etc.
- Rearrangement of the sensitive locations, through changes in the internal planning where possible
- Earthen berms between the highway and the receptor and,
- Vegetative barriers in the form of thick screen of vegetation etc.
- Noise barriers should be designed and proposed at sensitive locations. Keeping in view the above points, there has been done modifications in design of road alignment. Road widening diversion and bypasses has been proposed wherever there are highly populated and forest areas are falling on road stretch.

8.7.4 Water Environment

Road construction has a wide range of effects on water resources, stemming from construction activities. There is one perennial river in the project area and the New / re-construction of existing bridges may lead to degradation of water quality in terms of increased suspended solids as well as oil / grease concentration. However, during operation the overall impact on water resources will be positive except oil and grease content. Adequate precautionary / mitigation measures will be exercised to control these effects during construction and operation phase.

Water bodies along project road

There are some surface water bodies along/crossing project road out of which one River (Palar River) and others is pond. Depending upon their location and nature, they are used by

different groups. In order to make these water bodies more accessible and to enhance the water-front, landscape proposals will be prepared. This includes provision of toe/retaining wall, stone pitching and plantation of ornamental plants along the edge of these water bodies to enhance the aesthetics. Some of the water bodies along the project corridor are shown below in **Fig. 8.1**



Figure 8.1 Ponds along the Project Road

Impairment to Water Quality:

The contamination of the ground water resources due to the project are likely at the following locations: along construction sites, camps involving moving of construction equipments and machinery. At the various community water bodies and sources of water supply as hand pumps etc. and along the entire length of the corridor.

Water Quality:

The short-term increase in runoff during the construction stage may also occur due to the removal of trees, vegetative cover and compaction of the surrounding soil. The construction activities around the surface bodies can affect the water quality due to the disposal of solid and liquid wastes from labour camps, fuel and lubricant spills or leaks from construction vehicles, fuel storage and distribution sites and from bitumen or asphalt storage at hot-mix plants. The spoil heaps around the construction sites are also prone to erosion and contribute to the increased sediment load in the near-by water bodies. The major parameter of concern would be the sediment load from the spoils.

The major pollutants of concern are suspended solids, oil and grease, lead and other heavy metals. Concentration of suspended solids is likely to be highest during the construction stage and immediately after the construction when vegetation has not been fully established on the embankment slopes. Oil and grease form a film on the water surface and hinder the transfer of oxygen into water. Though the compounds of lead are suspected to be carcinogenic, it is unlikely that lead pollution to have significant effects as 90-95% of lead in run-off is inert, and will be further diluted in the receiving water bodies, where the lead concentrations are minimal.

Depletion of Water Source:

The water to be used for road construction will be met through availability of ample supply both from surface sources from nearby areas and ground water. So there will be direct impact on the water resources in the area.

Loss of Water bodies/Ground Water sources:

Some of the water bodies shall be partially filled up, due to the proposed improvement. Some water shall be relocated due to the project. Relocation of these water resources will be worked out in consultation with the community, and all community resources impacted due to the project will be relocated at suitable locations. The typical designs and details of the relocation of the hand pumps and the protection measures for the various categories of wells need to be worked out to minimise the impacts during both the construction and operation stages of the project.

Mitigation Measures

Protection of Banks and edges:

Road run-off is let off into natural drains of adequate capacity from ditches at the end of formation to prevent destabilization of the embankment. Release of road run-off directly from the ditches can erode edges of the water body into which the run-off is let off. To ensure that run-off does not damage the water body it enters, cascading for scour protection should be proposed.

Silt Fencing:

Silt fencing will be provided to prevent sediments from the construction site entering into the nearby watercourses. The silt fencing consists of geotextile (MIRAFI 140N or equal) with extremely small size supported by a wire-mesh mounted on a panel made up of angle frame. The frame should be installed at the edge of the water body along which construction is in progress. The wire-mesh will provide structural stability and the 25x25x3 mm angle section will act as posts for the silt fencing.

Sedimentation Chamber:

Excessive sediment loads are expected from road run off as it is discharged into the environment. To remove the sediment, a small sedimentation chamber at the end of ditches before discharging into the watercourse should be proposed. The entry into the chamber will be through a bar screen which can take care of large floating debris, if it finds its way into the run-off.

Oil interceptor:

Oil and Grease from road run-off is another major concern during construction as well as operation. During construction, discharge of Oil and Grease is most likely from vehicle parking areas of the contractors' camps. On the other hand, during the operation stage, the discharge can be from anywhere along the entire road stretch. Thus, the source is diffused and virtually unrestricted. In either case, the technique for the separation of oil and water is the same: gravity separation. Enough detention time is provided to run-off to allow oil to float on to the surface.

Sitting of Activities:

The location of all fuel storage and vehicle cleaning area should be at least 300 m from the nearest drain/ water body. In addition, the maintenance and repairs of vehicles should be carried out in a manner such that contamination of water bodies and drainage channels can be avoided. The slopes of embankments leading to water bodies should be modified and re canalized to prevent entry of contaminants into the water body.

Cross Drainage Structures:

Though during construction period, drainage alteration and downstream erosion/ citation is anticipated, design should begin a manner so that it can improve the drainage characteristics of the surrounding area.

Along the settlements, as part of the engineering design, provision has been made for drainage along the sides of road. These drains should be properly maintained by the MPRDC as part of its corridor management plan. To ensure efficient cross-drainage and to prevent water logging along the sides, adequate size and number of cross-drainage structures have been provided.

Recharging pit for roadside drain in urban areas:

In urban areas too, the run-off in roadside ditches needs to be disposed of. Provision should be made for urban recharging pits along stretches where the road passes through large urban areas. These vertical drains serve two purposes: they dispose of unwanted run-off and encourage recharging of underground water resources. The drains have gravel columns and geo-synthetic filter fabric at about 2 m depth from the top of the bores and to prevent the transportation of contaminants into the aquifer. The drains should be provided at the beginning and the end of each settlement and near the outfall to a natural drain if the highway crosses one inside a settlement.

It should be pointed out that all the devices being suggested require periodic maintenance and cleaning to operate at their design capacity.

8.7.5 Impact on Land Environment

The problem of soil erosion during the construction stage is likely to be more pronounced along bridge-end fills, Ghat sections, over steep banks and embankment slopes. To check soil erosion on critical road embankment slopes turffing with shrubs and grasses will be carried out, in accordance with the recommended practice for treatment of embankment slopes for erosion control. Soil erosion checking measures as the formation of sediment basins, slope drains, etc.; will be carried out at construction sites. Proper side drains for the storm water from the road will be constructed so as to avoid pooling of water near toe line of the road and combination of water bodies.

The alignment has been selected to minimize the acquisition of productive agriculture land, as the maximum portion of stretch falls in the agricultural plains. Agricultural areas will be avoided for borrowing of materials. Wherever unavoidable, the topsoil from all areas of cutting, to be permanently covered will be stripped to a specified depth and stored in stockpiles of specified height. The stored topsoil will be spread back to maintain the physico-chemical and biological activity of the soil. Water will be frequently spread during construction to stabilise the topsoil.

8.7.5.1 Soil Quality

Potential Impact

Loss of Productive Soil: The entire corridor lies in a fertile agricultural belt; the adjoining land use is predominantly agricultural. The loss of topsoil, especially in the irrigated areas, can be a long-term residual impact. Though this is a genuine concern, the benefits of realignment in terms of increased flows, safety and improvement in ambient air quality in settlements avoided will compensate at least in part for the loss to the economy as a whole.

Soil erosion:

There is possibility of soil erosion due to pavement embankment, if the side slopes are not properly designed. It will be an issue on most part of the project road. Erosion potential exists mostly at high embankment areas of the road, especially at bridge-approaches. Once the trees are removed during pre construction stage and the ground cover is cleared on the expanding side (mostly limited to one side of the existing carriageway) for the widening, the problem due to erosion could increase

Soil Quality:

Contamination of soil can take place in sites wherein construction vehicles are parked and serviced due to leakage or spillage of fuel and lubricants. Pollution of soil can also occur due to leakage or spillage of asphalt and bitumen and around hot-mix plants, refuse and solid waste generated from labour camps or due to accidental vehicles spills. As the proposed project enables smooth traffic-flow and removes traffic bottlenecks, it is expected that the impact on soil quality, overall, will not be detrimental.

Mitigation Measures

Minimizing Land Acquisition:

Land acquisition in the proposed project, especially along the stretches with pre-dominant agricultural land utilisation. Though the impact on the productive soil is unavoidable, adequate measures should be worked out for minimising the loss of soil, as by the storing of topsoil, to be laid back after the construction period etc.

Reinforced Earth Walls:

The project would improve the erosion situation by developing all the road embankments at a slope of 1:2. All high embankments along the bridges and RUBs are provided with reinforced earth walls. Gravity return walls will be provided on all bridges to encase the whole embankment.

Turfing of Slopes:

Incorporating appropriate type of treatments of slopes has reduced the potential for erosion of high embankments and bridge fills. The side slopes can be turfed with shrubs and grasses as per recommendations for the treatment of embankment slopes for erosion control, IRC: 56-1974.

Stone Pitching:

If the slope is steeper than 1:2, stone pitching will be carried out. Stones will be fixed on slopes by gentle hammering. The gaps between adjacent stones allow grass to grow which will hold the soil firmly together.

8.7.5.2 Quarries and Crushers

Potential Impact

The excavation of quarries and borrow pits used for obtaining rocks, soil and aggregate materials for road construction can cause direct and indirect long -term adverse impacts on the environment. Though the quarry materials are to be transported over long distances to the construction sites, almost all the quarries identified have proper access roads, therefore, no major impacts during the hauling of materials is envisaged.

As no new Quarry needs to be opened for this project (majority of the material being generated from cut operations within the site itself), therefore, no new impacts are likely to arise due to quarrying operations

Mitigation Measures

To ensure that quarrying operations do not have an indiscriminate impact on the environment, the material shall be procured only from licensed quarries and which have proper quarry redevelopment plans in place, to be adapted once the quarrying operations are over.

8.7.5.3 Borrow Areas

Potential Impacts

As the borrowing is to be carried out in accordance to the guidelines laid out in IRC-1 0-1 961, no major adverse impacts are anticipated. Also, productive agricultural areas have been avoided for borrowing. However the borrow area pits, if not treated properly after the borrowing is complete, can form stagnant pools and pose health hazards, to prevent this, redevelopment of borrow areas need to be worked out. At borrow area locations where the owners are willing to create ponds for fisheries etc, proper protection measures for the drainage of the surrounding land and slope protection measures need to be worked out.

However, cartage of the borrow materials to the construction sites can be of significance, as almost all such areas are accessible through dirt tracks only and therefore, spillage and compaction of soil along these tracks will be a significant impact. Proper protections measures need to be worked out for the minimizing of such impacts during the haulage of borrow materials.

Mitigation Measures

The borrow areas selection and recommendation for borrow areas for use in the proposed road project have been based on environmental as well as civil engineering considerations. The local people can be suggested to borrow off their land either to level off their high agricultural land or develop or deepen their ponds for fish culture.

Non-Cultivable lands

Borrowing of earth will be carried out to a depth of 1.0 m. The borrowing of earth shall not be done continuously the slope of the edges shall be maintained at not more than 1:4. Ridges of not less than 8m shall be left at intervals not exceeding 300 m, small drains shall be cut through the ridges, if necessary, to facilitate drainage.

Productive lands:

Borrowing of earth should not be carried out on productive lands. However, in the event of borrowing from productive lands or at the contractor has to obtain the prior permission of the Supervision Consultant. At such locations, the depth of borrow pits shall not exceed 45 cm and if may be dug out to a depth of not more than 30 cm after stripping the 15 cm top soil aside.

Elevated lands:

At locations where private owners desire their fields to be leveled, the borrowing shall be done to a depth of 1 m or up to the level of surrounding fields.

Fish Ponds:

At locations, where the private owners (or in some cases, the community) desire to develop lands (mostly low-lying areas) for fish culture purposes and for use as fish-ponds.

Borrow Areas near Settlements:

Borrow pit location should be located at least 0.8 km from villages and settlements. If unavoidable, they should not be dug for more than 30 cm and should be drained.

Enhancement Measures

Redevelopment of Borrow Areas:

To avoid any embankment slippages, the borrow areas will not be dug continuously, and the size and shape of borrow pits will be decided by the Supervision Consultant. The borrow pits will be redeveloped by filling and providing 150 mm thick layer of preserved top-soil; by creating a pond for fisheries, etc; or by leveling an elevated, raised earth mound and covering

it with 150 mm thick preserved top-soil. Replantation of trees along the edges of borrow areas will be carried out.

