CONSULTANCY SERVICES FOR
PREPARATION OF DPR FOR DEVELOPMENT OF

ECONOMIC CORRIDORS, INTER CORRIDORS, FEEDER ROUTES TO IMPROVE THE EFFICIENCY OF FREIGHT MOVEMENT IN INDIA

UNDER BHARATMALA PARIYOJANA LOT 3
ANDHRA PRADESH, KARNATAKA, GOA & KERALA / PACKAGE 1

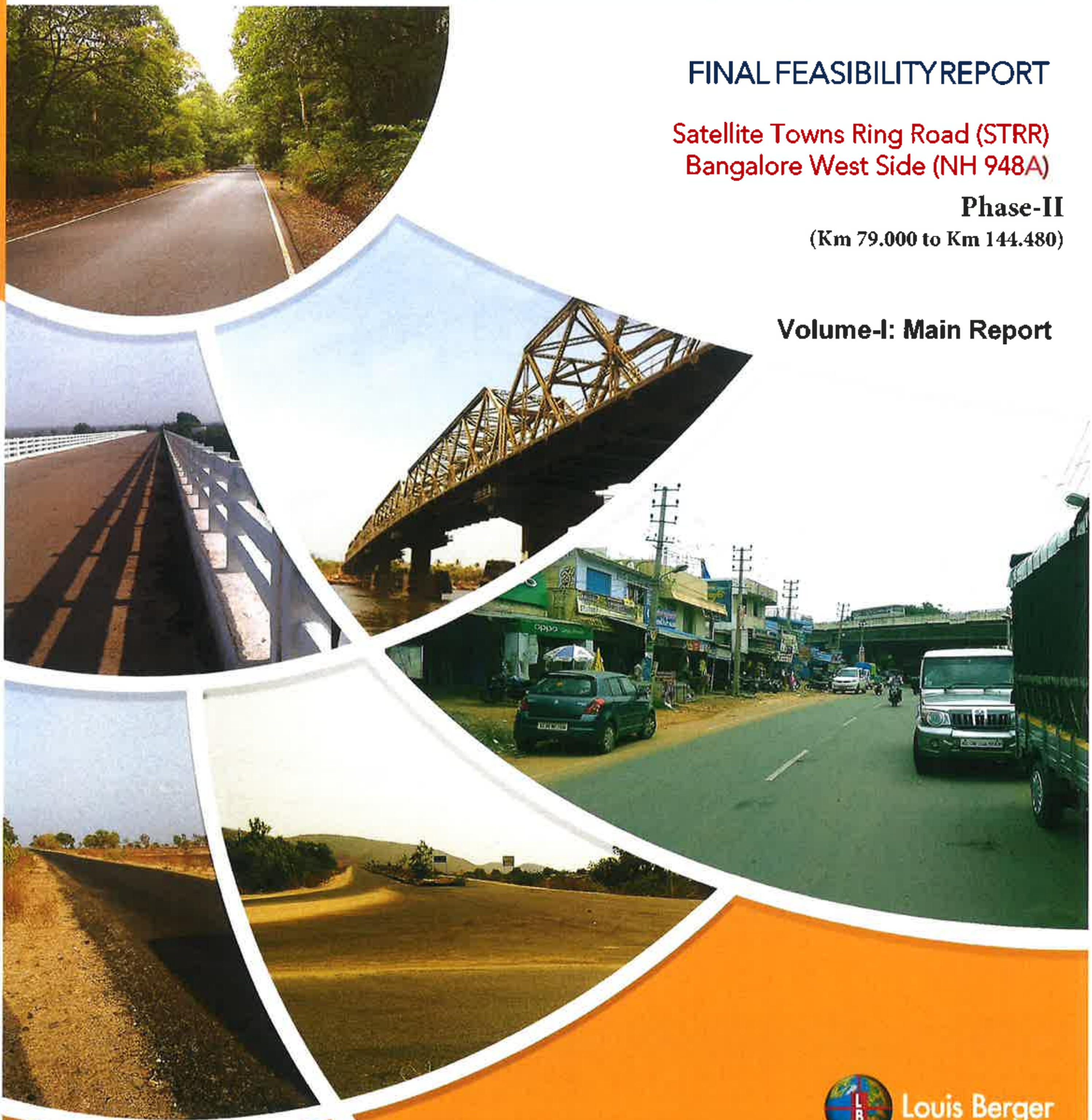
FINAL FEASIBILITY REPORT

Satellite Towns Ring Road (STRR)
Bangalore West Side (NH 948A)

Phase-II

(Km 79.000 to Km 144.480)

Volume-I: Main Report



Louis Berger

May 2019

FINAL FEASIBILITY REPORT

Project Name	*Consultancy Services for preparation of DPR for Development of Economic Corridors, Inter Corridors, Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojana - Lot 3/ Andhra Pradesh, Karnataka, GOA & Kerala /Package 1 (STRR Phase-II)*	
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FINAL FEASIBILITY REPORT

VOLUME I: MAIN REPORT

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1.1 INTRODUCTION

The Ministry of Road Transport and Highways (MORTH), Government of India has proposed "Bharat Mala Pariyojana" an Umbrella scheme of road development project through National Highways Authority of India (NHAI), National Highway and Industrial Development Corporation (NHIDC) and state Public Works Departments (PWD) at an estimated cost of INR 5,35,000crores. This is the second largest highways construction project in the country after NHDP, in that almost 50,000 km of roads targeted across the country. This project aim to improve connectivity particularly on economic corridors, border areas and to remote areas with an aim of rapid and safe movement of cargo to boost exports. International trade considered as a key aspect in this scheme and northeastern states have given special focus. The project cleared by the Union Cabinet on October 25, 2017.

The ambitious project expected to create nearly 100million man days of jobs during the construction and subsequently to about 22million jobs of the increased economic activity across the country. The construction will carried out through many means including debt funds, budgetary allocation, private investment, toll operator transfer etc. The total length of around 34,800km considered in phase 1 including

- Economic corridors of around 9,000km,
- Inter-corridor and feeder routes of around 6,000km,
- National Corridors Efficiency Program of about 5,000 km roads
- Border and international connectivity roads of around 2,000 km,
- Coastal and port connectivity roads of around 2,000 km,
- Expressways of around 800 km
- NHDP roads of 10,000km

In pursuance of the above program, NHAI appointed M/s Louis Berger Consulting Private Limited, New Delhi as Consultants to carry out the Consultancy Services for preparation of DPR for development of Economic Corridors, Inner corridors, feeder Routes and Costal Roads to improve the efficiency of fright movement in India - Lot 3/Andhra Pradesh, Karnataka, Goa & Kerala, / Package 1. The project consists the following stretches of roads finalized as per final Inception Report.

1. Aurad – Bidar road
2. Mydukur – Badvel road
3. Belagavi (Belgaum) – Sanquelim with a proper Connectivity to NH4A and NH 17 through existing SH
4. Chittoor – Thatchur Greenfield alignment
5. Balance Portion of Satellite Ring Road of Bangalore (West Side) including connection to Hosur town to ensure ring road connectivity for Bangalore.

1.2 SCOPE OF WORK

- Widening/improvement work be within the existing right of way and avoiding land acquisition, except for short bypasses, service roads, alignment corrections, improvement of intersections consider necessary, practicable, and cost effective.
- Proposals for widening/improvement of the existing road and strengthening of the carriageways to maintain the level of service over the design period.

- Study the possible locations of toll plaza, Wayside amenities segregation of local traffic from the main traffic.
- Carry out Environmental Impact Assessment, Environmental Management Plan, Rehabilitation, and Resettlement Studies.
- Preparation of Feasibility study & detailed project reports.
- Preparation of 3a, 3 A and 3D draft notifications for acquisition of land.
- GAD, detail engineering drawings, approval from the Railways, Clearances from Ministry of Environment & Forest approvals, estimates for shifting of utilities.
- Preparation of bid documents for EPC/HAM/PPP mode as per Manuals and relevant IRC codes.
- Assistance during bidding activities

Stages of completion

- Stage 1: Inception Report
- Stage 2: Feasibility Report
- Stage 3: LA & Clearances I Report
- Stage 4: Detailed Project Report (DPR)
- Stage 5: Technical Schedules
- Stage 6: submission of Draft 3D publication report
- Stage 7: Clearances II Report

The combined draft Feasibility report (DFR) for the entire STRR submitted vide our letter dated 09 May 2018. A presentation made on the DFR to RO/NHAI Bangalore on 07 September 2018. Subsequent meetings with PD/PIU/Bangalore and RO/NHAI/Bangalore held on 28 September 2018, 15 October 2018 and 28 November 2018. It only intimated by the NHAI during the meeting on 28 November 2018 to proceed further with the submission of the Final Feasibility Report (FFR), ensuring compliance with Bharatmala Guidelines. It also intimated by NHAI that Phase 3 would considered on priority, with the Final Feasibility Report needing to be prepared based on that.

The Final Feasibility Report including typical proposed cross-sectional details of the project road was prepared as per Bharatmala guidelines, taking into account the rolling terrain of the project road. Service roads were included only in built-up stretches to reduce the cost. Accordingly, the project cost worked out. During the meeting on 29 January 2019, it was intimated by PD/NHAI to consider service roads provisions on both sides of the entire STRR project road, irrespective of present requirements or needs (as had been provided in the Dabaspet – Hoskote section of NH 207). This was because, the NH-207 is the northeast quadrant of the STRR and it was important to maintain the same configuration for both project roads

In the meantime, the Dabaspet–Hoskote proposals were submitted to PIU & RO/NHAI Bangalore, and were forwarded to NHAI HQ for consideration for tendering. Accordingly, the project listed in the PATSC meeting on 22 February 2019. During the PATSC meeting at the NHAI, it pointed out that the estimated civil construction cost of the project was considerably high. It was required for the cost per km to be reduce to fall within a moderate range for the project to taken up for implementation. Accordingly, the provision of service roads revisited and contained only in the built up stretches. Based on the same format the services roads are limited in this phase also and the design modified accordingly

The current submission is Final Feasibility Report for Phase II from km 79.000 to km 144.480.

1.2.1 Project Description

In order to ensure safe, smooth, efficient, and high speed transport corridor to Bangalore city, it is impetus that the infrastructure of city and adjoining towns anticipated the development. National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of these traffic are not intend to pass through the Bangalore city. These traffic further aggravate the scenario in the city roads and resulting huge traffic jams.

The Government of Karnataka took steps to improve and augment network within and neighboring area of the city to match with its phase of development. Bangalore Metropolitan Regional Development Authority (BMRDA) had planned the following network of roads consisting the length of 367km to match these requirements.

- Satellite Towns Ring Road (STRR) – 204km
- Individual Town ring Roads (ITRR) – 163km

The total length of STRR (204km) is exclude the stretch passing within the ITRR except for Neelmangala town. The STRR connects the important towns namely Dobbaspet, Doddaballapura, Devanahalli, Sulibele, Hoskote, Sarjapur, Attibele, Anekal, Tattekere, Kanakapura, Ramanagara and Magadi.

BMRDA assigned M/s SECON for the consultancy services to undertake the topographical & Cadastral surveys, finalize the proposed alignment and to prepare the land acquisition report in year 2006. Subsequently, the same agency was engaged to carry out the consultancy for Techno –Economic Feasibility Report in 2007.The notification for land acquisition for STRR & ITRR issued on 12/09/2007 and the project report approved by BMRDA on 10/06/2008. The proposed STRR alignment has declared as State Highway (special) -2 as per the provisions of Karnataka Highways Act 1964 and the SE, PWD, Bangalore circle nominated as ‘The Highway Authority’. Land acquisition processes initiated vide notification NO4017-07-08 dated 19/10/2007.

The original corridor proposed with 90m right-of-way consists of divided 4lanes carriageways with depressed median of 20.50m, with service roads (7m) on both sides. Provision of high speed rail corridor of 15m on one side throughout also made. In addition to this utility corridor of 5m and bus lay-bye of 4m also considered on both sides. The corridor of 90m also frozen by the state government. Ring roads was also proposed to be developed individually for 8 major towns namely Anekal, Kanakapura, Ramanagara, Magadi, Neelmangala, Doddaballapura, Devanahalli & Hoskote to act as bypass for these towns. However, the project shelved due to paucity of funds with the State government.

The original alignment as think of by Karnataka State government and obtained from M/s SECON through NHAI is enclosed in **Figure 1.1**.

However, the earlier proposed alignment by the Karnataka state government passes through some of built up stretches, tanks including religious structures, burial grounds etc. Also during the course of time, some new activities also come up. Therefore, it was indispensable to further study the alignment and update, considering the current scenario along the original proposed alignment. Accordingly, modifications are propose to ensure minimal social Impact and to serve the alignment to wider spectrum of inhabitants in that region. The details given below.