8.8 Environmental Management Plan

The environmental management measures shall be implemented during the various stages of the project viz: Pre-construction stage, Construction Stage and Operational Stage. The Environmental Management Plan (EMP) consists of a set of mitigation, monitoring and institutional measures to be taken during the design, construction and operational phases of the project to eliminate adverse environmental impacts, to offset them, or to reduce them to acceptable levels. The main aim of the Environmental Management Plan is to ensure that the various adverse impacts are mitigated and the positive impacts are enhanced. The environmental management plan is as described below.

8.8.1 Pre-Construction Stage

Pre-construction activities by PIU/ Independent Consultant

Prior to the contractor mobilization, the PIU will ensure that an encumbrance free Corridor of Impact is handed over to enable the start of construction. Clearance involves the following activities:

- Removal and felling of trees is very minimal,
- Relocation of common property resources and community assets like telephone poles, electric poles and hand pumps will be impacted.
- Formal arrangements for maintenance of enhancement sites. This includes plantation of trees and barricades along the road.
- Modification (if any), of the contract documents by the Engineer of the Independent Consultant.

Pre-construction activities by Contractor

- Pre-construction stage involves mobilisation of the contractor and the activities undertaken by the contractor pertaining to the planning of logistics and site preparation necessary for commencing construction activities. The activities include:
- Joint field verification of EMP by the Environment Specialist of the Independent Consultant and Contractor.
- Identification and selection of material sources (quarry and borrow material, water, sand etc).

- Procurement of construction equipment / machinery such as crushers, hot mix plants, batching plants and other construction equipment and machinery.
- Selection, design and layout of construction areas, hot mix and batching plants, labour camps etc.
- Apply for and obtain all the necessary clearances/ NOC,s/ consents from the agencies concerned.
- Planning traffic diversions and detours including arrangements for temporary land acquisition.

8.8.2 Construction Stage

Construction activities by the Contractor

Construction stage is the most crucial stage in terms of activities that require careful management to avoid environmental impacts. There are several other environmental issues that have been addressed as part of good engineering practices, the costs for which have been accounted for in the Engineering Costs. They include providing roadside drainage, provision of cross drainage structures etc.

Construction activities by the PIU / Supervision Consultants

The PIU/Independent Consultant shall be involved in the smooth execution of the project and assisting the contractor during this phase. Their work shall include but not limited to:

- Monitoring and guiding the contractor on adopting good environmental and engineering practices.
- Arrangement of plantation through the Forest Department
- Arranging training to the contractor and other stakeholders according to the needs arising.
- Making changes in the design if need so arises.

8.8.3 Operation Stage

The operational stage involves the following activities by PIU:

- Monitoring of environmental conditions through approved monitoring agency.
- Monitoring of operational performance of the various mitigation / enhancement measures carried out.

8.9 Environmental Monitoring Programme

The purpose of the monitoring programme is to ensure that the envisaged purpose of the project is achieved and results in desired benefits to the target population. To ensure the effective implementation of the EMP, it is essential that an effective monitoring program be designed and carried out. The periodic monitoring programme will ensure checking whether the concentration of pollutants at the project site within the permissible limits prescribed by CPCB and in compliance with regulatory requirements. In addition, monitoring would enable early detection of rise in levels of critical pollutants and facilitate timely corrective actions to control pollution. The details of Environmental Monitoring Programme envisaged for the project is presented in **Table 8.2**.

Table 8.2: Environmental Monitoring Programme

Parameters	Locations	Duration	Frequency
Air Quality: SPM, RSPM, NO _x , SO ₂ and CO	Construction Area and Crushing or Hot Mix Plant sites	24 hours continuous sampling	Twice in a week for three season
Noise Level: Leq (day) & Leq (night)	Construction Area and Crushing or Hot Mix Plant sites	24 hours continuous sampling	Once in week for three season
Water Quality: Physical, Biological & Chemical parameters	Two surface water samples & two ground water samples	Close to construction area	Twice in a year (pre monsoon and post monsoon)
Soil Quality: For lead and Oil & Grease.	Oil storage yard and Machinery workshop site	Grab sampling	Once in a year (non monsoon season)
Maintenance of plantation	At selected locations	Throughout the year	Regularly throughout the year

8.10 Identification of Implementing Authority

Instead of a separate Environmental Management Cell (EMC), NH wings, GOTN may have a designated senior/middle level person in the Project Implementation Unit (PIU) who would look after and ensure the effective implementation of the EMP including environmental mitigative measures and monitoring programme during the construction and the operation phase of the project. The designated official will coordinate with other institutions/

organizations like Forest Department, State Pollution Control Board, State Public Health Department, State Revenue Department, etc as and when required. Monitoring of air, noise, water and soil quality may be carried out by the designated authority of PIU through an authorized agency.

8.11 Risk Assessment & Framework of Project Highway

Risk is involved in every aspect, and the construction of highway projects are no exception. Risk is defined as the possibility of loss, injury, disadvantage or destruction also as a combination of the probability of frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence. Risk assessment is a stepwise procedure consisting of risk identification, risk classification and risk analysis or evaluation. Risk assessment is determination of quantitative or qualitative estimate of risk.

Highway projects consist of many risks and this is due to involvement of many contracting parties including designers, contractors, sub-contractor and suppliers. Risks are the major cause of poor performance on highway construction projects. Construction of highways involves various risk factors from designing and planning stages to completion of project. Due to these factors, there are delays in completion of project which involve large funds. So risk assessment consisting of risk identification, risk classification and risk analysis or evaluation is necessary for maintaining cost and quality of the project and for scheduled completion of the project.

The solution to a decision making problem of budget allocation problem, to allocate funds to deserving and competing organizations can be done by using integrated Fuzzy, AHP and MCDM techniques. The major risk factors affecting highway construction project cause delay in making decision and land acquisition. Hence it needs to deploy the use of proper risk management. The most significant risks include inefficient planning, unexpected ground utilities, quality and integrity of design, and delays in approvals.

Risk assessment for highway construction project is done to prevent adverse impact at the design or planning stage, prioritize hazards and control measures, to maintain cost and quality of the project and for scheduled completion of the project. This study involves risk identification, risk classification, risk analysis or evaluation and ranking of risks using Relative Importance Index (RII).

8.11.1 Objectives and Importance

The objectives of this study are listed below:

- To define the various major risks involved in highway construction project.
- To identify and classify the various risks involved in construction of highway.
- To analyze or evaluate the risks involved in highway construction.

This study mainly focusses on assessment of various risk factors involved in construction of highway from designing and planning stages to completion of project. The risks are analyzed by using quantitative tool, i.e. RII. Risks are ranked according to their adverse impact on the highway construction project. Risk having Rank 1 has greater adverse impact than the risk having Rank 2. The assessment of risk factors will help in risk planning and risk management of any project. Further, this will help in improving the performance of highway construction projects - to maintain cost and quality of the project and for scheduled completion of the project.

8.11.2 Methodology

The various risks were identified and classified and based on that a questionnaire was prepared on “5-point Likert scale”, where point 1 to point 5 varies from very low risk to very high risk respectively. The data collection was done for the sample size of 52, through questionnaire survey. Further, this data was compiled and analyzed using Relative Importance Index (RII) method. The analyzed risks were ranked according to their importance of adverse impacts on highway construction project.

The methodology of this study is explained through the flow diagram of work as shown in Fig. below,



8.11.3 Identification and Classification Of Risks

Construction Risk:

Most risks associated with the construction are more likely to root in contractors and subcontractors. To keep the construction work on track, experienced contractors need to be involved in the project as early as possible to make sound preparations for developing valid construction programs. Machineries, delay due to rain and other causes, uncertain market conditions, contractor productivity issues, time etc. are the risks which construction phase constitutes.

Design Risk:

This may result from issues such as variations in design and defective designs. The design risks arise due to uncertainty in horizontal alignment, uncertain indirect costs and consideration of improper basic parameters while designing. To avoid defective design, the design team needs not only to fully understand what the clients want as defined in the project brief, but also to establish an efficient communication scheme among the designers.

Political Risk:

“Excessive approval procedures in administrative government departments” and “bureaucracy of government” are not seldom complained by clients and contractors. These risks are normally out of the control of the project stakeholders. To attract investment within their administrative territory, the government agencies should always make great efforts to create a friendly environment in which the approval procedures are reduced or at least the approval time is shortened, and the bureaucracy is minimized.

Organizational Risks:

Lack of skilled labour, lack in knowledge level of lead group, etc. are the example of organizational risks. Lack of skilled labour can lead to project delays, poor workmanship, safety and liability issues.

Accidental Risks:

Unanticipated damage during construction is a accidental risk. Any type of accidents on construction sites like machineries accidents, overexertion, accidental falls etc. can be disastrous for the project.

Uncertain market conditions:

Uncertain market conditions usually called as “price inflation of construction materials” is identified to be related to external environment. The price of construction materials is always changing in response to the inflation and the relation between supply and demand in the construction material market. As this risk is usually unavoidable, clients should choose an appropriate type of contract; while contractor should always avoid using fixed price contracts to bear the risk.

Time/Funds:

As time and cost are always closely correlated, a lengthy schedule will undoubtedly wreck the project cost benefit. Correlation between time and cost is a quantitative risk. In extreme cases the risk of time and cost overruns can compromise the economic viability of the project, making a potentially profitable investment untenable.

Utilities:

Utilities include: electricity, gas, water, fuel, etc. which plays a huge role in construction projects completion; shortage of these utilities would create problems on site. For example, use of ground water is prohibited by government agencies for highway construction projects in India.

8.11.4 Analysis of Risks

The data collected through questionnaire survey was analyzed by using quantitative method of relative importance index (RII) on a excel sheet. The RII is computed using the equation:

$$RII = \frac{\sum W}{A * N} \quad (0 \leq RII \leq 1)$$

Where, W – is the weight given to each risk by the respondents and ranges from 1 to 5, (where “1” is “very low risk” and “5” is “very high risk”)

A – is the highest weight (i.e. 5 in this case) and; N – is the total number of respondents.

The various risks categorized under different categories were calculated and ranked. The higher value of RII represent significant risks affecting construction of highway project.

CHAPTER - 9
INITIAL SOCIAL
ASSESSMENT AND
PRILIMINARY LAND
ACQUISITION /
RESETTLEMENT PLAN

CHAPTER 9
INITIAL SOCIAL ASSESSMENT AND
PRELIMINARY LAND ACQUISITION/RESETTLEMENT PLAN

9.1 General

This section provides the methodology and approach that will be adopted for carrying out social impact assessment, data collection and resettlement action plan in the project area. It also discusses the various methods used for field surveys and outlines the areas of concern and issues during the preparation of social impact assessment (SIA). The social assessment has been carried out in close coordination with environmental assessment and engineering design team. There will be intensive consultations with various stakeholders for providing necessary inputs to the project.

9.2 Project Road

The approved alignment of Vellore Bypass alignment starts at the Mangalore - Villupuram Road (at km 47/200 of NH-234), crosses the railway track between (Latheri & Virinchipuram station) crosses the Palar River and then reach NH-48 (Krishnagiri – Ranipet Road) at km 109/750 near poigai. Then alignment crosses the SH-122 at km 1/800 near Poigai mottur village, crosses the ODR-97 near Sekkanur, reaches the MDR -1028 (Nelvoy Pallikonda Road) at km 7/000, travels in existing road for the length 3200m, it takes right and runs parallel to the existing road to cross the railway track between (Pennathur to Kaniyambadi station) and then reaches the NH-234 at km 73/250. The total length of proposed bypass is 20.85 km. The proposed alignment avoids the reserved forest.

9.3 Project Impacts and Benefits

The proposed project can be viewed as boosting economic growth and poverty reduction which will bring substantial social and economic development in the region. The social benefits arising due to the proposed project will be triggered off due to improved accessibility to various services such as easy access to markets, health facilities, schools, workplace etc which in turn increases the income of the locals, and ultimately elevating their standard of living. The possible direct and indirect positive impacts are listed below. To enhance project benefits for roadside communities and road users, the project design has incorporated the following:

- The immediate benefits of road construction and improvement will come in the form of direct employment opportunities for the roadside communities and specially those who are engaged as wage laborers, petty contractors and suppliers of raw materials;
- Improved road networks provides for improved linkages between the village communities and urban centre, which provides wider marketing facilities;

- Road networks not only links the village communities to better markets, but also opens up wider work opportunities in distant places. People can shuttle to distant work sites and towns and engage in construction, factories, business as well as domestic works;
- Improved road networks encourage urban entrepreneurs to invest in far and remote areas in commercial farming and industrial activities;
- Improved roads also help people building strong institutional network with outside agencies. Essential and emergency services can be availed fast like schools, health centre, public distribution system etc.;
- Increased frequency of interaction with outsiders will increase the awareness level of the people in the village with regard to their health and nutrition, living style, value of education and proper utilization of available resources; and
- Interaction with the government, non-government and other development agents, help people gain new knowledge on improved farming, land development, development and maintenance of natural resources through the formation of various economic and social development committees.
- Improvement of geometric deficiencies;
- Provision of underpasses that carry pedestrian walkways, cart track, village, district and other roads;
- Provision of anti-crash barriers;
- Slope protection;
- Effective surface and sub-surface drainage system to ensure that there shall be no pooling of water on the highway and the adjacent area;
- Safety measures such as pedestrian rails, barriers, highway signs, pavement marking, traffic signals, landscaping, illumination, road furniture, truck lay-bys, and bus-bays
- Addition of truck parking for improved road safety and reduced road congestion;
- Public amenities such as rest rooms, telephone booths, facilities for public conveniences.
- Saving in vehicle operating cost
- Time saving – freight and passenger movement
- Employment potential – direct employment in road construction and allied activities and greater mobility
- Lower accidents, quick access to services like hospitals, markets, offices etc.

Although various positive impacts and benefits are expected from the proposed project as mentioned above, there will be some negative impacts on title holders and non-title holders such as encroachers and squatters who are living near the immediate corridor of impacts in terms of loss structures, livelihoods and fresh private land acquisition.

9.4 Study Approach

The project tasks incorporated integration of engineering, environment and social components within the planning exercise. Social impact assessment has been elucidated below:

1. Reconnaissance survey
2. Primary data were collected through physical survey of the stretch
3. Secondary data (District fact sheets 2011)

Consultations with various stakeholders and Public Consultation Meeting (PCMs).

9.4.1 Reconnaissance Survey

Preliminary reconnaissance of the project road was undertaken into account R&R issues. At this stage different sections of road having social impact and type of impacts were identified.

9.4.2 Primary Data Collection and Analysis

The survey also brought out issues pertaining to the bypass, which traverses through the open land and also built-up portion.

Simultaneously, a team comprising social and environmental experts, field investigators, surveyors and engineers carried out physical survey of the entire length of the project stretch to measure land and structures to be affected by the proposed bypass.

9.4.3 Secondary Data Collection and Analysis

The secondary data/information was collected from various government and nongovernment agencies so as to verify the ground realities and comprehend the socio economic characteristics, physical features and cultural set-up of the project area before undertaking detailed field investigations.

The relevant documents like the Handbook of Census 2011, District Gazetteer, Statistical Handbooks, Census publications were collected along with various published / unpublished reports on the issues, which helped in the preparation of the Social Impact Assessment.

The information pertaining to land rates was collected from Registrar office so as to ascertain the prevailing land estimates in the project area.

9.4.4 Public Consultations

The preliminary consultations will be organized at village level and will explore various issues related to the location of conservation of religious/cultural structures, the loss of sources of livelihood, the loss of residential structure, etc wherein providing key inputs in finalizing the design and measures for developing the mitigate plan.

For local level consultations, villages will be selected keeping in view social hotspots. Before initiating the Group Discussion, rapport is built with the villagers by involving them in general discussion on developmental aspects of the village, their problems, etc.

General perceptions about the project are presented below.

- People in general were aware about the project but not the details.
- People were convinced about the importance of developing the Bypass in their region since it will reduce the incidence of accidents and will enhance economic opportunities.
- Requests for facilities and amenities like underpasses, auto stand and safer accessibility at points of congestion and intersections.
- People came forward with suggestions on bypasses, provision of service roads and other social amenities such as bus bays, underpasses, etc.
- People requested employment opportunities during road construction and later phases of the project.
- Some of them were eager about employment during construction of the road, as they were willing to be part of it.
- People suggested adequate safety measures should be provided such as speed Breakers, signage's etc. near inhabited areas.

During the site visit we conducted Informal Public Meetings with the Villagers, about the Project awareness.

9.4.5 Minimization of Resettlement

Sufficient consideration has been given at this stage of the project preparation to minimize the adverse impacts on the community in the project area and efforts are made within the limitation of technical requirement. For the proposed work the following specific measures are taken to minimize resettlement in this project road.

- Saving cultural properties and community structures by adopting suitable measures;
- Providing bypass to avoid congested market and major resettlement impacts.
- Minimal impact on residential and commercial structures thus minimizing resettlement and loss of livelihood.

9.4.6 Impacts on Utilities

In addition to the impact on the private properties along the stand alone bypass, the project also has an impact on utilities that are used by the local community. The utilities mainly found are structures, power transformers like EB pole, HT lines, Mobile Tower and Religious properties.

9.5 Resettlement Plan (RP)

NH wing, GOTN, assisted by consultants, will prepare RPs for the subsequent subprojects. Social impact assessment surveys (census and 25% socio-economic survey of the APs) will be carried out, based on preliminary technical designs. The RP would also include measures to ensure that socio-economic condition, needs, and priorities of women are identified and that process of land acquisition and resettlement does not disadvantage women.

9.5.1 NH Act

In India, compensation for land acquisition and resettlement assistance for project affected people are governed by the Land Acquisition Act (1894), which has been amended from time to time. However, for the purpose of maintenance, sustenance and management of National Highways, a special act, The National Highways Act (NH Act), 1956 has been promulgated. Land acquisition in this project will be carried out under the NH Act, 1956. This Act provides for acquiring the land through "competent authority" which means any person or authority authorized by the Central Govt. by notification in the official Gazette to perform functions of the competent authority for such areas as may be specified in the notifications. Land acquisition carried out by the consultant in three stages i.e. 3(a), 3(A) & 3(D)

Table shown the details collected during Land Acquisition Progress

Table 9.1: Format for 3(a)

Sl.No	Competent Authority	Stretch of Land	District	Tahsil	Village	Police Station
1	2	3	4	5	6	7

Table 9.2: Format for 3(A)

Sl.No	Name of the District	Name of The Taluk	Name of the Viallage	Survey/Govt Number	Type of Land	Nature of Land	Area (in Sq.m)
1	2	3	4	5	6	7	

Table 9.3: Format for 3(D)

Sl.No	Name of the District	Name of The Taluk	Name of the Viallage	Survey/Govt Number	Type of Land	Nature of Land	Area (in Sq.m)	Name of the land owner
1	2	3	4	5	6	7		

9.5.2 Compensation and Resettlement Assistance

In general terms, the affected persons in the project will be entitled to five types of compensation and assistance: (i) Compensation for loss of land, crops/trees; (ii) Compensation for structures (residential/commercial) and other immovable assets; (iii) Assistance for loss of business/wage income; (iv) Assistance for shifting; and, (V) Assistance for re-building and/or restoration of community resources/facilities. A detailed description of each compensation measures and assistance is provided in the entitlement matrix. The affected SBEs/households may be entitled to a combination of compensation measures and resettlement assistance, depending on the nature of ownership rights of lost assets and scope of the impact, including social and economic vulnerability of the affected persons.

9.5.3 Eligibility and Entitlement

The RP's main objective is to provide the framework for compensation for lost assets and resettlement of APs. The RP identifies (i) The extent of losses; (ii) The policy and legal framework for compensation and resettlement; (iii) Institutional framework for participation and implementation; (iv) Provisions for employment and poverty reduction; and (v) Responsibilities for monitoring the implementation measures.

The resettlement activities of the project will be carried out in consultation with the APs and all efforts will be made to minimize disruption during project implementation. APs preferences will be taken into account in the selection of alternative relocation sites. A census will be conducted once the details of subproject works have been identified. The date of the census will be the cut-off date and any encroachers after that date will not be compensated.

An Entitlement matrix was prepared on the basis of currently known impacts. It identifies the categories of impact based on surveys carried out so far and shows the entitlements for each type of loss. If new impacts are identified later during detailed design then such losses will be included in the entitlement matrix and the RP will be appropriately revised.

9.5.4 Scope and Rational for Land Acquisition:

The impacts of the present project include loss of land (agriculture, residential and commercial); structure (residential, commercial and community, income and livelihood (owners, tenants, encroachers and squatters), community and cultural sites. Census of all the structures lying within 30/45m widths has been undertaken to assess the project impact on the population for displacement, resettlement and rehabilitation.

However, for the proposed stand alone bypass a minimum of 30/45 m of ROW is required as MORTH guidelines. Bypasses have been proposed to avoid impact on the properties and businesses along the road at these locations.

The proposed bypass passes through 13 nos of villages and their area of acquisition for 30/45m ROW are listed in **Table 9.1**.

Table 9.1 Land Acquisition Details for Vellore Bypass

S.No	Village	Total Required Land (Sqm)
1	Latteri	44435
2	Annangudi	63013
3	Thirumani	14079
4	Chozamar	58195
5	Kothamangalam	26860
6	Poigai	75995
7	Puthur	64678
8	Thellur	45299
9	Sekkanur	71206
10	Ariyur	40293
11	Pennathur	141935
12	Sathu madurai	21545
13	Nelvay	23810
Total	Sq.m	691343
	Ha:Ac:Sqm	69:13:43

9.5.5 Resettlement Sites

There are very few households that are displaced by the project. The possibility of block displacement has been reduced considerably. The households that all to be displaced are not concentrated at one location but at different points. However, the project will have an impact on the petty traders who are dependent on their commercial structures for their livelihood. A majority of the affected population likes to settle close to their place of displacement (as stated during the survey). Hence, the development of relocation sites is not required.

9.5.6 Resettlement Budget and Financing

The budget is indicative of outlays for the different expenditure categories and is calculated at the 2017 price index. These costs will be updated and adjusted to the inflation rate as the project continues and in respect of more specific information such as extra number of APs during the implementation, unit cost will be updated if the findings of the district level committee on market value assessment justify it.

As agreed upon the project financing proposal and provision made in the RP all R&R cost will be borne by the EA. EA will ensure allocation of funds and availability of resources for smooth implementation of the RP activities.

9.5.7 Information Dissemination Campaign

Information dissemination exercises for Project Affected Persons may be carried out prior to implementation of the Resettlement Action Plan. This campaign may be facilitated by the Project Authority and executed by the Partner Non-Government Organization(s) that would be appointed to implement the Resettlement Action Plan.

9.5.8 Institutional Arrangements

Implementation of this Resettlement Action Plan requires staff, resources and close coordination with different agencies and organizations working in the project area. This Resettlement Action Plan seeks to provide a strategy for developing the required implementation capacity on the part of the Project Authority.

Capacity building and training may be coordinated with the project implementation schedule in order to ensure that skilled staff members are available to implement this Resettlement Action Plan without any delay in civil works.

Orientation workshops may be organized by the Project Authority (Project Implementation Unit) and Partner Non-Government Organizations. An R&R Cell may be established within the Project Implementation Unit. Partner NGOs would be engaged to support the Project Authority and counter parted with PIU personnel to foster transfer of social development expertise. An independent external agency may provide professional services for monitoring and evaluating the R&R process.

The Project Authority may initiate high priority actions to establish institutional linkages necessary for time-bound delivery of the Project Affected Persons entitlements and assure coordination across agencies as well as between the various social and economic mitigation measures outlined in this Resettlement Action Plan.

9.5.9 Institutional Context

Effective implementation of this Resettlement Action Plan would require institutional relationships and responsibilities, rapid organizational development and collaborative efforts on the part of the Project Authority, State Government, Partner NGO(s) and Project Affected Persons.

9.5.10 R&R Coordination

The Project Implementation Unit would be responsible for coordinating with different Government Agencies. The R&R Cell would establish operational links to facilitate the critical process of project-induced resettlement. It may establish an effective process of dialogue between the Project Authority and the Project Affected Persons / Communities.

The R&R Cell would have to provide the means and mechanisms for coordinating the efficacious delivery of compensation and assistance entitlements to those adversely affected due to implementation of the project.

The R&R Cell would have to contribute social development perspectives and field-level inputs to ongoing project design and implementation by working closely with project planners, contractors and construction supervision consultants.