1.2.2 Modifications proposed

1. The original alignment passes through the Dobbaspet town connecting NH 4 on Bangalore side. This extended further on Doddaballapura side towards NH 207 to ensure avoidance of Dobbaspet town local traffic.
2. The original alignment (in the cross point of Hassan road) passes through thickly built up area in Gudermaranahalli from km 14.000 to km 22.000 This stretch consists of residential, school and religious structures.
3. The earlier alignment passes through thickly built up area from km 22.000 to km 25.600 in Harthi/Renganahalli.
4. The original alignment passes through Savanadurga Forest area from km 34.700 to km 41.700. This forest also has wildlife.
5. The original alignment pass through Siddadevarabetta Forest area from km 43.000 to km 46.700
6. The original alignment passes through Ramadevarabetta forest area from km 57.700 to km 58.300 near NH 275 crossing in Ramanagara

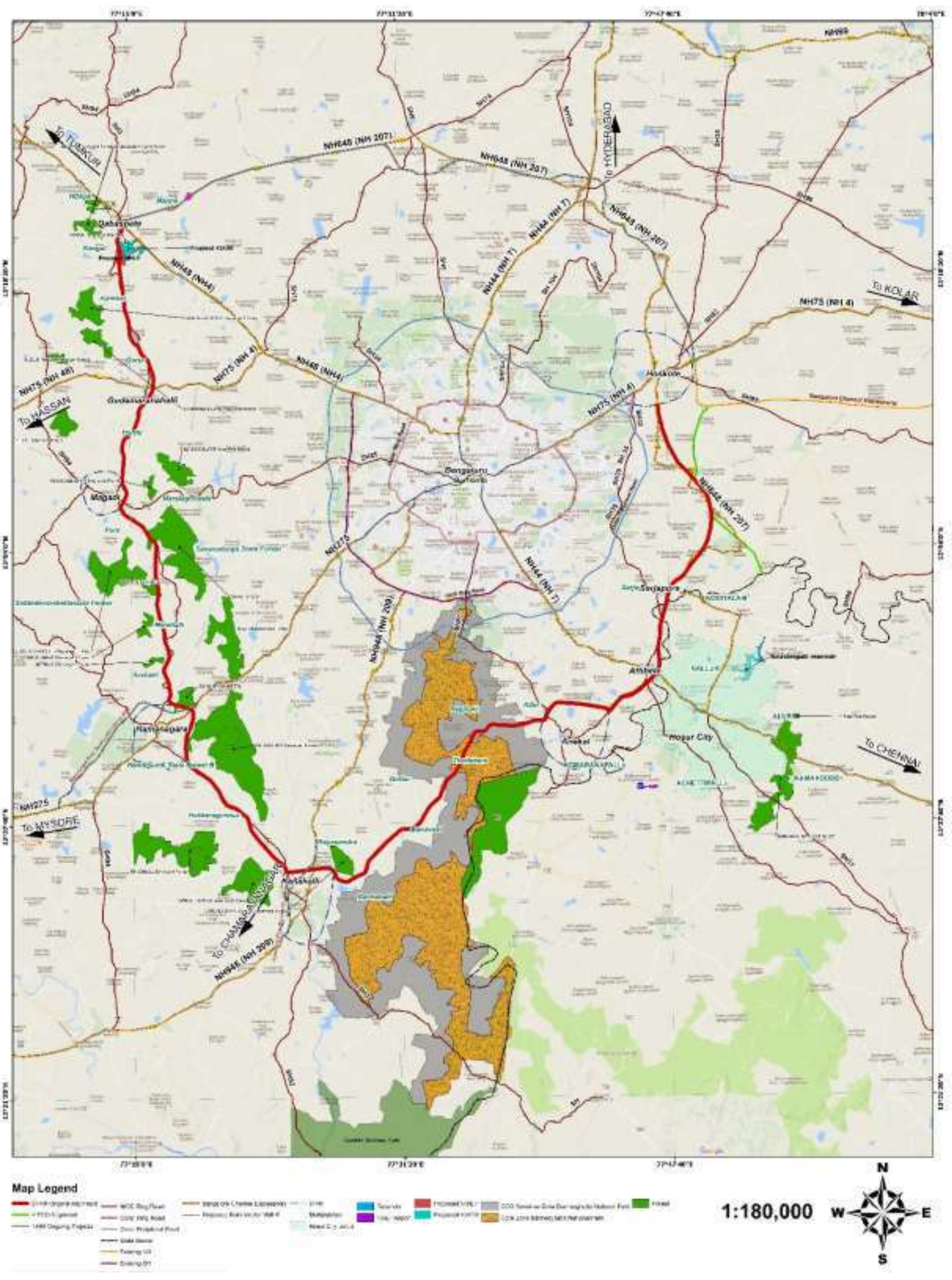

Figure .1.1: Original STRR Alignment as think of by Karnataka State Government

1.2.3 Value addition proposed

Further the alignment made value additions by connecting some cross roads and considering the current and future proposals in that location as per below details.

1. The starting point of the STRR extended to connect NH 207 (near km 131.200) with a bypass provision in Dobbaspet town on Pune side to ensure uninterrupted traffic flow, contrary to the earlier proposed location pass through the mid of built up area in Dobbaspet. It is relevant to mention that the through traffic contribute from Pune direction, on NH 4 is significant.
2. There is Multi Model Logistic Park (MMLP) and proposed KIADB coming up near Dobbaspet on SH 3 spread at about 250acres of land. The Feasibility study also done for the proposed MMLP project. Therefore, connection to this park is eminent and provision made accordingly to these logistic park & KIADB with proposed STRR.
3. NHAI is currently developing bypasses to Kankapura and Ramanagara towns under different programs to ease traffic congestion on NH 209 and NH 275 respectively. Thus, in order to ensure seamless traffic flow through these proposed bypasses, it is necessary to integrate with proposed STRR at these locations.
4. Hosur is an automobile industry town located in the vicinity of about 7km away from Karnataka state border. This city generates huge amount of through traffic and currently experiencing massive traffic congestion. It observed that the proposed STRR would further deteriorate the Hosur traffic. Therefore, consideration of STRR taking along this town necessitated.
5. The end of STRR will need integration with the alignment under finalization for 4 lanes of Sarjapur, Karnataka/Tamil Nadu border near Bagalur town in order to provide efficient connectivity accordingly the proposed STRR alignment is integrated.
6. The updated alignment presented and discussed with RO/NHAI/Bangalore and PD/NHAI on 12/3/2018, 21/3/2018 04/04/2018 & 07/04/2018 and Concurrences obtained from Competent Authority of NHAI through letter dated 05/05/201/8

Final updated alignment incorporating all modifications given **Figure 1.2.**

Further, while fixing the boundary stone for Phase III, near km 157.800, it noted that the alignment was passing through the school building. On the other hand during 3A land acquisition stage, a 100m corridor notified contrary to the requirements of 70m of proposed right of way requirements considering unanticipated interruptions as it is entirely a Greenfield corridor. . Therefore, considering school building, the safety to the children the alignment shifted away from the main building to the maximum extent possible within the 100m proposed width without compromising the geometry standard of the road and to ensure uninterrupted curriculum. The proposal approved NHAI vide letter NHAI/12012/BM/STRR/DPR/TN/2/2018/PIU- BNG (EXP)/765 dated 13/12/2018.

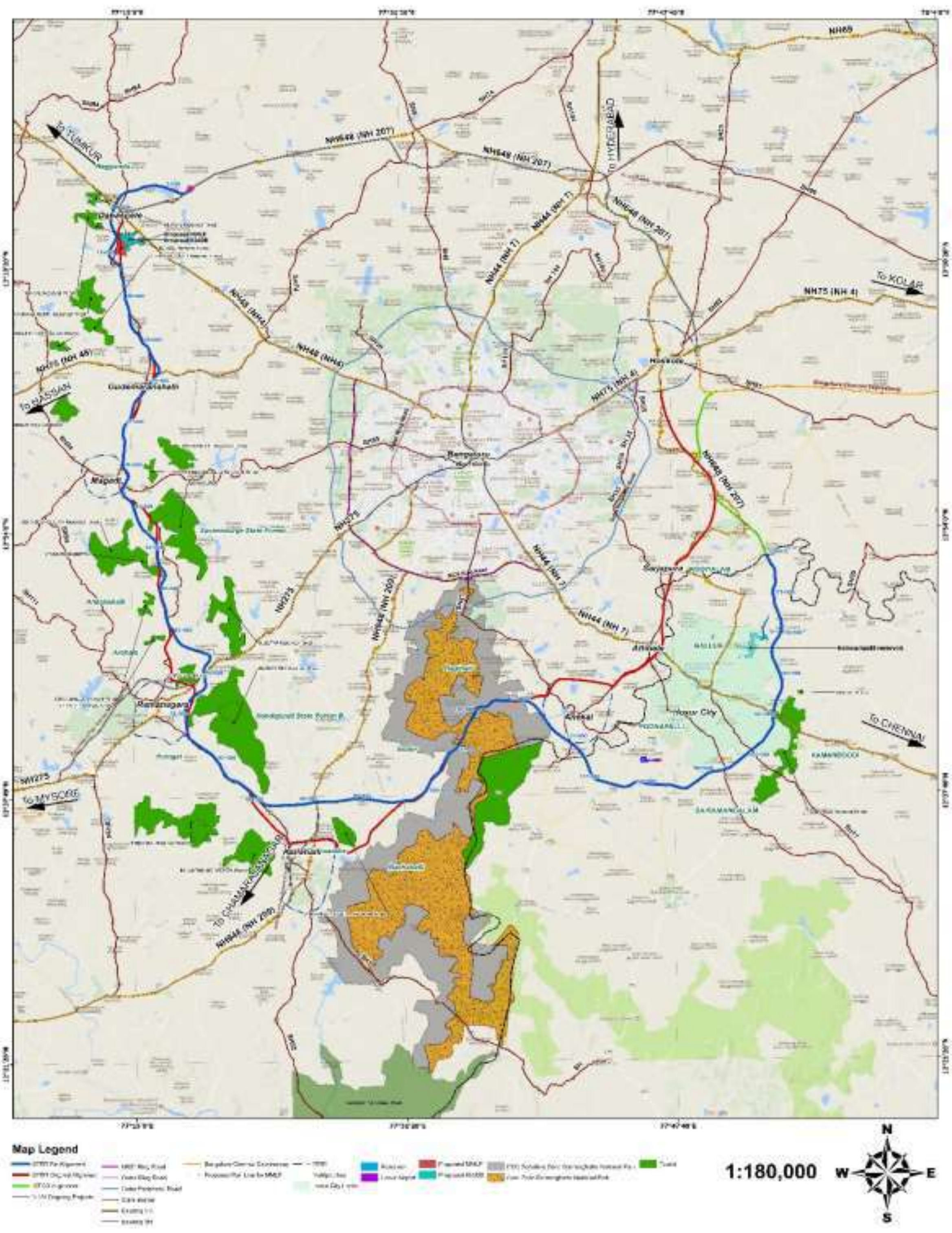

Figure 1.2: Final Alignment

1.3 SURVEY AND INVESTIGATIONS

1.3.1 Topographic Survey

The broad outlines of the scope of services are:

i) Fixing of control frame work comprising of the following activities:

a) Establishment of Main Control by DGPS

b) Establishment of Subsidiary Control Points by Total Station.

c) Establishment of Height Control by Digital Level

ii) Detailed Topographical Survey using LiDAR technique to the project road.

iii) The detailed topographical survey for the road corridor is under process.

1.3.2 Details of Right of Way

The proposed right of way for the Greenfield alignment is considered as 70m in the throughout corridor. Additional land for proposed interchanges, toll collection plaza, truck parking etc. will also envisaged.

1.4 TRAFFIC SURVEYS, ANALYSES AND FORECAST

1.4.1 Traffic Surveys and Analyses

Various traffic surveys and analysis have been carried out for addressing the objectives and issues pertaining to widening and strengthening of the project stretch. The surveys conducted include 7- day volume count, Turning movement survey, origin & destination survey, speed and delay survey, etc. The study aims at obtaining the existing traffic and travel characteristics on the project corridor and forecasting the same for the project horizon year considering various constituent streams and various scenarios. The results of this analysis will form inputs for developing capacity augmentation proposals, designing the pavement, design of intersections, decisions regarding grade separators, pedestrian facilities, and carrying out economic and financial analysis.

Considering the traffic generation/diversion point, the project stretch is divided into one homogeneous section for the purpose of analysis and presentation of traffic and travel characteristics. The following table gives the details for the study.

Table 1-1: Homogeneous Traffic Section

Homogeneous section	From	To
HS 1	Junction NH 4 - SH 3	Junction Hassan Road - SH 3
HS 2	Junction Hassan Road - SH 3	Junction SH 85 - SH 3
HS 3	Junction SH 85 - SH 3	Junction Mysuru Road - SH 3
HS 4	Junction Mysuru Road - SH 3	NH 209 (Chamrajnagar Road) - SH 3
HS 5	NH 209 (Chamrajnagar Road) - SH 3	Junction SH 85/SH35 (Anekal)
HS 6	Junction SH 85/SH35 (Anekal)	Junction NH 7 (Hosur Road) - SH 87
HS 7	Junction NH 7 (Hosur Road) - SH 87	Junction NH 7 (Hosur Road) - NH 648

The average daily traffic (ADT) has been converted to average annual daily traffic (AADT) using seasonal correction factors. The AADT is the input for various analyses like traffic forecast, capacity augmentation, pavement design, economic and financial analysis etc. Table below gives the ADT plying on the project road.