It would link the project with the concerned Government Agencies, provide liaison with Affected Communities, establish decentralized (grassroots) committees to coordinate social development and resettlement operations in the field, mobilize Partner NGO(s) and motivate local-level Community-Based Organizations to represent and safeguard the interests of Project Affected Persons.

It would also engage training services, oversee a grievance redress process, actively monitor Resettlement Action Plan implementation and cooperate with project evaluation exercises. The R&R Cell would be responsible for disseminating project-related information to the public and providing additional opportunities for civil societal feedback.

9.5.11 Inter-Departmental Coordination

Resettlement Action Plan entitlements for Income Restoration Programs and Project Affected Groups are exclusively the responsibility of the Project Authority (apart from the land

acquisition and compensation components in which the Revenue Department and the Project Authority would jointly provide entitlements). Several entitlements comprise services and benefits ordinarily provided by other government-sponsored social development programs such as the vulnerable groups' housing schemes.

The R&R Cell may establish liaison with these ongoing programs to facilitate access of the Project Affected Persons and take advantage of services and programs already in place. It may negotiate cost-sharing arrangements wherever feasible. Restoration of community assets would require coordination with the Public Health Engineering Department.

The R&R Cell's coordination with the Education Department would be required in the event schools are adversely impacted. A variety of State and Central Government programs addressing women's needs may be associated with other group entitlements, including those responding to potential transmission of sexually transmitted diseases as well as reproductive and child health.

9.6 Grievance Redress Mechanism

The Resettlement Action Plan's participatory processes as well as its compensation and support mechanisms are expected to enhance acceptance of the resettlement program and reduce complaints. There may nevertheless be individuals or groups who perceive that they have not received adequate support or that their needs have not been properly addressed.

The Project Authority would, therefore, establish a Grievance Redress Committee. This Committee would have representation from Project Affected Persons, NGO(s) / CBO(s) involved in the Resettlement Action Plan implementation, local-level Government Officials and the Project Authority.

This Committee would hear complaints and facilitate solutions. This process is expected to promote settlement of disputes through mediation in order to reduce the volume of time-consuming litigation. The Project Authority would take final decision on different aspects related to grievance redress of Project Affected Persons.

9.7 Monitoring & Evaluation

Monitoring & Evaluation are critical activities in the process of involuntary resettlement. Monitoring involves periodic checking to ascertain whether R&R activities are going according to the Resettlement Action Plan. It provides required feedback to the Project

Authority to ensure that the Resettlement Action Plan implementation program runs on schedule. Evaluation is basically the post-project assessment of whether the implementation program was finally able to achieve its stated objectives. An independent external agency may be engaged by the Project Authority to carry out the (impact) Monitoring and Evaluation of the project with regard to implementation of the Resettlement Action Plan. M&E would measure project performance against project objectives.

Long-term impact indicators may be examined during the project evaluation stage. The Project Authority may contract an external agency (such as an academic institution) that would undertake independent evaluation studies at least twice during the lifetime of the project. These evaluations would provide inputs to the mid-term review and the post project report. Independent evaluation exercises may focus on assessing whether the overall objectives of the project are being met and would utilize the impact indicators as a basis for evaluation. The Project Authority would take final decisions on all M&E (and related) aspects of the project.

Monitoring of involuntary resettlement operations require an application of general project monitoring procedures to the processes occurring in resettlement with particular attention to the specific high risks intrinsic in such operations. This means that monitoring of R&R requires certain specialized skills. To meet this requirement a subunit within the R&R Cell may be established.

An external agency may be appointed to monitor and evaluate the R&R program on a periodic basis. This additional perspective in Resettlement Action Plan implementation is critical because conventional M&E exercises carried out by Government Agencies may not adequately focus on certain aspects of importance to the implementing agencies. This external agency would be required to streamline the R&R process. External M&E studies may synchronize with the implementation of the Resettlement Action Plan. The external agency may submit periodic reports on the progress of Resettlement Action Plan implementation to the Project Authority. It may also identify the issues and concerns that require attention and subsequent action on the part of the Project Authority.

9.8 Income Restoration

Restoration of pre-project levels of income is an important part of rehabilitating in affected communities. The entitlement policy of HPSRP has many provisions in it for restoration of income of affected persons with an aim of improving the socioeconomic conditions of PAPs. In addition to this, the project will facilitate in taking full advantage of existing government schemes by the affected persons. The NGO will coordinate with various departments to integrate with overall project scenarios. The project has provision of training to upgrade the skill level and one time economic rehabilitation grant to vulnerable families in re-establishing themselves economically.

9.9 Conclusions

- Implementation of the Resettlement Action Plan would require sensitive handling of the critical issue of involuntary displacement that is a necessary result of infrastructural development projects involving roads and highways, flyovers and interchanges etc.
- Legal owners of land and structures would suffer in terms of loss of immovable assets while their tenants would suffer losses either in terms of residence or livelihood or both.
- Resettlement of affected persons and rehabilitation of their lost assets (land and/or structures) and livelihood are critical yet imperative social development exercises of infrastructure development projects that require displacement of individuals and groups.

9.10 Recommendations

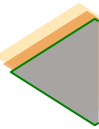
- The Project Authority may set up a dedicated office in order to provide information with regard to the R&R guidelines and the Resettlement Action Plan.
- Fixation of compensation to the legal owners of affected land and structures should be based on the present market rate.
- The Grievance Redress Committee may expedite the process of redress of grievances. Project Affected Persons may be counseled by Partner Non- Government Organization(s) as and when required.
- Unauthorized encroachers and squatters as such do not have any legal rights to their occupied land and structures but the vulnerable groups among such illegal occupants may be considered by the Project Authority for R&R support/assistance.

- Illegal encroachers and squatters may be allowed to salvage the dismantled materials. The Project Authority may consider appointing such persons (belonging to vulnerable groups) as casual workers during the construction stage of the project in order to provide livelihood at least on a short-term basis in order to mitigate the adverse impacts of involuntary displacement.
- Representatives from the local bodies such as municipalities/ panchayats, officials from the local administration and police, local Community Based Organizations / Non Government Organizations may be consulted on a periodic basis to ensure efficient implementation of the Resettlement Action Plan.

Involuntary resettlement caused by infrastructure development projects should be informed by comprehensive mitigation measures in order to reduce adverse impacts on the existing social fabric of Project Affected Persons.

CHAPTER - 10

COST ESTIMATE



CHAPTER 10

COST ESTIMATE

10.1 General

This chapter provides the Detailed Cost Estimate for construction of Vellore Bypass for Four lane with Paved shoulder Configuration.

10.2 Methodology

The following procedure has been adopted for estimation:

- The data for working out rate analysis, is based on the latest standard data book as approved and communicated by MoRTH using Tamil Nadu PWD SOR 2024- 2025 for structures and TN Highways Department SOR 2024-2025 for road works with Bitumen rate as on 01/12/2024. For non SOR items local market rates are used.
- Also the rates for cement, reinforcement steel and structural steel as per current SOR, Tamil Nadu schedule of rates 2024-2025 have been incorporated.
- The cost of labour is considered based on the Tamil Nadu PWD schedule of rates 2024-2025 and TN Highways Department SOR for road works.
- The quantities of earth work, pavement and other appurtenance works have been worked out as per topo survey data, pavement design and typical cross sections adopted respectively.
- Cost of structures like ROB,VUB, Grade Separator, Major Bridge, Minor bridges and Culverts has been worked out from GADs and designs.

10.3 Project Cost

The costs of highway, Structure works are calculated based on the designs. The detailed cost estimate is given in **Separate volume** and the abstract of cost is given in **Table 10.1**.

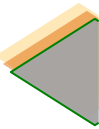
Table 10.1 Project Cost

Bill No.	Description	Total Cost in Lacs
1	Road Work include RE Wall Approaches	2,79,10,04,818.00
2	ROB @ Ch 0/592 (Railway portion)	24,72,66,092.00
3	ROB @ Ch 20/084(Railway portion)	18,89,05,896.00
4	Elevated Rotary	34,78,00,818.00
5	Grade Separator CH @ 0+ 592	10,12,34,992.00
6	Major Bridge Ch @ 3+995	10,28,85,781.00
7	Major Bridge Ch @ 5+419	20,13,28,852.00
8	Grade Separator @ CH 6+500	8,23,05,819.00
9	VUP CH @ 7+964, 13+700, 16+200	16,07,01,222.00
10	VUP CH @ 11+015, 18/0	3,96,33,900.00
11	Slab Bridge @ CH : 3+238	3,60,77,307.00
12	Slab Bridge @ CH :5+586	1,66,06,782.00
13	Slab Bridge @ CH :5+828	2,92,84,062.00
14	Slab Bridge @ CH : 6+852	2,92,84,062.00
15	Slab Bridge @ CH :10+714	3,63,92,649.00
16	ROB Approach Viaduct Span @ CH 20+084	2,91,59,232.00
17	Retaining Wall	1,77,64,497.00
18	Road Furniture	20,15,87,543.00
19	Box Culvert	19,78,93,121.00
20	Avenue plantation	5,33,70,000.00
21	Rainwater harvesting	46,46,563.00
	Sub Total Civil Cost (A)	4,91,51,34,008.00
1	Utility shifting Civil Cost	6,62,72,762.00
	Sub Total Civil Cost (B)	4,98,14,06,770.00
2	Add 18% GST (B)	89,66,53,219.00
3	Contingencies @ 1.0% on (A)	4,91,51,340.00
4	Supervision charges @ 3% on (A)	14,74,54,020.00
5	Agency charges @ 3% on (A)	14,74,54,020.00

6	Price Escalation charges @ 5% on (A) with GST 18%	28,99,92,906.47
7	Maintenance Charges (2.5% x A+GST 18%)	14,49,96,453.24
8	Provision for Utility shifting Supervision Charge (2.5%)	16,56,819.05
9	LS for Aditional LA for ROW 50/70.0m (43.00 Ha) in Road Portion & Rotary Portion LA - 1.8 HA (Per HA Cost = 2.0 Cr)	86,56,15,771
10	Preparation of Estimate & Project Reports by the Consultant engaged by State PWD (20x2.5Lacs)	50,00,000.00
		7,52,93,81,319.00
	or	752.94 Cr

CHAPTER - 11

ECOCNOMIC ANALYSIS



ECONOMIC ANALYSIS

1.1 Introduction

The objective of economic analysis is to determine the feasibility of the project from the social and economic perspective of the project area. The obtained results of economic analysis are used for justifying the investment to the particular project and to assess the impact of the project on improving the economic welfare of the region. This analysis mainly depends on the major parameters of road characteristics and the characteristics of the vehicle fleet plying on the road network. The quantification of social benefits & costs on implementation of this proposed 4-laning with paved shoulder of the project road stretch has been analyzed using IRC SP-30-2019. These road improvements bring about a reduction in transportation cost in terms of reduced vehicle operating cost, travel time cost, Accident cost etc.,

1.2 Methodology of the analysis

This economic evaluation has been carried out by comparing ‘Do Minimum’ alternative with the ‘Project Case’ situation. The packages considered for the analysis are Strengthening of the existing pavement by way of providing routine maintenance to the existing two lanes is taken as the ‘Do minimum’ case. The proposed road is bypass for vellore town to form 2-lane with paved shoulder is taken as the ‘Project Case’ situation. These two alternatives are analyzed for a period of 20 years.

Also, the sensitivity analysis is carried out for the two packages by varying the costs and benefits streams of the project. Usually, the following three scenarios are taken up in the sensitivity analysis.

- a) Increase the project cost by 15%
- b) Decrease the benefit for the project by 15%
- c) Increase the project cost by 15% and decrease the benefit by 15%.

1.3 Stages of Economic Analysis

The economic evaluation of the project involves many stages and some such major heads are given below.

1. Definition of Road Networks
2. Definition of Vehicle fleet and their characteristics
3. Definition of improvement strategies – Lane addition, Periodic & Routine Maintenance
4. Analysis of the Project

1.3.1 Definition of Road Networks

Based on subgrade CBR, existing pavement condition and the traffic characteristics of vehicles plying on the road stretch the road network can be analyzed. The following features will be taken into account for the road network analysis.

- Inventory details such as length, shoulder width,
- Geometric details such as rise and fall, average horizontal curvature, speed limit,
- Pavement inventory details including roughness, percentage of cracking, ravelled area etc.,
- CBR of the soil, characteristic deflection

1.3.2 Definition of vehicle fleet and their characteristics

On defining the road network, the next stage is the definitions of corresponding vehicle fleets plying along the project road stretch. The vehicles taken in the analysis are as follows.

1. Two-wheeler
2. Three-wheeler
3. Car
4. LCV
5. Two axle trucks
6. Three axle trucks
7. Multi axle trucks

Factors considered in the Vehicle fleet are given below,

- a) Type
- b) Age
- c) Make
- d) Engine horse-power
- e) Power - Weight ratio

Table 1.1 Vehicle Operating Cost for Do Minimum Case.

RF – 15	Two/Four Lane Road			Roughness - 4000		
VOC Factors	Car	T/W	2-axle	MAV	LCV	Bus
Fuel Cost	2.18	0.79	6.08	11.66	6.51	6.39
Tyre Cost	0.24	0.08	3.24	4.67	0.84	2.39
Engine Oil Cost	0.52	0.04	0.28	1.47	0.22	0.18
Other Oil Cost	0.06	0.06	0.10	0.10	0.11	0.09
Grease Cost	0.11	0.11	0.04	0.04	0.01	0.15
Spare Parts Cost	0.48	0.17	2.17	3.25	0.36	1.87
Maintenance Cost	0.87	0.09	1.71	2.58	0.30	2.20
Sub-Total	4.46	1.35	13.62	23.78	8.35	13.26
(Linking Factor – 1.56)	6.96	2.10	21.25	37.09	13.03	20.69
Fixed Cost	1.03	0.28	4.21	4.38	6.35	1.09
Depreciation Cost	0.11	0.05	0.71	0.84	1.06	0.31
Crew Cost			6.83	6.36	7.90	5.32
Sub-Total	1.14	0.33	11.74	11.58	15.31	6.71
Passenger/commodity Cost	7.53	1.75	3.38	4.03	1.04	13.38
Total	8.68	2.08	15.12	15.61	16.35	20.10
(Linking Factor – 1.56)	13.54	3.24	23.58	24.35	25.50	31.35

Table 1.2 Vehicle Operating Cost for Project Case.

RF – 15	Four Lane Road			Roughness - 2000		
VOC Factors	Car	T/W	2-axle	MAV	LCV	Bus
Fuel Cost	2.22	0.86	5.42	9.79	7.24	6.72
Tyre Cost	0.2	0.07	3.05	4.41	0.79	2.19
Engine Oil Cost	0.49	0.04	0.27	1.33	0.21	0.13
Other Oil Cost	0.05	0.05	0.09	0.09	0.07	0.06
Grease Cost	0.11	0.11	0.04	0.04	0.01	0.15
Spare Parts Cost	0	0	1.55	2.33	0.25	1.57
Maintenance Cost	0	0	1.23	1.84	0.22	1.85
Sub-Total	3.07	1.13	11.65	19.83	8.79	12.67
(Linking Factor – 1.56)	5	2	18	31	14	20
Fixed Cost	0.87	0.23	3.75	3.64	5.44	0.9
Depreciation Cost	0.09	0.04	0.63	0.7	0.91	0.26
Crew Cost			6.09	5.29	6.76	4.39
Sub-Total	0.96	0.27	10.47	9.63	13.11	5.55
Passenger/commodity Cost	7.37	1.44	4.4	5.02	1.12	11.06
Total	8.33	1.71	14.87	14.65	14.23	16.61
(Linking Factor – 1.56)	13	3	23	23	22	26

1.3.3 Routine and Periodic Maintenance cost

The project road is given routine maintenance like patching, edge repair works, etc and around Rs.5, lakhs is allotted every year for each kilometer. Also, the periodic maintenance of providing overlay is done for every 5 years and nearly 35 lakhs is allotted for each kilometer. The respective costs for 2/4-lane roads (without project), were considered proportionately. The project road is given maintenance both periodic and routine as per the following scheme.

- Periodic Maintenance-Overlay (Alternative 0) : Scheduled (Every 5th Year)
- Routine maintenance (Alternative 0) : Scheduled (Every Year)
- Periodic Maintenance-Overlay (Alternative 1) : Scheduled (Every 5th Year)
- Routine maintenance (Alternative 1) : Scheduled (Every Year)

1.3.4 Analysis of the Project

On inputting the above-mentioned parameters, the project is carried out for a period of 20years. The major factors considered in the project analysis are

Discount rate	:	12%
Salvage value	:	15%
Standard Conversion Factor	:	0.9
Construction period	:	2 years
Phasing for the new construction	:	50% in 1 st Year & 50% in 2 nd Year

The analysis is done for a period of 20 years by comparing two alternatives.

- Alternative 0 - Do minimum Situation
- Alternative 1 – Forming Bypass to Vellore Town (Four lane with Paved Shoulder)

Do minimum alternative is the one in which the existing pavement has not been subjected to any major changes and given only routine maintenance and periodic maintenance. In the Project Case alternative, the proposed road is developed into Four lane with paved shoulder .

1.4 Project cost

The project cost includes the lane addition cost, repair & rehabilitation of bridges & cross drainage structures all along the project road stretch. The cost estimate for the entire length of the project road has been calculated separately based on the quantities worked out for the major items of work to be executed in the project on the basis of preliminary engineering design of roads, structures and adopted rates.

Table 1.3 Project Cost - 2 lane with paved shoulder of the project road

Project Cost	Length (km)	Total Project Cost include LA (Rs. In Crores)
Vellore Bypass	20.492	752.94 + 117.0 = 869.94~870.0 Cr

1.5 Project Benefits

The net benefits of the project can be quantified under the three major heads of

1. Road Agency Costs
2. Vehicles Operating Costs
3. Accident Cost

The benefits of project include the benefits accrued on providing overlay to existing road and addition of lanes to the existing two lanes. The vehicle operating cost includes the cost of the tyres, fuels, lubricants, etc. The increase in the road agency cost of the project has substantially decreased the vehicle operating cost and the travel time cost.

The appropriate saving in travel time and vehicle operating costs on utilizing the proposed project road are also quantified and the results of the same are enclosed. A more efficient facility enables the speed of the vehicle to go up and thereby reducing the travel time. The benefit streams have been computed annually over the 20 years benefit period for all the homogenous sections. The result of Economic analysis is given in Table 1.4

Table 1.4: Economic Analysis Summary (Rs. in Lacs)

Economic Internal Rate of Return							
Year	Do Minimum		Project Case		Cost	Benefit	Net Benefit
	Maintenance	VOC	Maintenance	VOC	Lacs	Lacs	Lacs
2025	407	44628	43500		43907	0	-43907
2026	427	46414	43500		43927	0	-43927
2027	449	48270	313	29663	136	18607	18471
2028	471	50201	328	31147	143	19054	18911
2029	495	52209	345	32704	150	19505	19355
2030	520	54297	362	34339	158	19958	19801
2031	546	56469	380	36056	165	20413	20248
2032	3819	58728	2661	37859	1158	20869	19711
2033	602	61077	419	39752	182	21325	21143
2034	632	63520	440	41739	192	21781	21589
2035	663	66061	462	43826	201	22235	22033
2036	696	68703	485	46018	211	22686	22474
2037	4874	71451	3396	48319	1478	23133	21655
2038	768	74310	535	50734	233	23575	23342
2039	806	77282	562	53271	244	24011	23766

Economic Internal Rate of Return							
Year	Do Minimum		Project Case		Cost	Benefit	Net Benefit
2040	846	80373	590	55935	257	24438	24182
2041	889	83588	619	58732	270	24857	24587
2042	6221	86932	4335	61668	1887	25264	23377
2043	980	90409	683	64751	297	25657	25360
2044	1029	94025	717	67989	312	26036	25724
2045	1080	97786	753	71389	328	26398	26070
2046	1134	101698	790	74958	344	26740	26396
2047	7940	105766	5532	78706	2408	27060	24652
						IRR	20.55%

1.6 Sensitivity analysis

Sensitivity analysis has been carried out for three variations in costs and benefits. The following are the cases considered for the analysis,

- Case I : Cost increased by 15% and Base Benefits
- Case II : Base Cost and Reduction in Benefit by 15%
- Case III : Cost increased by 15% and Reduction in Benefit by 15%

Sensitivity analysis has been performed for both with time and without time alternatives. The scenarios has taken into account, the possible construction costs overrun, traffic volume, revenue shortfalls, interest rate volatility, non-compliance or default by contractors, and political risks. **Table 1.5** give the result of the sensitivity analysis with time savings for the project road. The summary of the sensitivity analysis is furnished in the following Table.

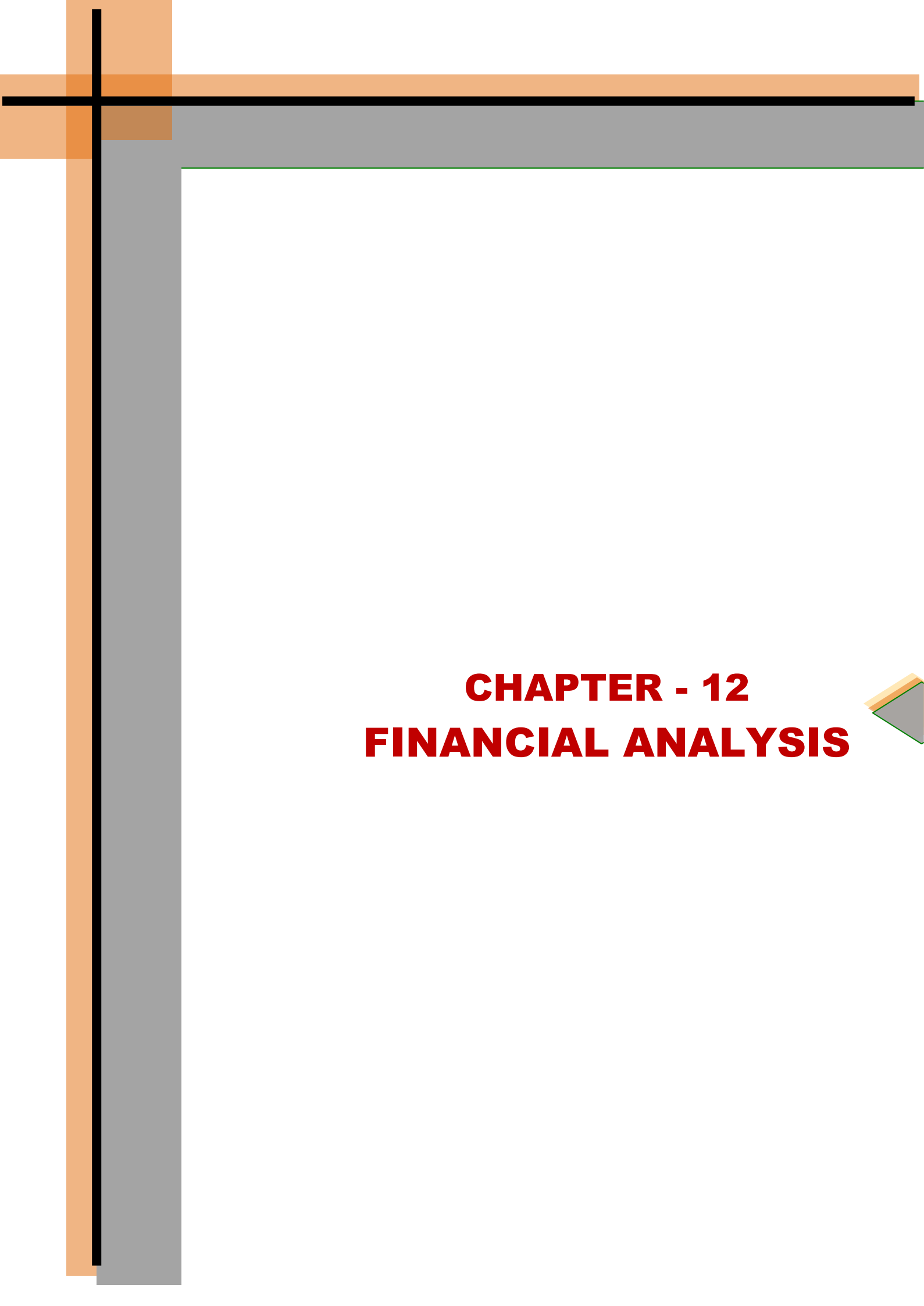
Table 1.5: Sensitivity analysis with Vehicle Operating Cost and Time Savings (Rs. in lakhs) for Vellore Bypass