Table 1-2: Summary of Average Daily Traffic (ADT) at count location.

	NH 4CH 51	SH 85	NH - 275 Km 30.8	NH 209 CH 419	NH 48CH 44+200	NH 7 CH 49+000
Car	16156	2631	13040	2411	11690	15470
Mini Bus	345	48	485	57	275	407
Bus	2855	364	1223	312	1528	2782
LMV	2261	393	1217	341	908	2146
LCV (4 Wheels)	334	36	116	28	76	125
LCV (6 Wheels)	2755	96	863	78	853	2866
2 Axle	1853	47	619	114	583	1847
3 Axle	2837	54	424	69	339	2947
MAV (4 to 6 Axles)	4064	18	179	22	557	3525
MAV (7++ Axles)	1	0	0	0	0	1
JCB/HCM	6	2	2	2	2	3
3 Wheeler	820	1799	2057	475	563	114
2 wheeler	9414	11499	10863	4571	6640	10432
Tractor Without Trailer	6	8	6	4	7	5
Tractor With Trailer	22	58	29	16	22	29
Cycle	3	84	29	22	3	6
Cycle Rickshaw	0	1	0	0	0	0
Animal Drawn	0	3	1	0	0	0
Car Exempt	1	0	2	1	4	3
Mini Bus_Exempt	12	0	4	1	7	9
Bus_Exempt	0	0	0	0	0	0
LCV_Exempt	1	0	1	0	3	1
Truck Exempt	0	0	0	0	0	0
Total	43,746	17,142	31,159	8,524	24,061	42,718
PCU	70,014	12,648	31,660	7,426	28,247	66,747

Table 1.3: Summary of Average Daily Traffic (ADT) at count location

	NH 7 CH 31	**SH 3 CH 118**	**NH 207 CH 138**	**NH-4 NICE ROAD**	**NH- 7 Before NICE Road**	**NH - 275 NICE Road**	**SH 3**
Car	24582	462	2230	48418	26163	29386	817
Mini Bus	1230	8	119	2040	1617	1834	17
Bus	3889	33	207	6318	3144	3848	117
LMV	3734	78	505	6679	2893	3529	141
LCV (4 Wheels)	553	12	22	1732	478	692	12
LCV (6 Wheels)	4161	51	412	5735	1862	3961	39
2 Axle	2530	54	313	1853	482	1743	18
3 Axle	3828	46	409	1918	787	2384	13
MAV (4 to 6 Axles)	3489	47	357	1818	277	1116	3
MAV (7++ Axles)	1	0	0	0	0	0	0
JCB/HCM	2	1	3	4	9	7	0
3 Wheeler	482	76	957	5935	2910	2747	151
2 wheeler	32099	1386	6642	54862	37086	25670	3527
Tractor Without Trailer	1	4	5	5	2	5	0
Tractor With Trailer	15	11	61	39	12	21	16
Cycle	28	2	7	33	35	5	31
Cycle Rickshaw	0	0	0	1	1	1	0
Animal Drawn	0	0	0	0	0	0	0
Car Exempt	2	0	1	6	3	6	0
Mini Bus_Exempt	6	0	0	19	4	15	0
Bus_Exempt	0	0	1	1	0	1	0
LCV_Exempt	2	0	0	4	1	2	0
Truck Exempt	1	0	5	0	0	0	0
Total	**80,635**	**2,273**	**12,255**	**1,37,418**	**77,766**	**76,974**	**4,903**
PCU	**1,00,041**	**2,087**	**12,544**	**1,40,565**	**70,819**	**87,002**	**3,517**

1.4.2 Traffic Forecast

Traffic demand plays the most important factor in deciding the type of facility (infrastructure) to be provided. This in turn determines likely costs to develop and benefits arising out of the improvement. A highway project of this nature calls for significant investment. Prediction of traffic demand becomes an important task and need to be carried out accurately. For the design of pavement, plan for future maintenance program as well as capacity augmentation and for economic & financial evaluation, it is necessary to have realistic estimation of the size of traffic to the concession period.

Traffic forecasting is made by determining the past trend of traffic flow and by the use of economic models developed to co-relate past vehicle registration data with economic indices such as per capital income (PCI), net state domestic product (NSDP) and gross domestic product (GDP). By using the elasticity values obtained from the economic models and the likely rate of growth of indicators, the mode wise growth rates are obtained. Applying these growth rates, future traffic volume is estimated. The traffic forecast are given in the Table below.

Table 1.4: Traffic Forecast

STRR				
	HS 4		**HS 5**	
	ADT	**PCU**	**ADT**	**PCU**
2021	17083	17762	17811	18518
2025	36014	36610	38201	38854
2030	56909	56090	60422	59693
2035	89426	85571	95033	91322
2040	139728	129993	148621	139118
2045	217072	196638	231085	211024
2050	335280	296197	357213	318730

A comprehensive set of traffic surveys conducted along the project road. The traffic surveys included classified traffic volume counts, OD surveys, and axle load surveys. The project road divided in 7 homogeneous sections. Traffic volume count conducted at all thirteen locations shows variations in term of ADT and PCU from 4,903 to 137,418 and 3,517 to 140,565 respectively. The base year count and its projection to future year show, that homogenous section HS4 and HS5 of STRR (Phase II) need to develop as six lane immediately.

1.4.3 Pavement Design

Pavement is the most significant component of a road and therefore its performance must be ensured to support the projected traffic loading throughout the design period. Its cost represents a major proportion of the total construction cost.

The project road has seven homogeneous sections based on the traffic, CBR and existing Pavement composition. The design inputs considered for pavement design have been summarized below. Flexible Pavement (Granular Base and Granular Sub-base), Flexible Pavement (Cement Treated Base and Granular Sub-base) & Rigid Pavement options are considered

Based on the projection of traffic and the Vehicle Damage Factor of various types of commercial vehicles, Cumulative standard Axles (CSA) for all homogeneous section are as given below:

Table 1.5: Design Traffic (msa)

Homogeneous Section	Chainage (km)		Cumulative Standard Axle (CSA) - in msa					Design Traffic (20 yr Design Period)	Design Traffic (30 yr Design Period)
	From	To	10th Year	15th Year	20th Year	25th Year	30th Year		
HS 1	0.000	30.381	20.56	37.67	61.43	94.02	138.13	65	140
HS 2	30.381	44.576	21.09	38.66	63.07	96.57	141.92	65	145
HS 3	44.576	70.032	21.76	39.92	65.16	99.80	146.72	70	150
HS 4	70.032	95.365	21.37	39.17	63.90	97.86	143.90	65	145
HS 5	95.365	152.365	21.21	38.88	63.42	97.11	142.78	65	145
HS 6	152.365	161.430	21.15	38.76	63.21	96.77	142.25	65	145
HS 7	161.430	179.969	26.00	47.64	77.70	118.93	174.79	80	175

Pavement options are worked out as terms of references based on design traffic. Three pavement options are worked out and the details are as summarized below.

1.4.4 Flexible Pavement

Phase	Chainage (km)		Length (km)	Design Traffic (20 years)
	From	To		
Phase II	79.000	144.480	65.480	65.000

Traffic	Phase II	Remarks
Allowable Horizontal Tensile Strain (x 10^{-6})	166.51	
Allowable Vertical Compressive Strain (x 10^{-6})	350.79	
Bituminous Concrete (BC)	50	PMB-40 (IRC:SP:53)
Dense Bituminous Macadam (DBM)	95	VG-40
Wet Mix Macadam (WMM)	250	
Granular Sub-base (GSB)	200	Gradation V or VI of MoRTH
Effective Subgrade (CBR >= 14%)	500	
Actual Horizontal Tensile Strain (x 10^{-6})	163.2	
Actual Vertical Compressive Strain (x 10^{-6})	247.6	

1.4.5 Paved Shoulder

The composition of the paved shoulder will be same as that of main carriageway.

1.4.6 Bridges and Structures

The proposed bridges and structures are as below

Detail of structure	Phase II
Major Bridges	1no
Minor Bridges	8no
Interchanges	3no
ROB	Nil
Vehicular Underpasses	16no
Light Vehicular Underpasses	18no
Overpasses	10no
Viaducts	4no

1.5 PRELIMINARY COST ESTIMATES

The consultants have framed the project cost for 6anes with paved shoulder configuration based on contract packages proposed by NHAI. The civil cost for flexible pavement option is as below.

Civil Cost: INR 2464.25 crores and the cost per km is INR **37.63** crores

Based on life cycle cost analysis, flexible pavement option is preferable.

1.6 ECONOMIC ANALYSIS

Economic evaluation has been carried out based on incremental costs & benefits comparing the total net benefits in “Without project” situation with “With Project” situation. The term “Without project” is defined as the base strategy for economic analysis i.e. without project situation. The term “With project” is defined as widening and strengthening of existing facility. Economic analysis has been carried out for with time and accident benefits. Sensitivity analysis has been carried out for the four cases mentioned below, with both the Alternatives.

- Scenario - I Base Costs and Base Benefits
- Scenario - II Base Costs plus 1 5% and Base Benefits
- Scenario - III Base Costs and Base Benefits minus 15%
- Scenario - IV Base Costs plus 15% and Base Benefits minus 15%

The Sensitivity analysis has been carried out as per the requirements of TOR. The relevant EIRR and corresponding NPV are presented below for each option.

Scenario	Phase II	
	EIRR (%)	**NPV (million)**
Scenario 1:Base Costs and Base Benefits	20.9	17,434
Scenario 2:Base Costs Plus 15% and Base Benefits	19.8	15,028
Scenario 3:Base Costs and Base Benefits Minus 15%	19.0	15,057
Scenario 4:Base Costs Plus 15% and Base Benefits Minus 15%	18.0	12,651

It is evident from results that EIRR for current project proposal give a higher value as compared with the cut-off rate (12 %). Also the sensitivity analysis also shows that for current project proposal, considering the worst case, EIRR remains above cut-off rate. It is, therefore concluded that both packages are economically viable at current price

1.7 FINANCIAL ANALYSIS

It concluded from financial analysis carried out separately for both packages that the project is not viable on commercial format. The traffic on the project stretch is considerably low. At 40% grant component the Project IRR and Equity IRR are coming at 12.0% and 13.1% for Phase II. The Analysis has carried out by providing brand new Satellite town ring road. The Project may implemented on differed payment system, which is Annuity based or else on EPC contract basis with Government fund

1.8 CONCLUSIONS AND RECOMMENDATIONS

- To ensure safe, smooth and efficient transport corridor to Bangalore city, it is impetus that infrastructure of city and adjoining towns anticipated the development.
- National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of these traffic are not intend to pass through the Bangalore city.
- The proposed road facility connect important satellite towns such as Dobbasapete, Magadi, Ramanagara, Kanakapura and Anekal in Karnataka & Hosur in Krishnagiri district
- Hosur is an automobile industry town located near to Karnataka state border and generates huge amount of through traffic this proposed facility will ease traffic in Hosur city.
- Considering the Banneragatta National Park’s wildlife Clearances involved in the project it is proposed to take up in project in three phases so that the section which is encumbrance free from BNP wildlife Clearances and could get implemented without any delays
- A comprehensive set of traffic surveys and analysis reveal a six lane facility to the entire corridor.
- The Bannerghatta National Park of core zone including of more than one Km length on both sides of eco sensitive zone are provisioned with elevated 6-lane structure on single pear to avoid human and animal conflicts.
- The economic appraisal of the project reveal that the project as a whole is economically viable considering direct benefits.
- The project is not viable on commercial format. Therefore is recommended to take up on Annuity or EPC mode for implementation.

Chapter-2 :
Overview of NHAI'S Organisation & Activities, Project Financing and Cost Recovery Mechanism

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CHAPTER-2: OVERVIEW OF NHAI'S ORGANISATION & ACTIVITIES, PROJECT FINANCING AND COST RECOVERY MECHANISM

2.1 ESTABLISHMENT

The National Highways Authority of India was constitute by an act of Parliament, the National Highways Authority of India Act, 1988. NHAI is responsible for the development, maintenance and management of National Highways entrusted to it and for matters connected therewith or incidental there to. The Authority was operational from February 1995 as an autonomous body with the appointment of full time Chairman and other members.

2.2 ORGANIZATION

A full time Chairman heads NHAI. As per NHAI act, there are five full time Members, namely Member (Admin.), Member (Finance) and three Members (Technical). There are also four part time (ex officio) Members of the Authority. The Authority has its field offices in the form of Project Implementation Units (PIUs), Regional offices (RO) and Corridor Management Units (CMU) spread all over the country. These units headed by Project Directors (PD) and Regional officers (RO) who are responsible for implementation of various Projects and operation and maintenance of the completed sections.