Year	Net Benefit	Cost + 15%	Benefit - 15%	Cost+15 & Benefit-15%
2025	-43907	-50493	-43907	-50493
2026	-43927	-50517	-43927	-50517
2027	18471	18450	15680	15659
2028	18911	18890	16053	16032
2029	19355	19332	16429	16407
2030	19801	19777	16807	16783
2031	20248	20223	17186	17161
2032	19711	19537	16581	16407
2033	21143	21115	17944	17917
2034	21589	21560	18322	18293
2035	22033	22003	18698	18668
2036	22474	22443	19072	19040
2037	21655	21433	18185	17963
2038	23342	23307	19806	19771

Year	Net Benefit	Cost + 15%	Benefit - 15%	Cost+15 & Benefit-15%
2039	23766	23730	20165	20128
2040	24182	24143	20516	20477
2041	24587	24547	20859	20818
2042	23377	23094	19587	19304
2043	25360	25316	21512	21467
2044	25724	25677	21819	21772
2045	26070	26021	22111	22061
2046	26396	26344	22385	22333
2047	24652	24291	20593	20232
IRR	20.55%	17.99%	17.59%	15.28%

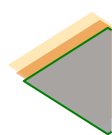
1.7 Result of Economic Analysis

The results suggest that the development of the project road with higher order traffic facilities (a 4-Lane with Paved Shoulder) for smooth and efficient movement of the traffic results in positive economic returns. Excluding value of time (or only VOC savings), the returns calculated as 20.55%. The project is economically viable for proposed bypass to Four lane with paved shoulder carriageway standards without time saving options. The EIRR is higher than the discount rate of 12%. **Hence, the project is Economically Viable.**



CHAPTER - 12

FINANCIAL ANALYSIS



FINANCIAL ANALYSIS

1.0 Introduction

The Construction of roads brings about a variety of benefits that are enjoyed practically by all sectors of the economy. Scarcity of resources and competing demands from various sectors are the important features of a developing economy. It therefore, becomes extremely necessary to allocate the scarce resources in the most beneficial manner. In view of the above, it is necessary to ensure that the projects selected for investment are thoroughly evaluated to determine the financial benefits offered by the project. Highway financial analysis is a technique whereby the cost and benefit from a scheme are quantified over a selected time horizon and evaluated by a common yardstick.

Financial analysis and modeling is used to determine the cost recovery tariff required to support the desired coverage targets and service levels. The financial helps to achieve the right balance of affordability, cost recovery and investment. The model will help prioritize investments and inform decisions on who should pay for investments, depending on the respective cost of capital.

1.1 Objective

The objective of project evaluation is to assess the financial viability of Vellore bypass (Four lane with Paved Shoulder)

1.2 Basic Approach & Methodology

The financial feasibility is carried out to assess the Re-payment of loan for the improvement/up-gradation of project road to calculate the optimal concession period to gain the profit. The analysis period is considered as 30 years including two years of construction period. The construction works are expected to get initiated in the year 2025 (say April), and carry on till the end of year 2027 (say March). Therefore, the construction cost phasing has been distributed as 40% in 1st Year & 60% in 2nd Year.

1.3 Capital Cost

The total expenditure incurred during the construction period for the development of the project road is given below in Table 1. The proposed project road would be opened to traffic in April 2027. The cost of the project considered in the analysis is the estimated cost of civil works involved in the formation of the roads including structures. The project cost is excluding shifting of utilities, land acquisition, rehabilitation and resettlement and environmental mitigation measures.

Table 1 Project Cost without Grant

SI.No.	Description	Cost
		Rs Cr/-
1	Total Civil Construction cost	498.14
2	Labour Welfare Fund (1% of Project Cost)	5.0
3	Quality Control (0.5% of Project cost)	2.5
4	Contingencies (2.5% of Project Cost)	12.5
	Total EPC Cost	518.07
5	IC & Pre-operative expenses @ 1% of EPC	5.18
6	Escalation @ 5% Per Annum for Civil Cost	40.60
7	Financial Cost 2% for Debt Amount	8.62
8	Interest During Construction for Debt Amount	43.09
9	Government Grant	0.00
TOTAL PROJECT COST *		615.55

Table 2: Project Cost with 40% Grant

SI.No.	Description	Cost
		Rs Cr/-
1	Total Civil Construction cost	498.14
2	Labour Welfare Fund (1% of Project Cost)	5.0
3	Quality Control (0.5% of Project cost)	2.5
4	Contingencies (2.5% of Project Cost)	12.5
	Total EPC Cost	518.07
5	IC & Pre-operative expenses @ 1% of EPC	5.18
6	Escalation @ 5% Per Annum for Civil Cost	40.60
7	Financial Cost 2% for Debt Amount	5.59
8	Interest During Construction for Debt Amount	29.06
9	Government Grant (40%)	-199.26
TOTAL PROJECT COST *		399.24

1.4 Proposed Sources of Finance

In general, the developer shall crystallize the sources of finance by optimizing his equity returns keeping in view of the project cash flows, terms and conditions of various financing options available. Further the market standing and financial strength of the Developer would largely determine the terms and conditions of finance offered to the Developer by various lending agencies. For the purpose of the study, following sources of finance have been taken:

- Equity: To be provided by the Developer/Concessionaire
- Subsidy / Grant for viability of funding, to be provided by the Highways Department, Government of Tamil Nadu.
- Debt: To be arranged by the Developer / Concessionaire

Total Means of finance (without Grant)

Means of Finance	Amount (Rs. Cr)
Government Grant	0.00
Equity/Quasi Equity	184.67
Debt	430.89
TOTAL PROJECT COST *	615.55

Total Means of finance (with Grant upto 40% on civil Cost)

Means of Finance	Amount (Rs. Cr)
Government Grant (40%)	199.26
Equity/Quasi Equity	119.77
Debt	279.47
TOTAL PROJECT COST *	598.50

1.5 Expenses

Expenses can broadly be classified based on the phases in which these are incurred, viz. construction period expenses and operation & maintenance period expenses. Construction period expenses includes Interest during Construction, contingencies, Escalation, etc. Operation and Maintenance period expenses includes:

- Administrative expenses for day-to-day operation.
- Maintenance expenses, which include routine and periodic maintenance.
- Interest expenses incurred for servicing term loans.
- Lighting expenses.
- Patrolling Expenses.
- Insurance

1.6 Operation and Maintenance Cost

Routine maintenance costs comprise of maintenance of the pavement, collection of litter, lighting, traffic management (policing), accident repairs and all ancillary works including beautification.

The periodic maintenance costs include cost of overlay, repair/renovation of road furniture, drains, buildings etc. The periodic maintenance includes periodic renewals at every 5th years. The details of the maintenance costs are given below in Table 2.

Table 3 Routine & Periodic Maintenance

Sl. No.	Description	Amount (Cr/km)
1	Routine maintenance in every year cost per km for the four lane with paved shoulder.	0.10
2	Periodic maintenance in every 5 th year cost per km for the four lane with paved shoulder.	1

1.7 Minimum Return Criteria

The minimum return criteria for the BOT project is considered as follows: -

- The return on project investment (Post Tax FIRR) should be between 14% to 16% while the return on equity (Post Tax Equity IRR) ranges from 14% - 16%.
- The minimum average DSCR (Debt Service Coverage Ratio) is taken as 1.3

1.8 Financial Internal Rate of Return (FIRR)

The main objective of undertaking this study is to assess whether the project is financially viable or not. It is important to note that the proposal should be an attractive proposition for private sector participation under Build, Operate and Transfer (BOT) system. The basic methodology followed for estimating the financial viability of the project is to calculate the FIRR (Financial Internal Rate of Return) on the investment for the project.

The following assumptions are taken into consideration for the financial analysis: -

- Evaluation year for cost estimate - 2024
- Year of construction begins - April 2025
- Construction period (months) - 24
- Opening year to traffic - April 2027
- Total length of project road (km) - 20.85
- Total Project Cost (civil) - 371.89 Cr
- Debt - 70%
- Equity - 30%
- Discount for local commercial traffic - 25%
(incl. excepted vehicles, toll leakage, Multiple Trip & Monthly Packages etc.,)
- Insurance expenses for TPC (per year) - 0.05% on Total Project Cost
- Routine maintenance (Crore/km/year) - 0.10

- Periodic maintenance (Crore/km/year) - 1.00
- Electrical Expenses (Crore/km/year) - 0.05
- Toll collection expense (Crore/year) - 0.25
- Miscellaneous Expenses (Crore/km/year)- 0.05
(Recovery Van, First Aid, and Ambulance Etc.)
- Office expenses (Crore/year) - 0.25
- Estimated escalation (per year) - 5 %
- Interest during Construction (%) - 10%
- Interest during Operation (%) - 10%
- Project Phasing - 40% (1st Year) & 60% (2nd Year)
- Loan Repayment period - 10 years
- Moratorium - 2 years
- Depreciation as per IT Act - WDV (10%)
- MAT (Minimum Alternate Tax) - 20.96%
- Concession Period - 30 Years

1.9 Analysis

Based on the project structure, study of all possible sources of revenue, financial feasibility analysis has been carried out as per the methodology outlined in earlier sections. The objective of the financial analysis is to ascertain the existence of sustainable project returns, which shall successfully meet the expectations of its financial investors. The analysis reveals various FIRR values corresponding to each year of operation. FIRR for the Returns on Investment and Returns on Equity for the years from 2024 and 2053 (concession period 30 years including 2 years construction period) for the following alternatives with varying subsidy options are: -

- Option - 1: Nil Grant with 30 years concession period (BoT – Toll)
- Option - 2: Hybrid Annuity with 15 years concession period (Hybrid Annuity Mode)

With the abovementioned options financial analysis has been carried and their details given in **Annexure - 1**. The results are given below in Table 4 &5.

1.10 Results of Financial Analysis- Base Case

The result of the financial analysis in the base case has been presented in the Table 4.

Table 4: Results of the Analysis in Base Case (Option -1)

Indicators	Vellore bypass (Option -1)
<i>Loan Repayment Schedule</i>	
Concession Period	30 Years
Moratorium	2
Repayment Period	10
Results	
Pre-Tax IRR (%)	9.80
Post-Tax IRR (%)	8.75
Return on Equity (%)	8.63
Minimum DSCR	0.14
Average DSCR	0.54
Payback Period	21 Years 2 Months

The project is not commercially viable. This is primarily due to relatively high cost of construction.

1.11 Sensitivity Analysis: Viability Gap Funding (option – 2)

The base case does not show financial viability with the toll alone revenue. Therefore, an assessment to the extent the viability changes/ improves, in case viability gap funding is forwarded by the government, has been examined. The grant amount is restricted to 40% of the project cost. The result of the analysis has been presented in Table 5.

Table 5: Results in case of Viability Gap Funding

Indicators	Vellore bypass (Option -2)
Concession Period	15 Yrs
Viability Gap Funding (%)	40%
Viability Gap Funding (Rs. Cr.)	192.85
Pre-Tax IRR (%)	15.56
Post-Tax IRR (%)	14.00
Return on Equity (%)	20.60
Minimum DSCR	1.20
Average DSCR	1.64
Payback Period	11 years 8 Months
Annuity Amount	82.50 Cr (41.25 Cr Semi – Annually)

With maximum VGF, the project seems to be a very attractive venture for private sector.

1.12 Results and Conclusion

It is clear from the results of the options shows that the project is financially viable in Hybrid Annity Mode. Therefore, the project is not financially viable in BOT. If government planned to execute this project as a socioeconomic importance, the implementation shall be EPC/HAM mode is recommended.