All procurement related to works, services, equipment and goods i.e. civil contractors, consultants and suppliers are made by the head office predominantly and as well as by Regional Offices . PDs are also responsible for all pre construction activities and liaison to the Departments concerned of Union and State Government for successful implementation of the Projects.

The Government has approved a proposal of restructuring NHAI. The salient points of the proposal are, inter alia; increase of full-time Members from 5 to 6 and part time Members from 4 to 6, creation of 26 posts at the level of CGM and to build a core of permanent employee of NHAI over a period of time. This process has taken up.

A detailed organization chart of NHAI given in **Fig. 2.1.**

2.3 FUNCTIONS

The function and activities of National Highways authority of India are stipulate in NHAI Act. 1988. The clear mandate given by the Act is to develop, maintain and manage the National Highways and other highways vested in or entrusted to it by the Government of India. The main activities of the NHAI as stipulated in the Act and Rules are:

- Survey, develop, maintain and manage highways vested in or entrusted to it;
- Construct offices or workshops and establish and maintain, hotels, motels, restaurant and rest rooms along or near the highways vested in, or entrusted to it;
- Construct residential buildings and townships for its employees;
- Regulate and control the plying of vehicles on the highways vested in or entrusted to it for the proper management thereof;
- Develop and provide consultancy and construction services in India and abroad and carry on research activities in relation to the development, maintenance and management of highways or any facilities, thereat;

- Provide such facilities and amenities for the users of the highways vested in or entrusted to it, as are, in the opinion of NHAI, necessary for the smooth flow of traffic on such highways
- Form one or more companies under the Companies Act, 1956 (Act 1 of 1956) to further the efficient discharge of the functions imposed, on it by this Act;
- Engage, or entrust any of its functions to any person, on such terms and conditions as may be prescribed;
- Advise the Central Government on matters relating to highways;
- Assist, on such terms and conditions as may be mutually agreed upon, any State Government in formulation and implementation of schemes for highway development;
- Collect fees on behalf of Central Government for services rendered;
- Take all such steps as may be necessary or convenient for or may be incidental to, the exercise of any power or the discharge of any of its functions

2.4 MANDATE

National Highways Authority of India (NHAI) is mandate to implement National Highways Development Project (NHDP), which is

- India 's Largest ever highways project
- World class roads with uninterrupted traffic flow

The National Highways have a total length of 71,772 km to serve as the arterial network of the country. The development of National Highways is the responsibility of the Government of India. The Government of India has launched major initiatives to upgrade and strengthen National Highways through various phases of National Highways Development project (NHDP), which are briefly as under:

NHDP Phase I

NHDP Phase I was approved by Cabinet Committee on Economic Affairs (CCEA) in December 2000 at an estimated cost of Rs.30,000 crore comprises mostly of GQ (5,846 km) and NS-EW Corridor (981km), port connectivity (356 km) and others (315 km).

NHDP Phase II

NHDP Phase II was approved by CCEA in December 2003 at an estimated cost of Rs.34,339 crore (2002 prices) comprises mostly NS-EW Corridor (6,161 km) and other National Highways of 486 km length, the total length being 6,647 km. The total length of Phase II is 6,647 km.

NHDP Phase-III

Government approved on 5.3.2005 up gradation and 4 lanes of 4,035 km of National Highways on BOT basis at an estimated cost of Rs. 22,207 crores (2004 prices). Government approved in April 2007 up gradation and 4 lanes at 8074 km at an estimated cost of Rs. 54,339 crore.

NHDP Phase V

CCEA has approved on 5.10.2006 six lanes of 6,500 km of existing 4 lane highways under NHDP Phase V (on DBFO basis). Six lanes of 6,500 km includes 5,700 km of GQ and other stretches.

NHDP Phase VI

CCEA has approved on November 2006 for 1000 km of expressways at an estimated cost of Rs. 16680 crores.

NHDP Phase VII

CCEA has approved on December 2007 for 700 km of Ring Roads, Bypasses and flyovers and selected stretches at an estimated cost of Rs. 16680 crores.

Bharatmala

The Ministry of Road Transport and Highways (MORTH), Government of India has proposed "Bharat Mala Pariyojana" an Umbrella scheme of road development project through National Highways Authority of India (NHAI), National Highway and Industrial Development Corporation (NHIDC) and state Public Works Departments (PWD) at an estimated cost of INR 5,35,000crores. This is the second largest highways construction project in the country after NHDP, in that almost 50,000 km of roads targeted across the country. This project aim to improve connectivity particularly on economic corridors, border areas and to remote areas with an aim of rapid and safe movement of cargo to boost exports. International trade considered as a key aspect in this scheme and northeastern states have given special focus. The project cleared by the Union Cabinet on October 25, 2017.

The ambitious project expected to create nearly 100million man-days of jobs during the construction and subsequently to about 22million jobs of the increased economic activity across the country. The construction will carried out through many means including debt funds, budgetary allocation, private investment, toll operator transfer etc. The total length Identified is of 66,100 km and upgrade proposed in Phase 1 is 24,800km including

- Economic corridors of around 9,000km,
- Inter-corridor and feeder routes of around 6,000km,
- National Corridors Efficiency Program of about 5,000 km roads
- Border and international connectivity roads of around 2,000 km,
- Coastal and port connectivity roads of around 2,000 km,
- Expressways of around 800 km

2.5 FINANCING MECHANISMS

NHAI proposes to finance its projects by a host of financing mechanisms. Some of them are as follows

a) Through budgetary allocations from the Government of India

b) Budgetary Allocation

In a historic decision, the Government of India introduced a Cess on both Petrol and Diesel. This amount at that time (at 1999 prices) came to a total of approximately Rs. 2,000crores per annum. Further, Parliament decreed that the fund so collected were to put aside in a Central Road Fund (CRF) for exclusive utilization for the development of a modern road network. The developmental work that it could tapped to fund and the agencies to whom it was available were clearly define as:

1. Construction and Maintenance of State Highways by State Governments.
2. Development of Rural Roads by State Governments
3. Construction of Rail over- bridges by Indian Railways
4. Construction and Maintenance of National Highways by NHDP and Ministry of Road Transport & Highways. Today, The Cess contributes between Rs 5 to 6 Thousands crores per annum towards NHDP

c) Loan Assistance from International Funding Agencies

Loan assistance for implementation of specific projects taken from multilateral development agencies like Asian Development Bank, World Bank and Japanese Bank of International Co - Operation.

d) Market Borrowing

NHAI proposes to tap the market by securities cess receipts.

e) Private Sector Participation

Major policy initiatives have taken by the Government to attract foreign as well as domestic private investments. To promote involvement of the private sector in construction and maintenance of National Highways, Some Projects are offer on Build Operate and Transfer (BOT) basis to private agencies. After the concession period, which can range up to 30 years, this road is to transferred back to NHAI by the Concessionaries.

NHAI funds also leveraged by the setting up of Special Purpose Vehicles (SPVs).The SPVs will be borrowing funds and repaying these through toll revenues in the future. This model will also be try in some other projects. Some more models may emerge in the near future for better leveraging of funds available with NHAI such as Annuity, which is a variant of BOT model

f) Govt. Policy Initiatives

Following incentives to attract private sectors for development of highways have announced by the Government.

- Government will carry out all preparatory work including land acquisition and utility shifting. Right of way (ROW) made available to concessionaires free from all encumbrances.
- Government to provide capital grant up to 40% of project cost to enhance viability on a case to case basis;
- 100% tax exemption in any 10 consecutive years within a period of 20 years;
- Concession period allowed up to 30 years;
- Well defined transparent procurement procedure with Standard Bidding Document;
- Arbitration and Conciliation Act 1996 based on UNICITRAL provisions;
- BOT projects entrepreneur are allowed to collect and retain tolls;
- Duty free import of specified modem high capacity equipment for highway construction.

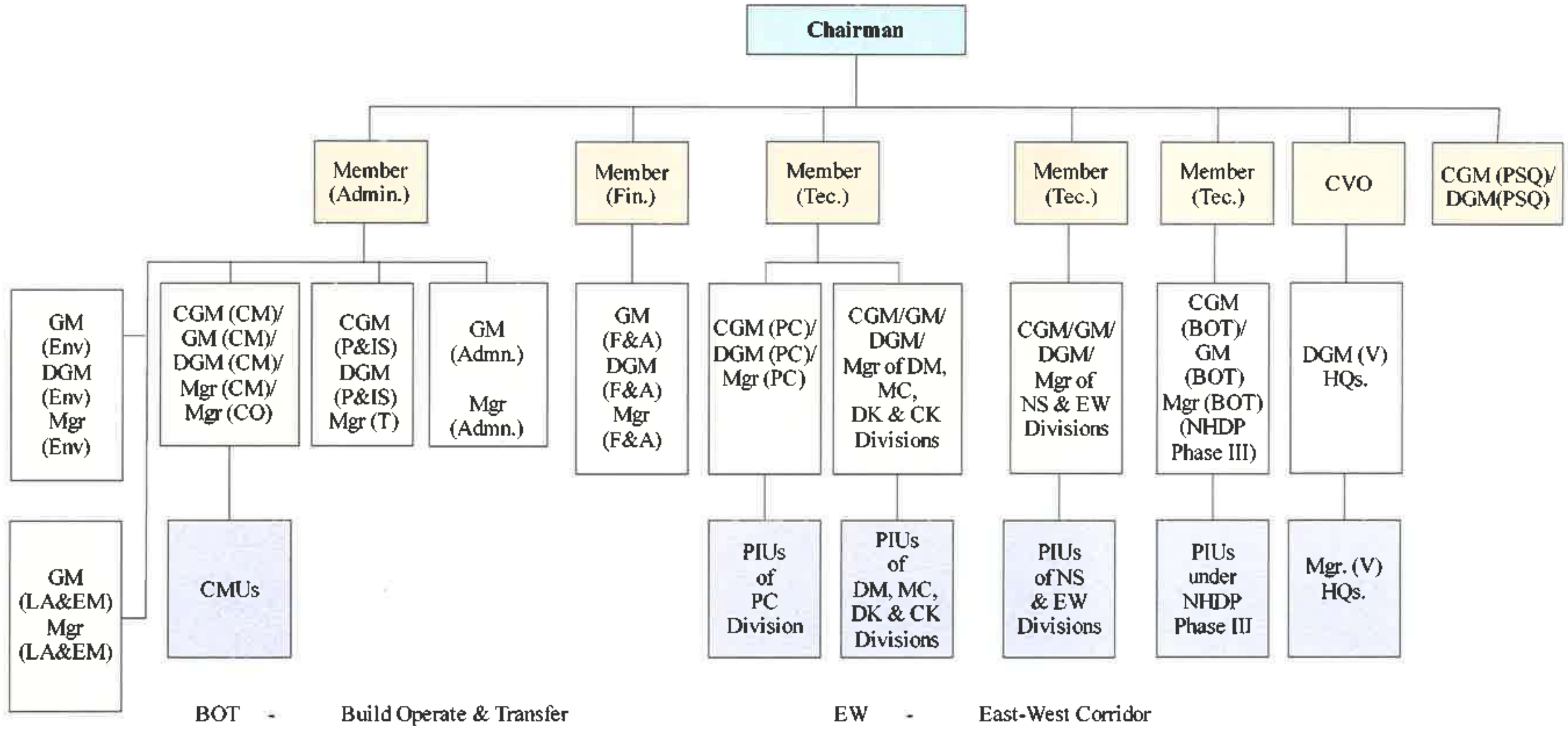
2.6 COST RECOVERY MECHANISM

2.6.1 Toll Revenue

The National Highways Act empowers NHAI to charge users' fees on the sections of National Highways, bridges on it. NHAI is charging users' fees on completed four/six lane sections of National Highways. Part of this fund used for maintenance purpose. The surplus amount of user' fees are also a part of financing of NHDP and other projects.

2.6.2 Negative Grant

NHAI has received negative grant in few projects where the intensity of toll able traffic is very high. This amount is also a part of financing of these projects.



BOT	-	Build Operate & Transfer	EW	-	East-West Corridor
CGM	-	Chief General Manager	ENV	-	Environment
CK	-	Chennai-Kolkata Section of GQ	F & A	-	Finance & Accounts
CM	-	Corridor Management	GM	-	General Manager
CMU	-	Corridor Management Unit	GQ	-	Golden Quadrilateral
CO	-	Commercial Operations	LA & EM	-	Land Acquisition & Estate Management
CVO	-	Chief Vigilance Officer	MC	-	Mumbai-Chennai Section of GQ
DGM	-	Deputy General Manager	P&IS	-	Planning and Information Systems
DK	-	Delhi-Kolkata Section of GQ	PC	-	Port Connectivity
DM	-	Delhi-Mumbai Section of GQ	NS	-	North-South Corridor
PIU	-	Project Implementation Unit			

Figure 2.1: Organization Chart of NHAI

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Chapter-3 :

Project Description Including Possible Alternative Alignments / Bypass and Technical/Engineering Alternatives

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3.1 GENERAL

The Ministry of Road Transport and Highways (MORTH), Government of India has proposed "Bharat Mala Pariyojana" an Umbrella scheme of road development project through National Highways Authority of India (NHAI), National Highway and Industrial Development Corporation (NHIDC) and state Public Works Departments (PWD) at an estimated cost of INR 5,35,000crores. This is the second largest highways construction project in the country after NHDP, in that almost 50,000 km of roads targeted across the country. This project aim to improve connectivity particularly on economic corridors, border areas and to remote areas with an aim of rapid and safe movement of cargo to boost exports. International trade considered as a key aspect in this scheme and northeastern states have given special focus. The project cleared by the Union Cabinet on October 25, 2017.

The ambitious project expected to create nearly 100million man-days of jobs during the construction and subsequently to about 22million jobs of the increased economic activity across the country. The construction will carried out through many means including debt funds, budgetary allocation, private investment, toll operator transfer etc. The total length of around 34,800km considered in phase 1 including

- Economic corridors of around 9,000km,
- Inter-corridor and feeder routes of around 6,000km,
- National Corridors Efficiency Program of about 5,000 km roads
- Border and international connectivity roads of around 2,000 km,
- Coastal and port connectivity roads of around 2,000 km,
- Expressways of around 800 km
- NHDP roads of 10,000km

In pursuance of the above program, NHAI appointed M/s Louis Berger Consulting Private Limited, New Delhi as Consultants to carry out the Consultancy Services for preparation of DPR for development of Economic Corridors, Inner corridors, feeder Routes and Costal Roads to improve the efficiency of fright movement in India - Lot 3/Andhra Pradesh, Karnataka, Goa & Kerala, / Package 1. The project consists the following stretches of roads finalized as per final Inception Report.

1. Aurad – Bidar section - KA SH 15
2. Mydukur – Badvel section – NH 67
3. Puttur - Janappanchatram section - AP SH 4421 & TN SH 51
4. Belagavi (Belgaum) – Sanquelim with a proper Connectivity to NH4A and NH 17 through existing SH – KA SH 54, KA SH 31, GA SH 4
5. Balance Portion of Satellite Ring Road of Bangalore (West Side) including connection to Hosur town & Feasibility for widening the existing SH between Anekal to Sarjapur for Passenger traffic bound to Attibele/ Sarjapur to ensure ring road connectivity for Bangalore.

The Letter of Acceptance was communicated vide NHAI letter NHAI/Planning/ EC/2016/DPR/Lot 3/ Ap. Knt. Goa &KL/Package 1/98598 dated 21/04/2017. The contract agreement signed on 11/5/2017 vide letter NHAI/planning/EC/2016/DPR/Lot 3/AP, Karnataka, Goa &KL, / Package 1/99575 dated 11/05/2017 with immediate commencement date.

The draft alignment report submitted vie dated 10/11/2017. Based on joint site visit and further discussions held with RO/NHAI/Bangalore and PD/Bangalore some modifications made. The alignment declared NH 948A.

3.2 ORIGINAL STRR ALIGNMENT

In order to ensure safe, smooth, efficient, and high-speed transport corridor to Bangalore city, it is impetus that the infrastructure of city and adjoining towns anticipated the development. National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of this traffic are not intend to pass through the Bangalore city. This traffic further aggravate the scenario in the city roads and resulting huge traffic jams.

The Government of Karnataka took steps to improve and augment network within and neighboring area of the city to match with its phase of development. Bangalore Metropolitan Regional Development Authority (BMRDA) had planned the following network of roads consisting the length of 367km to match these requirements.

- Satellite Towns Ring Road (STRR) – 204km
- Individual Town ring Roads (ITRR) – 163km

The total length of STRR (204km) is exclude the stretch passing within the ITRR except for Neelmangala town. The STRR connects the important towns namely Dobbaspet, Doddaballapura, Devanahalli, Sulibele, Hoskote, Sarjapura, Attibele, Anekal, Tattekere, Kanakapura, Ramanagara and Magadi.

BMRDA assigned M/s SECON for the consultancy services to undertake the topographical & Cadastral surveys, finalize the proposed alignment and to prepare the land acquisition report in year 2006. Subsequently, the same agency was engaged to carry out the consultancy for Techno –Economic Feasibility Report in 2007.The notification for land acquisition for STRR & ITRR issued on 12/09/2007 and the project report approved by BMRDA on 10/06/2008. The proposed STRR alignment has declared as State Highway (special) -2 as per the provisions of Karnataka Highways Act 1964 and the SE, PWD, Bangalore circle nominated as 'The Highway Authority'. Land acquisition processes initiated vide notification NO4017-07-08 dated 19/10/2007.

The original corridor proposed with 90m right-of-way consists of divided 4lanes carriageways with depressed median of 20.50m, with service roads (7m) on both sides. Provision of high-speed rail corridor of 15m on one side throughout also made. In addition to this utility corridor of 5m and bus lay-bye of 4m also considered on both sides. The corridor of 90m also frozen by the state government. Ring roads was also proposed to be developed individually for 8 major towns namely Anekal, Kanakapura, Ramanagara, Magadi, Neelmangala, Doddaballapura, Devanahalli & Hoskote to act as bypass for these towns. However, the project shelved due to paucity of funds with the State government.

The original alignment as think of by Karnataka State government and obtained from M/s SECON through NHAI enclosed in **Figure 3.1**.

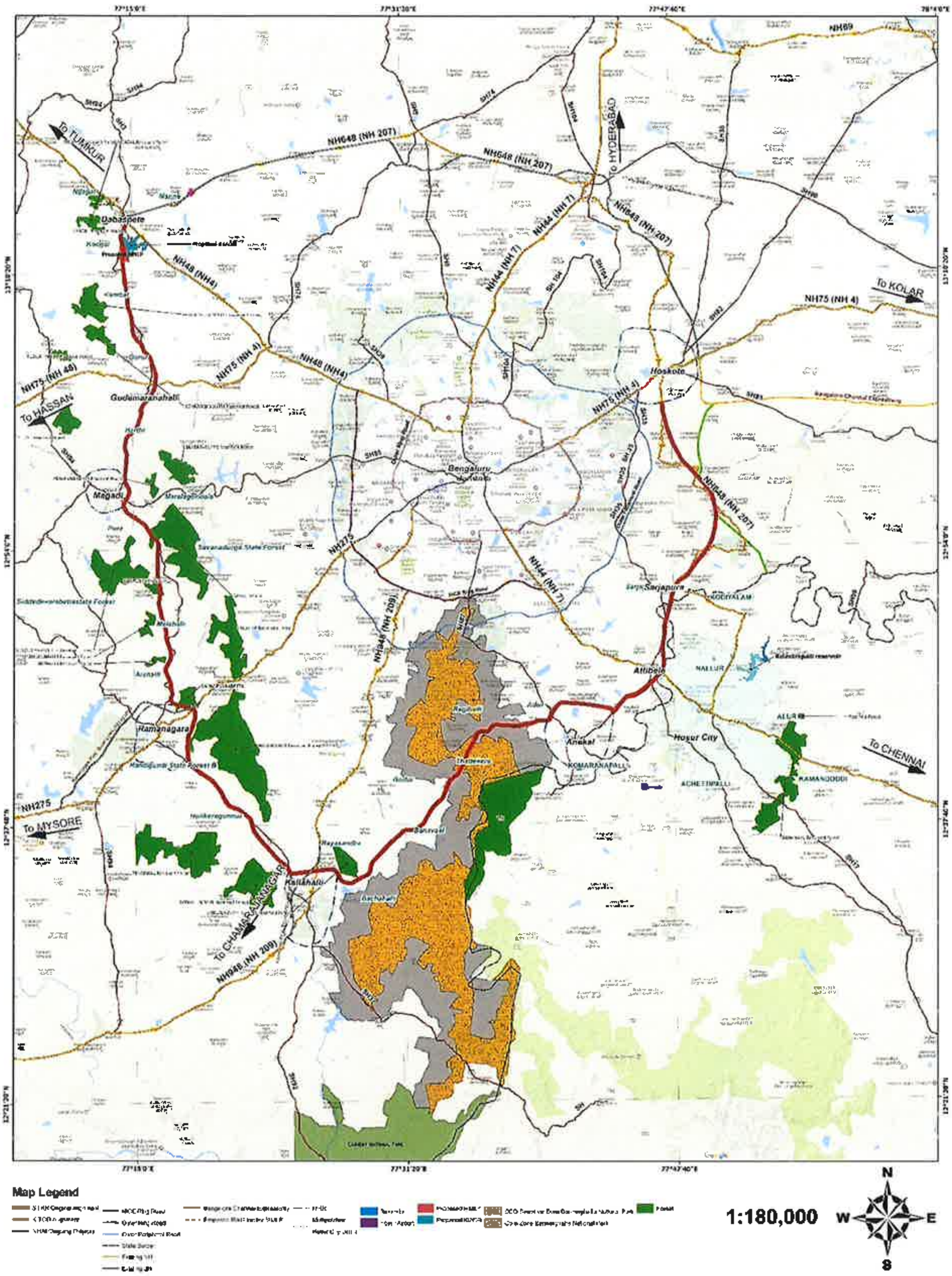


Figure 3.1: Original STRR Alignment as think of by Karnataka State Government

However, the earlier proposed alignment by the Karnataka state government passes through some of built up stretches, tanks including religious structures, burial grounds etc. Also during the course of time, some new activities also come up. Therefore, it was indispensable to further study the alignment and update, considering the current scenario along the original proposed alignment. Accordingly, modifications are propose to ensure minimal social Impact and to serve the alignment to wider spectrum of inhabitants in that region. The details given below.

3.2.1 *Modifications proposed*

1. The original alignment passes through the Dobbaspet town connecting NH 4 on Bangalore side. This extended further on Doddaballapura side towards NH 207 to ensure avoidance of Dobbaspet town local traffic.
2. The original alignment (in the cross point of Hassan road) passes through thickly built up area in Gudermaranahalli from km 14.000 to km 22.000 This stretch consists of residential, school and religious structures.
3. The earlier alignment passes through thickly built up area from km 22.000 to km 25.600 in Harthi/Renganahalli.
4. The original alignment passes through Savanadurga Forest area from km 34.700 to km 41.700. This forest also has wildlife.
5. The original alignment pass through Siddadevarabetta Forest area from km 43.000 to km 46.700
6. The original alignment passes through Ramadevarabetta forest area from km 57.700 to km 58.300 near NH 275 crossing in Ramanagara.

3.2.2 *Value addition proposed*

Further the alignment made value additions by connecting some cross roads and considering the current and future proposals in that location as per below details.

1. The starting point of the STRR extended to connect NH 207 (near km 131.200) with a bypass provision in Dobbaspet town on Pune side to ensure uninterrupted traffic flow, contrary to the earlier proposed location pass through the mid of built up area in Dobbaspet. It is relevant to mention that the through traffic contribute from Pune direction, on NH 4 is significant.
2. There is Multi Model Logistic Park (MMLP) and proposed KIADB coming up near Dobbaspet on SH 3 spread at about 250acres of land. The Feasibility study also done for the proposed MMLP project. Therefore, connection to this park is eminent and provision made accordingly to these logistic park & KIADB with proposed STRR.
3. NHAI is currently developing bypasses to Kankapura and Ramanagara towns under different programs to ease traffic congestion on NH 209 and NH 275 respectively. Thus, in order to ensure seamless traffic flow through these proposed bypasses, it is necessary to integrate with proposed STRR at these locations.
4. Hosur is an automobile industry town located near about 7km away from Karnataka state border. This city generates huge amount of through traffic and currently experiencing massive traffic congestion. It observed that the proposed STRR would further deteriorate the Hosur traffic. Therefore, consideration of STRR taking along this town necessitated.

The modification proposed to original alignment of Karnataka state portion tabulated as below.