Nil Grant with 30 years concession period (Four lane)

<u>Project Parameters</u>		<u>Financial Parameters</u>	
<u>Project Details</u>		Concession Period (Inclu Const. period) years	
Evaluation Year for Costs Estimates	2024	30	
Year of Construction begins	2025	<u>Discount for Local/Commercial Traffic & Return Traffic</u>	
Construction Period (months)	24	exempted, leakage etc.	
Opening Year to Traffic	2027	<u>O & M Cost and Other Assumptions</u>	
Total Length of the Project (km)	20.85	Routine Maintenance Cost	0.10 Crores/Km/Annum
No. of Toll Plaza	1	Periodic Maintenance Cost (Once in 5 Years)	1.00 Crores/Km/Annum
<u>Project Cost</u>		Elec. Exp.	0.05 Crores/Km/Annum
Total Project Cost	615.55 Crore	Toll Collection Exp.	0.25 Crores/Annum
Grant (Govt) - 28%	0.00 Crore	Office Exp	0.25 Crores/Annum
Debt(70%)	430.89 Crore	Insurance Exp.	0.05 % of TPC
Equity(30%)	184.67 Crore	Miscellaneous Exp.	0.05 Crores/Km/Annum
Annual Esclation in Toll Rate(%)	5% CAGR	Interest Rate during Construction	10.00%
Estimated Esclation in Cost(%)	5% Per Annum	Interest Rate during Operation	10.00%

Year	Constructio n Cost	REVENUE			OPERATION & MAINTENANCE COST								Net Operating Income	Pre - Tax of Operating Income, FIRR	Pre - Tax of Operating Income, NPV	Depreciat ion (WDV 10%)	Loan Interest	Net Profit/Los s before Tax	Tax Rate	Net Operating Income after Tax	Post Tax of Operating Income, FIRR	Post - Tax of Operating Income, NPV	Net Equity after Tax Amount	Cumulativ e Equity after Tax Amount	Return on Equity, FIRR	Return on Equity, NPV	Total Profit/Loss after Tax	CASH FLOW STATEMENT				DSCR			
		Toll Revenue	Less Discount	Net Revenue	Routine Maintena nce	Periodic Maintena nce	Toll Collection Exp.	Office Exp.	Insurance Exp.	Electrical Exp.	Miscellan eous Exp.	Total Exp.																20.96%	Cash In - Flow	Cash Out -Flow					
			25%																Net Operating Income											Loan Re- payment	Interest		Total		
1	2	3	4	5(3-4)	6	7	8	9	10	11	12	13 (6+7+8+9 +10+11+12)	14 (5-13)				15	16	17 (14-15- 16)	18	19 (14-18)			20 (14-16- 18)					21 (17-18)						
2025 2026	615.55											615.55	-615.55						-615.55		-615.55				-184.67	-184.67				-615.55					
2027		37.24	9.31	27.93	2.30			0.28	0.28	0.31	1.15	1.15	5.46	22.47		Rs. -595.49	51.81	41.11	-70.45	0.00	22.47	-	Rs. -595.49	-18.64	-61.73	-	Rs. -239.78	-70.45	22.47	43.09	41.11	84.20	0.27		
2028		40.26	10.06	30.19	2.41		0.29	0.29	0.31	1.21	1.21	5.71	24.48		Rs. -575.97	46.63	36.80	-58.95	0.00	24.48	-	Rs. -575.97	-12.32	-55.41	-	Rs. -283.96	-58.95	24.48	43.09	36.80	79.89	0.31			
2029		44.75	11.19	33.56	2.53		0.30	0.30	0.31	1.27	1.27	5.98	27.58		Rs. -556.34	41.96	32.50	-46.88	0.00	27.58	-	Rs. -556.34	-4.92	-48.01	-	Rs. -318.13	-46.88	27.58	43.09	32.50	75.58	0.36			
2030		49.32	12.33	36.99	2.66		0.32	0.32	0.31	1.33	1.33	6.27	30.72		Rs. -536.82	37.77	28.19	-35.23	0.00	30.72	-	Rs. -536.82	2.54	-40.55	-	Rs. -343.90	-35.23	30.72	43.09	28.19	71.28	0.43			
2031		55.09	13.77	41.32		27.94	0.34	0.34	0.31	1.40	1.40	31.71	9.61		Rs. -531.37	33.99	23.88	-48.26	0.00	9.61	-	Rs. -531.37	-14.27	-57.36	-	Rs. -376.45	-48.26	9.61	43.09	23.88	66.97	0.14			
2032		60.47	15.12	45.36	2.93		0.35	0.35	0.31	1.47	1.47	6.88	38.48		Rs. -511.87	30.59	19.57	-11.68	0.00	38.48	-	Rs. -511.87	18.91	-24.18	-	Rs. -388.70	-11.68	38.48	43.09	19.57	62.66	0.61			
2033		66.58	16.65	49.94	3.08		0.37	0.37	0.31	1.54	1.54	7.21	42.73		Rs. -492.54	27.53	15.26	-0.06	0.00	42.73	-	Rs. -492.54	27.47	-15.62	-	Rs. -395.76	-0.06	42.73	43.09	15.26	58.35	0.73			
2034		73.15	18.29	54.87	3.23		0.39	0.39	0.31	1.62	1.62	7.55	47.31		Rs. -473.43	24.78	10.95	11.58	0.00	47.31	-	Rs. -473.43	36.36	-6.73	-	Rs. -398.48	11.58	47.31	43.09	10.95	54.04	0.88			
2035		80.56	20.14	60.42	3.40		0.41	0.41	0.31	1.70	1.70	7.91	52.50		Rs. -454.50	22.30	6.64	23.56	0.00	52.50	-	Rs. -454.50	45.86	2.77	-	Rs. -397.48	23.56	52.50	43.09	6.64	49.73	1.06			
2036		89.23	22.31	66.92		35.66	0.43	0.43	0.31	1.78	1.78	40.39	26.53		Rs. -445.96	20.07	2.33	4.13	0.00	26.53	-	Rs. -445.96	24.20	-18.89	-	Rs. -403.56	4.13	26.53	43.09	2.33	45.42	0.58			
2037		97.88	24.47	73.41	3.74		0.45	0.45	0.31	1.87	1.87	8.69	64.71	-6.21%	Rs. -427.35	18.06		46.65	9.78	54.94	-6.62%	Rs. -430.17	54.94	54.94	-	Rs. -387.77	36.87								
2038		108.35	27.09	81.26	3.93		0.47	0.47	0.31	1.97	1.97	9.11	72.15	-3.62%	Rs. -408.84	16.26		55.89	11.72	60.43	-4.28%	Rs. -414.65	60.43	60.43	-	Rs. -372.26	44.18								
2039		118.88	29.72	89.16	4.13		0.49	0.49	0.31	2.06	2.06	9.55	79.61	-1.53%	Rs. -390.59	14.63		64.98	13.62	65.99	-2.35%	Rs. -399.53	65.99	65.99	-	Rs. -357.13	51.36								
2040		131.87	32.97	98.90	4.33		0.52	0.52	0.31	2.17	2.17	10.02	88.88	0.21%	Rs. -372.40	13.17		75.71	15.87	73.01	-0.72%	Rs. -384.59	73.01	73.01	-	Rs. -342.19	59.84								
2041		145.01	36.25	108.76		45.51	0.55	0.55	0.31	2.28	2.28	51.46	57.29	1.11%	Rs. -361.94	11.85		45.44	9.52	47.77	0.15%	Rs. -375.86	47.77	47.77	-	Rs. -333.47	35.92								
2042		160.63	40.16	120.47	4.78		0.57	0.57	0.31	2.39	2.39	11.01	109.46	2.49%	Rs. -344.08	10.67		98.80	20.71	88.75	1.47%	Rs. -361.39	88.75	88.75	-	Rs. -318.99	78.09								
2043		175.49	43.87	131.62	5.02		0.60	0.60	0.31	2.51	2.51	11.55	120.07	3.64%	Rs. -326.59	9.60		110.47	23.15	96.92	2.58%	Rs. -347.27	96.92	96.92	-0.38%	Rs. -304.87	87.32								
2044		193.55	48.39	145.16	5.27		0.63	0.63	0.31	2.63	2.63	12.11	133.05	4.63%	Rs. -309.29	8.64		124.41	26.08	106.98	3.55%	Rs. -333.36	106.98	106.98	1.22%	Rs. -290.96	98.34								
2045		215.21	53.80	161.41	5.53		0.66	0.66	0.31	2.77	2.77	12.70	148.71	5.50%	Rs. -292.03	7.78		140.93	29.54	119.17	4.40%	Rs. -319.52	119.17	119.17	2.57%	Rs. -277.13	111.39								
2046		236.32	59.08	177.24		58.09	0.70	0.70	0.31	2.90	2.90	65.60	111.64	6.03%	Rs. -280.45	7.00		104.65	21.93	89.71	4.93%	Rs. -310.22	89.71	89.71	3.37%	Rs. -267.83	82.71								
2047		260.30	65.07	195.22	6.10		0.73	0.73	0.31	3.05	3.05	13.97	181.25	6.73%	Rs. -263.68	6.30		174.96	36.67	144.58	5.62%	Rs. -296.84	144.58	144.58	4.40%	Rs. -254.44	138.28								
2048		288.06	72.02	216.05	6.40		0.77	0.77	0.31	3.20	3.20	14.65	201.40	7.34%	Rs. -247.03	5.67		195.73	41.02	160.37	6.24%	Rs. -283.59	160.37	160.37	5.28%	Rs. -241.19	154.70								
2049		315.98	78.99	236.98	6.72		0.81	0.81	0.31	3.36	3.36	15.37	221.61	7.89%	Rs. -230.68	5.10		216.51	45.38	176.23	6.79%	Rs. -270.58	176.23	176.23	6.05%	Rs. -228.19	171.13								
2050		348.83	87.21	261.62	7.06		0.85	0.85	0.31	3.53	3.53	16.12	245.50	8.37%	Rs. -214.50	4.59		240.91	50.49	195.01	7.28%	Rs. -257.74	195.01	195.01	6.71%	Rs. -215.34	190.41								
2051		385.01	96.25	288.75		74.14	0.89	0.89	0.31	3.71	3.71	83.63	205.12	8.71%	Rs. -202.44	4.13		200.99	42.13	162.99	7.62%	Rs. -248.15	162.99	162.99	7.17%	Rs. -205.75	158.86								
2052		424.82	106.21	318.62	7.78		0.93	0.93	0.31	3.89	3.89	17.74	300.87	9.11%	Rs. -186.64	3.72		297.15	62.28	238.59	8.04%	Rs. -235.62	238.59	238.59	7.71%	Rs. -193.22	234.87								
2053		467.82	116.96	350.87	8.17		0.98	0.98	0.31	4.09	4.09	18.61	332.25	9.47%	Rs. -171.06	3.35		328.90	68.94	263.31	8.41%	Rs. -232.27	263.31	263.31	8.19%	Rs. -180.87	259.97								
2054		514.98	128.74	386.23	8.58		1.03	1.03	0.31	4.29	4.29	19.53	366.70	9.80%	Rs. -155.70	3.01		363.69	76.23	290.47	8.75%	Rs. -211.11	290.47	290.47	8.63%	Rs. -168.71	287.46								

Summary of Results

Pre-Tax Operating Income, FIRR in 30 th year	9.80%
Pre-Tax Operating Income, NPV in 30 th year	Rs. -155.70
Equity FIRR in 30 th year	8.63%
Equity NPV in 30 th year	Rs. -168.71
Post-Tax Operating Income, FIRR in 30 th year	8.75%
Post-Tax Operating Income, NPV in 30 th year	Rs. -211.11
Average DSCR	0.54
Minimum DSCR	0.14
Maximum DSCR	1.06