Table 3.1: Modified proposed Original alignment of Karnataka

S. No	STRR Original alignment (km) as received			Modified STRR Alignment (km)			Re-Alignment Side w.r.t Original STRR Alignment	Reason for change
	From	To	Length (km)	From	To	Length (km)		
1	0.00	6.50	6.50	0.00	17.50	17.50	Right	To provide Bypass to Dobbasapete town and to connect NH 207 and Proposed MMLP in Dobbasapete
2	6.50	14.00	7.50	17.50	25.00	7.50		No change in original alignment
3	14.00	22.00	8.00	25.00	33.40	8.40	Left	To avoid Temple and Pond
4	22.00	25.60	3.60	33.40	37.00	3.60	Left	To avoid Built-up area
5	25.60	34.70	9.10	37.00	46.00	9.00		No change in original alignment
6	34.70	41.70	7.00	46.00	52.70	6.70	Right	To avoid Savanadurga forest.
7	41.70	43.00	1.30	52.70	54.00	1.30		No change in original alignment
8	43.00	46.70	3.70	54.00	58.00	4.00	Left	To avoid Siddadevarabetta Reserve Forest.
9	46.70	51.00	4.30	58.00	62.20	4.20		No change in original alignment
10	51.00	68.00	17.00	62.20	80.80	18.60	Left	To avoid Siddadevarabetta Vulture Sanctuary (Ramanagara)
11	68.00	74.00	6.00	80.80	86.75	5.95		No change in original alignment
12	74.00	99.00	25.00	86.75	106.00	19.25	Left	To avoid Reserve forest and Hill cutting (Kanakapura)
13	99.00	115.00	16.00	106.00	121.85	15.85		No change in original alignment
14	115.00	End	-	121.85	179.63	57.78		Due to inclusion of Ring Road of Hosur town, Automobile Hub of Tamil Nadu and Connecting with proposed KITCO alignment

3.3 CONNECTION TO HOSUR CITY

It was also envisage connecting the Hosur city with the proposed STRR alignment as per the meeting held with CGM/NHAI in Bangalore during the Inception study. The city is located in the proximity of only 7km from Karnataka state border. The Industrial town of Hosur is also an automobile hub of Tamil Nadu. Thus, this proposal will enable to disburse the traffic toward further south in a methodical manner. It also further enables a connectivity for Hosur to the proposed Bangalore - Chennai Expressway.

The proposed alignment also discussed with District Commissioner, Krishnagiri and with various stakeholders, district level officers, and NHAI. Four options proposed and all options discussed with its merits and demerits. The details given in **Figure 3.2.**

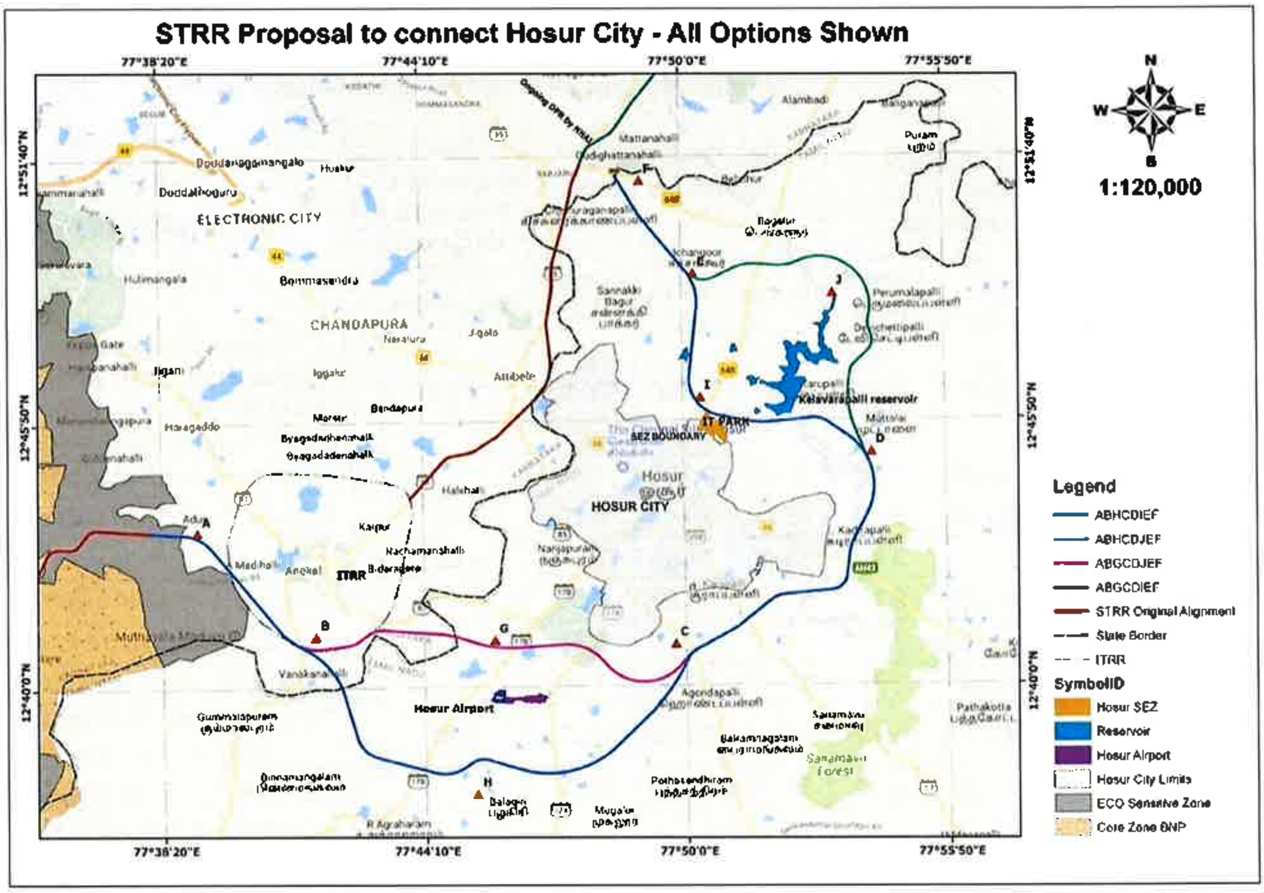


Figure 3.2: STRR proposal connect Hosur city with four options

The comparative statements of all options of proposed Hosur bypass alignment are as below

Table 3.2: Comparative Statement of Proposed Alignment

No	Description	Option - 1 (ABHCDIEF)	Option - 2 (ABGCDIEF)	Option - 3 (ABHCDJEF)	Option - 4 (ABGCDJEF)
1	Starting	139.000	139.000	139.000	139.000
2	Ending	190.000	190.000	190.000	190.000
3	Route Alignment side	After Hosur airport & away from Kelavarapalli reservoir area	Before Hosur airport & away from Kelavarapalli reservoir area	After Hosur airport & Close to Kelavarapalli reservoir area	Before Hosur airport & Close to Kelavarapalli reservoir area
4	Length of Bypass (km)	60	59	63	59
5	Length of existing alignment/ bypassed (km)	nil	nil	nil	nil
6	Built-up stretch (km)	nil	nil	nil	nil
7	Terrain	Plain	Plain	Plain	Plain
8	Speed	100 km/h	100 km/h	100 km/h	100 km/h
9	Geometries	Geometry is good, supports 100 km/h speed. Good	Geometry is good, supports 100 km/h speed. Good sight	Geometry is good, supports 100 km/h	Geometry is good, supports 100 km/h speed.

No	Description	Option - 1 (ABHCDIEF)	Option - 2 (ABGCDIEF)	Option - 3 (ABHCDJEF)	Option - 4 (ABGCDJEF)
		sight distance with curves widely spaced.	distance with curves widely spaced.	speed. Good sight distance with curves widely spaced.	Good sight distance with curves widely spaced.
10	Intersection developments	7	7	7	7
11	Existing Land use pattern through proposed alignment	Agricultural Land and barren land	Agricultural Land and barren land	Agricultural Land and barren land	Agricultural Land and barren land
12	Major Bridge	2	2	2	2
13	Minor Bridge	3	3	2	2
14	Approximate Culverts (no)	120	120	130	120
15	ROB	1	1	1	1
16	Interchange	7	7	7	7
17	VUP	nil	nil	nil	nil
18	PUP	nil	nil	nil	nil
19	Proposed ROW	90	90	90	90
20	Existing ROW	0	0	0	0
21	No of affected Settlements	nil	nil	nil	nil
22	Alignment passes through villages	Agasa Timanahalli, Patnagere Gollahalli, Muttur, Mattakur, Agraharam, Achettipalli, Kothur, Peranadapalli, Attur, Pathamuthalli, Avalapalli, Eluvapalli, Nallur, Chikhanathpuram, Kothapalli, Sarjapur	Agasa Timanahalli, Singasandra, KomaranapalliPoonahalli, Achettipalli, Kothur, Peranadapalli, Attur, Pathamuthalli, Avalapalli, Eluvapalli, Nallur, Chikhanathpuram, Kothapalli, Sarjapur	Agasa Timanahalli, Patnagere Gollahalli, Muttur, Mattakur, Agraharam, Achettipalli, Kothur, Peranadapalli, Nandi maglam, Baglur, Kaganur Sarjapur.	Agasa Timanahalli, Singasandra, Komaranapalli, Poonahalli, Achettipalli, Kothur, Peranadapalli, Nandimaglam, Baglur, Kaganur Sarjapur.
23	Social Impact	Not significant	Not significant	Not significant	Not significant
24	Environmental Impact	Not significant	Not significant	Not significant	Not significant

The merits and demerits for the Hosur alignment inclusion in STRR are as follow.

Merits

- Enabling new spatial distribution of business/ housing in Hosur city
- Improved road geometry will ensure enhanced traffic safety and reduction in road accident rate.
- Major cross roads intersections will provisioned with free flow interchanges and will catalyzed development of Industrial sited located near to this places
- Will remove through truck traffic from city's main artery
- More local traffic may get encouraged to use a route previously avoided due to heavy truck traffic
- Proactive planning by local authorities will further catalyze industrial development
- Will benefits the town in revenues, real estate, and job opportunities

Demerit

- The overall alignment length will increase and result higher land acquisition and construction costs.

Based on facts presented, the district administration recommended and approved Option 4 (ABGCDJEF) for consideration.

3.4 SUBMISSION & APPROVALS FROM GOVERNMENT OF KARNATAKA & TAMIL NADU

Karnataka

The original alignment validated with current developments in that region and the updated alignment discussed with NHAI. Accordingly, this updated STRR alignment submitted to NHAI vide our reference 4800182-GGN-OC-019 dated 05/10/2017 for Concurrences from Government of Karnataka. NHAI submitted to Government of Karnataka to seek consent to the modifications proposed in STRR vide letter NHAI/12012/Lot 3/Package 1/I/2017/PIU-BNG (EXP)/530 dated 09/10/2017.

The government of Karnataka vide its letter PWD/518/CNH2017 dated 27/10/2017 conveyed the concurrences. NHAI vide letter NHAI/Planning/EC/2016/DPR/Lot 3/AP-KT-Goa & Kerala/Pkg 1/1087-28 dated 17/11/2017 agreed to the further modification proposed.

The approval letters obtained from the government of Karnataka and the approved alignment given in **Figure 3.3 & Figure 3.4.**

Tamil Nadu

The concurrences for Hosur portion of Tamil Nadu obtained vide letter 14787/HV1/2017-2 dated 24/01/2018. The approval letters obtained from government of Tamil Nadu with approved alignments given in **Figure 3.5 & Figure 3.6.**

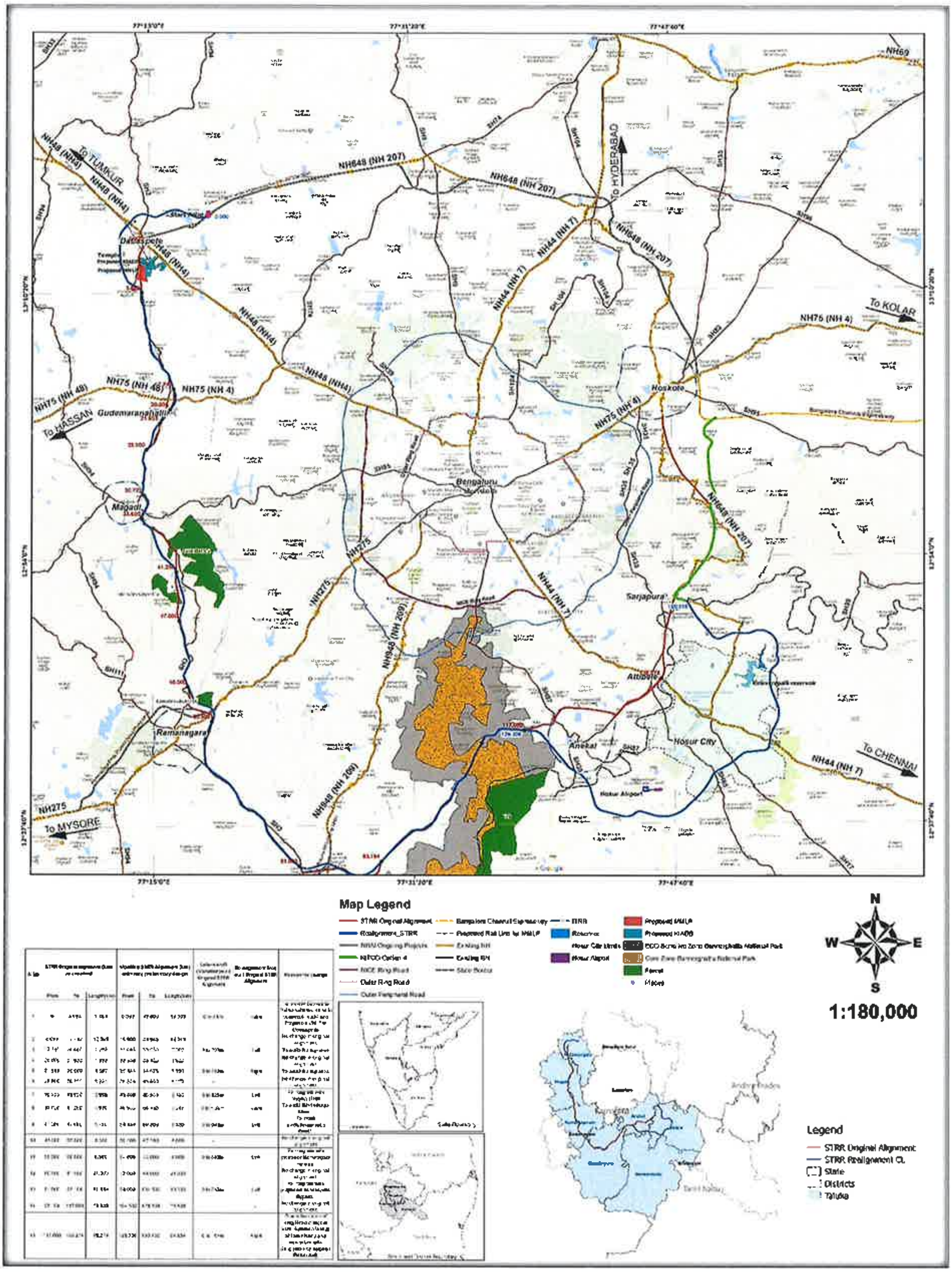


Figure 3.3: Concurrence obtained for alignment from Karnataka state

GOVERNMENT OF KARNATAKA

No. PWD 518 CNH 2017.

Karnataka Government Secretariat
Vikasa Soudha,
Bengaluru, dated 27.10.2017.

From:

The Additional Chief Secretary to Government,
Public Works, Ports & Inland Water
Transport Department, Bangalore.

To:

The Deputy General Manager(Tech),
& Project Director,
PIU-Bangalore (Expressway)
National Highways Authority of India,
(Ministry of Road Transport & Highways)
Nagasandra, Near Deepak Bus Stand,
Bangalore-Tumkur Road, NH-4,
M.S.Ramaiah Enclave,
Bangalore-560 073.

Sir,

Sub: NHAI, PIU-Bangalore (Expressway)-Preparation of DPR for Development of Economic Corridors, Inner Corridors, Feeder Routes and Coastal roads to improve the Efficiency of Fright Movement in India -Lot 3/Andhra Pradesh, Karnataka, Goa & Kerala/Package -I Consent of Government of Karnataka for taking up STRR (west side) along with the concurrence for the modifications-requested- reg.

Ref: Your letter No.NHAI/12012/Lot3/Package-1/1/2017/PIU-BNG (EXP)/ 1530 dated 19.10.2017.

*****

With reference to the above subject, the Government of Karnataka examined the above referred your proposal for the modifications to the STRR [west side] alignment and agrees for the same. Further I am directed to convey the concurrence for taking up further studies and for initiation of preconstruction activities such as Land acquisition, MOEF and wildlife clearance etc., for the development of STRR around Bangalore.

Yours faithfully,

(M. LAKSHMINARAYANA)
Additional Chief Secretary to Government,
Public Works, Ports & Inland Water
Transport Department.

Figure 3.4: Concurrence obtained for alignment from Karnataka state

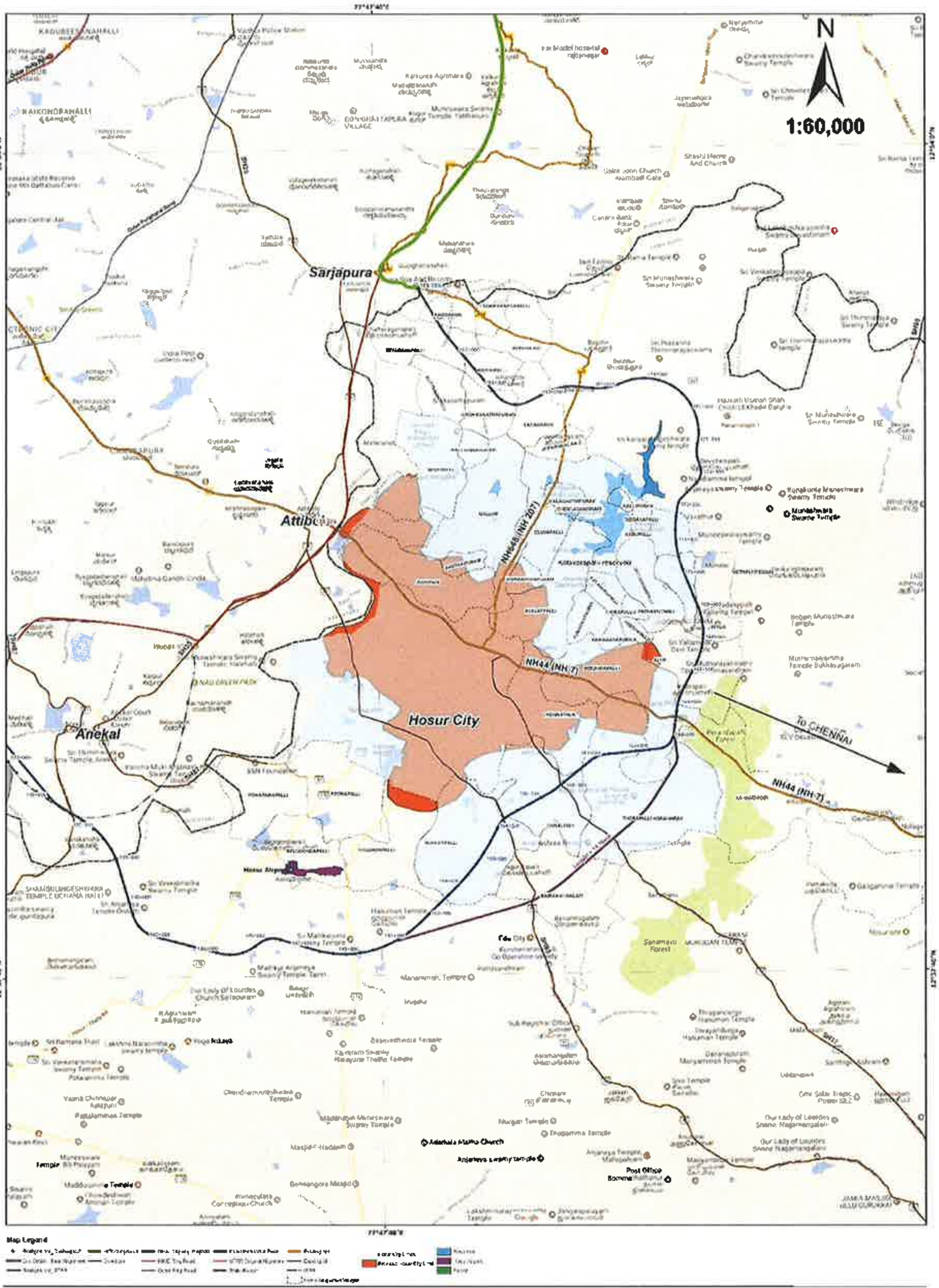


Figure 3.5: Concurrence obtained for alignment of Hosur portion of Tamil Nadu

Highways and Minor Ports (HV1) Department,
Secretariat, Chennai-600 009.

Letter No. 14787/HV1/2017-2, dated 24.01.2018

From
Dr. Rajeev Ranjan, I.A.S.,
Additional Chief Secretary to Government.

To
The Secretary to Government of India,
Ministry of Road Transport and Highways,
No.1, Parliament Street, Transport Bhawan,
New Delhi-110001.

The Chairman,
National Highways Authority of India,
New Delhi.

Sir,

Sub National Highways Authority of India -Bangalore- Preparation of Detailed Project Report for development of Economic Corridors, Inner Corridors, Feeder Routes and Coastal Roads to improve the Efficiency of Freight Movement in India- Concurrence for the alignment – Satellite Town Ring Road (west side)Concurrence for the alignment of Hosur Ring Road as a part of STRR, Bangalore – Regarding.

Ref From the Deputy General Manager (T) & Project Director, Bangalore letter No. NHAI/12012/Lot3/package-1/2017/PIU-BNG (EXP) 653, dated 29.11.2017 addressed to the District Collector, Krishnagiri.

****

I am directed to invite your attention to the reference cited wherein it was informed that National Highways Authority of India has awarded Consultancy Services for Preparation of Detailed Project Report for Development of Economic Corridors, Feeder Routes and Coastal roads to improve the Efficiency of Freight Movement in India-Lot 3 / Andhra Pradesh, Karnataka, Goa and Kerala / Package 1 to M/s Louis Berger Consultants, Gurgaon. The package includes Satellite Ring Road of Bangalore (STRR) (west side) joining NH-4 to NH-7 and it is proposed to extend STRR connecting

Hosur with Sarjapur (TN/KNT border). As suggested during the Stake holders meeting held under the Chairmanship of the District Collector of Krishnagiri, the Consultant has submitted a tentative alignment with modifications. The new alignment proposes to include Hosur Ring Road as part of Satellite Town Ring Road (STRR), Bangalore.

2. In this regard, it is stated that the Hosur Outer Ring Road proposed by State Highways Department from Perandapalli to Attebele is formed from km 33/6 to 48/6 of NH-7. The proposed alignment for Satellite Town Ring Road (STRR) approximately crosses at km 51/4 of NH-7 and will not affect the purpose of the formation of Hosur Outer Ring Road Further District Collector, Krishnagiri has also stated that there is no cost implication to the Government of Tamil Nadu for the formation of Hosur Outer peripheral road as it becomes a part of STRR and also stated that the National Highways Authority of India has also consented to bear the cost of land acquisition for this proposed extension of road to the extent of 300 hectares. The new alignment of Satellite Town Ring Road (STRR) around Hosur town in Krishnagiri District would lead to fast development of Hosur town and adjacent villages.

3. In the above perspective, I am to convey concurrence to include the Hosur Ring Road as part of Satellite Town Ring Road (STRR), Bangalore and also to request you to provide interchanges / flyover at the intersection point without affecting the traffic in State Highways.

Yours faithfully,

H. Saraswathy
24.1.18

for Additional Chief Secretary to Government.

Copy to,
The District Collector,
Krishnagiri.

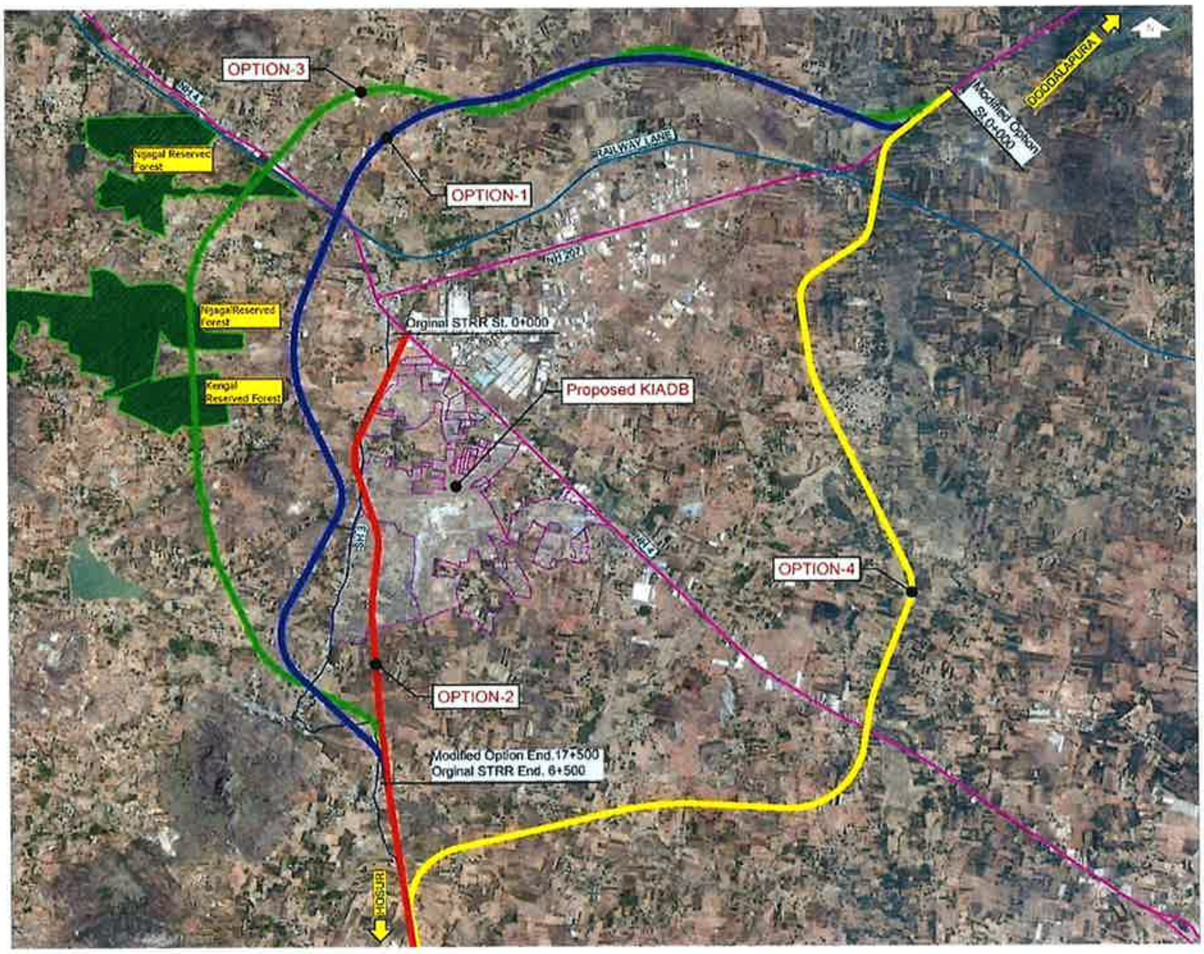
The Chief Engineer (Construction and Maintenance),
Highways Department, Chennai-25.