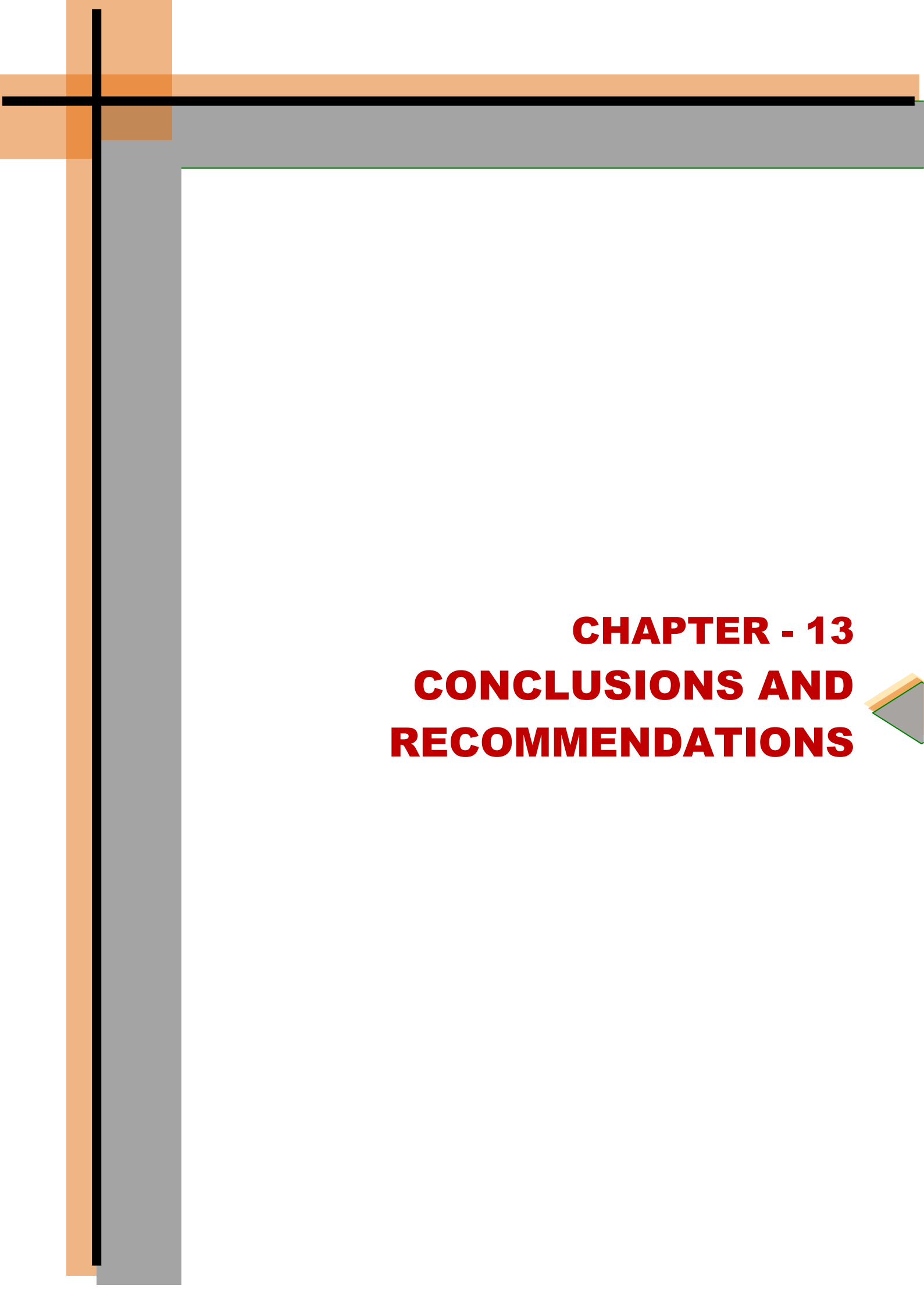
Option - 2: Hybird Annuity with 15 years concession period (BoT – Annuity)

<u>Project Parameters</u>		<u>Financial Parameters</u>		
<u>Project Details</u>				
Evaluation Year for Costs Estimates	2024	Concession Period (Inclu Const. period) years	15	Years
Year of Construction begins	2025			
Construction Period (months)	24	<u>O & M Cost and Other Assumptions</u>		
Opening Year to Traffic	2027	Routine Maintenance Cost	0.10	Crores/Km/Annum
Total Length of the Project (km)	20.85	Periodic Maintenance Cost	1.00	Crores/Km/Annum
No. of Toll Plaza	1	(Once in 5 Years)		
		Elec. Exp.	0.05	Crores/Km/Annum
		Insurance Exp.	0.05 % of TPC	
		Miscellaneous Exp.	0.05	Crores/Km/Annum
		Interest Rate during Construction	10.00%	
		Interest Rate during Operation	10.00%	
<u>Project Cost</u>				
Total Project Cost	598.50 Crore			
Grant (Govt)	199.26 Crore			
Debt(70%)	279.47 Crore			
Equity(30%)	119.77 Crore			
Annual Esclation in Toll Rate(%)	5% CAGR			
Estimated Esclation in Cost(%)	5% Per Annum			

Year	Construc tion Cost	OPERATION & MAINTENANCE COST						Annuity Installment Per Annum	Net Operating Income	Pre - Tax of Operating Income FIRR	Pre - Tax of Operating Income, NPV	Depreciat ion (WDV 10%)	Loan Interest	Net Profit/Los s before Tax	Tax Rate	Net Operating Income after Tax	Post Tax of Operating Income FIRR	Post - Tax of Operating Income, NPV	Net Equity after Tax Amount	Cumulati ve Equity after Tax Amount	Return on Equity FIRR	Return on Equity, NPV	Total Profit/Loss after Tax	Post Tax FIRR	CASH FLOW STATEMENT				DSCR
		O&M		Miscellan eous Exp.	Insurance Exp.	Electrical Exp.	Total Exp.																		Cash In - Flow	Cash Out -Flow			
		Routine Maintena nce	Periodic Maintena nce												20.96%											Net Operating Income	Loan Re- payment	Interest	
1	2	3	4	5	6	7	8 (2+3+4+5 +6+7)	9	10 (9-8)			11	12	13 (10-11- 12)	14	15 (10-14)			16 (10-12- 14)				17 (13-14)						
2025	399.24						399.24		-399.24					-399.24		-399.24			-119.77	-119.77			-399.24						
2026																													
2027		2.30		1.15	0.30	1.15	4.90	82.50	77.60	-	Rs. -329.95	51.81	26.67	-0.87	-0.18	77.79	-	Rs. -329.79	51.12	23.17	-	Rs. -99.08	-0.69		77.60	27.95	26.67	54.61	1.42
2028		2.41		1.21	0.30	1.21	5.13	82.50	77.37	-45.20%	Rs. -268.27	46.63	23.87	6.88	1.44	75.93	-45.57%	Rs. -269.26	52.06	24.11	-44.43%	Rs. -79.86	5.43	-	77.37	27.95	23.87	51.82	1.49
2029		2.53		1.27	0.30	1.27	5.37	82.50	77.13	-22.91%	Rs. -213.37	41.96	21.08	14.09	2.95	74.18	-23.69%	Rs. -216.46	53.10	25.15	-21.24%	Rs. -61.95	11.14	-57.25%	77.13	27.95	21.08	49.02	1.57
2030		2.66		1.33	0.30	1.33	5.62	82.50	76.88	-9.53%	Rs. -164.51	37.77	18.28	20.83	4.37	72.51	-10.59%	Rs. -170.38	54.23	26.28	-7.17%	Rs. -45.25	16.46	-42.78%	76.88	27.95	18.28	46.23	1.66
2031		2.79		1.40	0.30	1.40	5.89	82.50	76.61	-1.15%	Rs. -121.04	33.99	15.49	27.13	5.69	70.93	-2.40%	Rs. -130.13	55.44	27.49	1.72%	Rs. -29.65	21.45	-32.04%	76.61	27.95	15.49	43.43	1.76
2032		2.93		1.47	0.30	1.47	6.17	82.50	76.33	4.35%	Rs. -82.37	30.59	12.69	33.05	6.93	69.41	2.96%	Rs. -94.97	56.71	28.77	7.60%	Rs. -15.08	26.12	-24.00%	76.33	27.95	12.69	40.64	1.88
2033		3.08	30.80	1.54	0.30	1.54	37.27	82.50	45.23	6.71%	Rs. -61.91	27.53	9.90	7.80	1.64	43.60	5.42%	Rs. -75.25	33.70	5.75	8.47%	Rs. -12.48	6.17	-22.41%	45.23	27.95	9.90	37.84	1.20
2034		3.23		1.62	0.30	1.62	6.77	82.50	75.73	9.64%	Rs. -31.32	24.78	7.10	43.85	9.19	66.54	8.24%	Rs. -48.37	59.44	31.49	12.06%	Rs. 0.24	34.66	-15.67%	75.73	27.95	7.10	35.05	2.16
2035		3.40		1.70	0.30	1.70	7.09	82.50	75.41	11.72%	Rs. -4.13	22.30	4.31	48.80	10.23	65.18	10.25%	Rs. -24.87	60.87	32.92	14.56%	Rs. 12.12	38.57	-11.13%	75.41	27.95	4.31	32.26	2.34
2036		3.57		1.78	0.30	1.78	7.43	82.50	75.07	13.24%	Rs. 20.04	20.07	1.51	53.48	11.21	63.86	11.72%	Rs. -4.31	62.34	34.40	16.38%	Rs. 23.19	42.27	-7.75%	75.07	27.95	1.51	29.46	2.55
2037		3.74		1.87	0.30	1.87	7.79	82.50	74.71	14.38%	Rs. 41.52	18.06		56.65	11.87	62.84	12.83%	Rs. 13.76	62.84	62.84	18.62%	Rs. 41.26	44.77	-5.16%					
2038		3.93		1.97	0.30	1.97	8.16	82.50	74.34	15.25%	Rs. 60.60	16.26		58.08	12.17	62.16	13.68%	Rs. 29.71	62.16	62.16	20.10%	Rs. 57.21	45.91	-3.16%					
2039		4.13	41.28	2.06	0.30	2.06	49.84	82.50	32.66	15.56%	Rs. 68.09	14.63		18.03	3.78	28.88	14.00%	Rs. 36.33	28.88	28.88	20.60%	Rs. 63.83	14.25	-2.64%					

Summary of Results

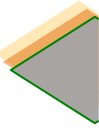
Annuity (semi - Annual) - Rs in Cr.	41.25
Pre-Tax Operating Income, FIRR in 15 th year	15.56%
Pre-Tax Operating Income, NPV in 15 th year	Rs. 68.09
Equity FIRR in 15 th year	20.60%
Equity NPV in 15 th year	Rs. 63.83
Post-Tax Operating Income, FIRR in 15 th year	14.00%
Post-Tax Operating Income, NPV in 15 th year	Rs. 36.33
Average DSCR	1.64
Minimum DSCR	1.20
Maximum DSCR	2.16



CHAPTER - 13

CONCLUSIONS AND

RECOMMENDATIONS



CHAPTER 13

CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusion

The project corridor will be an important transport corridor and provide better connectivity around Vellore Town. This road will provide connectivity from all the radial roads in turn provide efficient commercial transportation. Hence forming bypass is essential.

Vellore Bypass:

The approved alignment of Vellore Bypass alignment starts at the Mangalore - Villupuram Road (at km 47/200 of NH-234), crosses the railway track between (Latheri & Virinchipuram station) crosses the Palar River and then reach NH-48 (Krishnagiri – Ranipet Road) at km 109/750 near poigai. Then alignment crosses the SH-122 at km 1/800 near Poigai mottur village, crosses the ODR-97 near Sekkanur, reaches the MDR -1028 (Nelvoy Pallikonda Road) at km 7/000, travels in existing road for the length 3200m, it takes right and runs parallel to the existing road to cross the railway track between (Pennathur to Kaniyambadi station) and then reaches the NH-234 at km 73/250. The total length of proposed bypass is 20.85 km. The proposed alignment avoids the reserved forest.

The alignment passes through 13 nos. of villages such as Thirumani, Annankudi, Chozhamur, Kothamangalam, Poigai, Puthur, Thellur, Budur, Sekkanur, Ariyur, Pennathur, Sattumadurai and Nelvay.

Proposed Right of Way for the bypass is 50/70m. The project road components are designed as access controlled road, as per the parameters recommended in the relevant standards of the Indian Roads Congress (IRC) and MoRTH circulars, based on the findings of field surveys and investigations.

Flexible pavement is proposed for the project road. Flyover proposed at the National Highway crossings and underpasses proposed at important road crossings locations. Major/minor bridges proposed at waterway crossings. Cross drainage structures proposed as per the site condition and drainage requirements.

As the project road is like a bypass/ring road, no other wayside amenities like truck-laybye, rest area, etc are proposed. Road furniture including sign boards, marking, studs, guard rail, etc are proposed as per the standards.

Environmental screening indicates that there are no major environmental concerns in construction of the project road. Land acquisition is required for the project. Hence the project will have social impact in terms of loss of livelihood or shelter for which suitable mitigation plan should be prepared.

The construction cost of the project road is estimated as Rs. 498.14 Crores. The cost of non-civil works like land acquisition, R&R, utility shifting, EMP, etc shall be prepared to arrive the total project cost.

The project indicates that, there will be considerable economic gains in terms of reduced travel time.

13.2 Recommendations

Cost of the project is very high due to its configuration and extent of land acquisition. The project is Economic viability in terms of running cost and also provide connectivity from all the radial roads in turn provide efficient commercial transportation and also Economic development all along the project corridor. Hence forming bypass is essential.

Implementation of the project can be taken up after acquiring the land and R&R works. Project required shifting of existing utilities, so continuous interaction among the implementing authority, contractor and various utility departments would be necessary during construction period.

Signature Not Verified

Digitally signed by ANIL KUMAR MEENA
Date: 2026.04.22 14:39:02 IST
Location: eProcure-EPROC