Figure 3.6: Concurrence obtained for alignment of Hosur portion of Tamil Nadu

3.5 MODIFICATIONS IN ORIGINAL STRR

1. **Inclusion of Multi Model Logistic Park (MMLP) & proposed KIADB in Dobbaspet:** change km 0.000 to km 17.500 (original km 0.000 to km 6.500)

Alignment options



Comparative statement

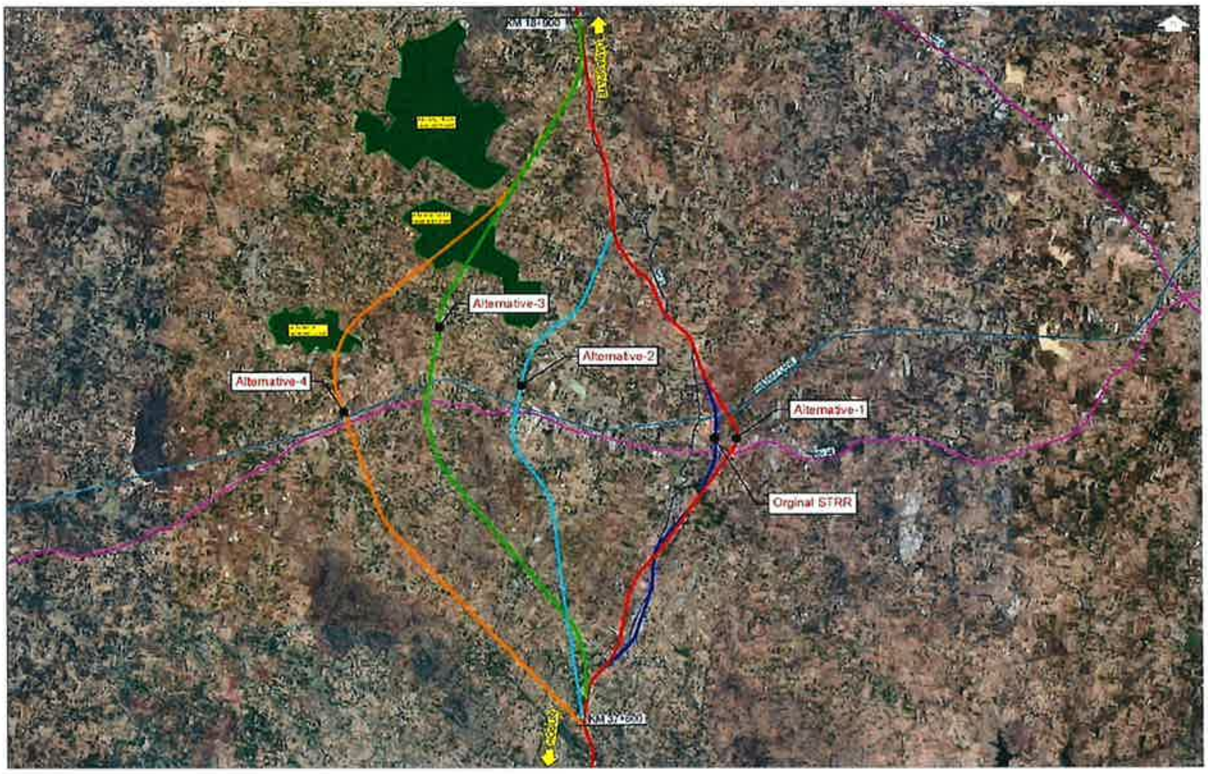
The comparative statements of all four options of proposed modifications in Dobbaspet given below.

S. No.	Description	Option-1	Option 2 (Original STRR)	Option-3	Option-4
1	Length of Alignment (km)	17.5	6.5	19.6	17.54
2	Built-up stretch	Nil	Nil	Nil	Nil
3	Terrain	Plain	Plain	Plain	Plain
4	Speed	100 kmph	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.

S. No.	Description	Option-1	Option 2 (Original STRR)	Option-3	Option-4
6	Existing Land use pattern through proposed alignment	Agricultural Land/Barren Land	Industrial Land / Agricultural Land	Agricultural Land / Forest Land	Agricultural Land / Residential
7	Proposed ROW (m)	75	75	75	75
8	Total Additional land required in hec.	131.25	48.75	147	131.55
9	No of affected Structures (tentative)	0	20	5	20
10	ROB	1	0	1	1
11	Bridge	0	0	0	0
12	Interchange	1	0	0	0
13	Environmental Impact	No significant environmental impact is envisaged	No significant environmental impact is envisaged	The proposed alignment will passes through Nijagal and Kengal Reserve Forest	No significant environmental impact is envisaged
15	Tentative cost (INR in crores)	941.05	320.89	994.576	1029.5624
16	Merits	1. No structure/establishment is affected 2. Connectivity given to proposed MMLP in Dobbasapete 3. Comparatively shorter alignment		Better road geometry could be achieved	
17	Demerits		1. Alignment passes through built-up location at Dobbasapete 2. Passes through the proposed MMLP Industrial location in Dobbasapete 3.Not connecting Dobbasapete as a whole	1. Larger alignment length 2. Passes through Forestland & thus forest clearance need to be obtain before implementation of project 3. Passes through the aggregate quarry area 4. Passes through abutting CISF land	1.Poor alignment Geometry 2.Passing through Built-up stretch 3.Land cost will be more as the alignment passing through built-up region
18	Recommendation	Recommended	Not Recommended	Not Recommended	Not Recommended

2. Design chainage km 25.000 to km 33.400 (Original km 14.000 to km 22.000)

Alignment options



Comparative statement

The comparative statements of all four options of proposed modifications in Dobbaspet given below

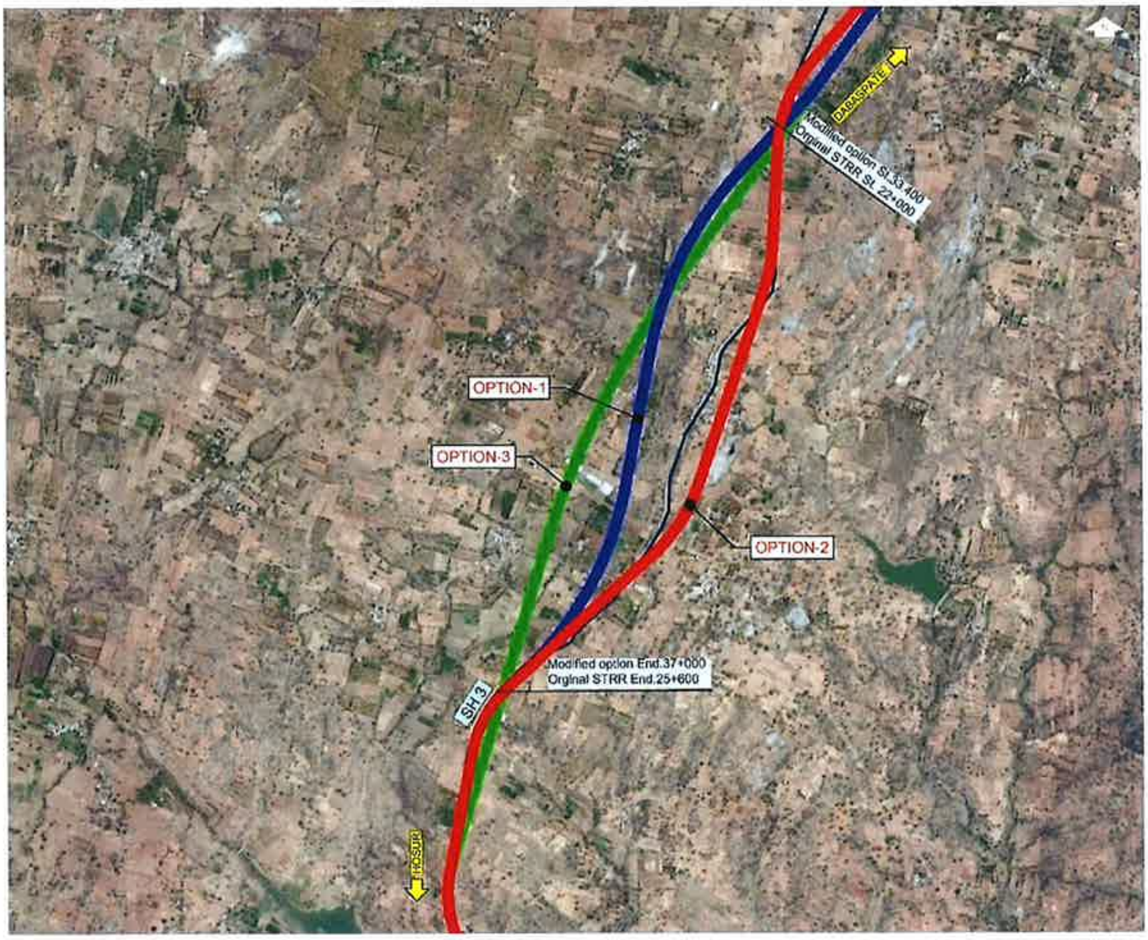
S. No.	Description	Original STRR	Alt 1	Alt 2	Alt 3	Alt 4
1	Length of Alignment (km)	26	27.2	26.1	27.2	29.3
2	Built-up stretch	Nil	Nil	Nil	Nil	Nil
3	Terrain	Plain/rolling	Plain/rolling	Plain/rolling	Plain/rolling	Plain/rolling
4	Speed	100 kmph	100 kmph	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced. Ground profile is undulating of about 50 to90 resulting huge cut and fill	Ground profile is undulating of about 50 to90 resulting huge cut and fill quantities. Horizontal Geometry is good, supports 100 kmph speed.
6	Existing Land use pattern through	Mostly Agricultural Land	Mostly Agricultural Land	Barren/Agricult ural Land	Barren/Agricult ural Land	Barren/Agricult ural Land

S. No.	Description	Original STRR	Alt 1	Alt 2	Alt 3	Alt 4
	proposed alignment					
7	Proposed ROW (m)	75	75	75	75	75
8	Total Additional land required in Hectare	195	204	195.75	204	219.75
9	No of affected Structures (tentative)	50	20	20	5	5
10	ROB	1	1	1	1	1
11	Major Bridge	0	0	0	0	0
12	Interchange	1	1	1	1	1
13	Environmental Impact	Pass through mid of pond	No significant environmental impact is envisaged	No significant environmental impact is envisaged	No significant environmental impact is envisaged	No significant environmental impact is envisaged
15	Tentative civil cost (INR in crores)	1574.06	1512.432	1510.341	1572.432	1627.333
16	Merits	-	Less construction cost and better alignment geometry	The alignment will be comparatively closer Mangalore side	The alignment will be close to Mangalore side and the VOC in long run will be reduced as most of traffic comes from Mangalore port	The alignment will be close to Mangalore side and the VOC in long run will be reduced as most of traffic comes from Mangalore port
17	Demerits	Passes through large number of structures including religious structure, resulting higher land & social cost Passes through the mid of a pond. Interchange and ROB provisions will be close to 1000m and so combined provision of single structure is required.	About 15 to 20 structure only affected. Interchange and ROB provisions will be separate as the distance is about 1.1km	Passes through close to a community graveyard and provision of interchange will be affect and Passes through big plots comprising soap factory, restaurant etc. structures also the alignment is closed to Milk plant, electrical substation, railway station and major water body. Interchange and ROB provisions will be close (250m) and so combined	Interchange and ROB provisions will be close (300m) and so combined provision of single structure is required. Higher construction cost	Interchange and ROB provisions will be close (100m) and so combined provision of single structure is required. Higher construction cost

S. No.	Description	Original STRR	Alt 1	Alt 2	Alt 3	Alt 4
		Higher construction cost		provision of single structure is required. Height of ROB will be in second level due to existing ROB approach. Higher construction cost		
18	Recommendation	Not Recommended	Recommended	Not Recommended	Not Recommended	Not Recommended

3 Avoiding thick built up area in Rangenahalli
Chainage km 33.400 to km 37.000 (original km 22.000 to km 25.600)

Alignment options



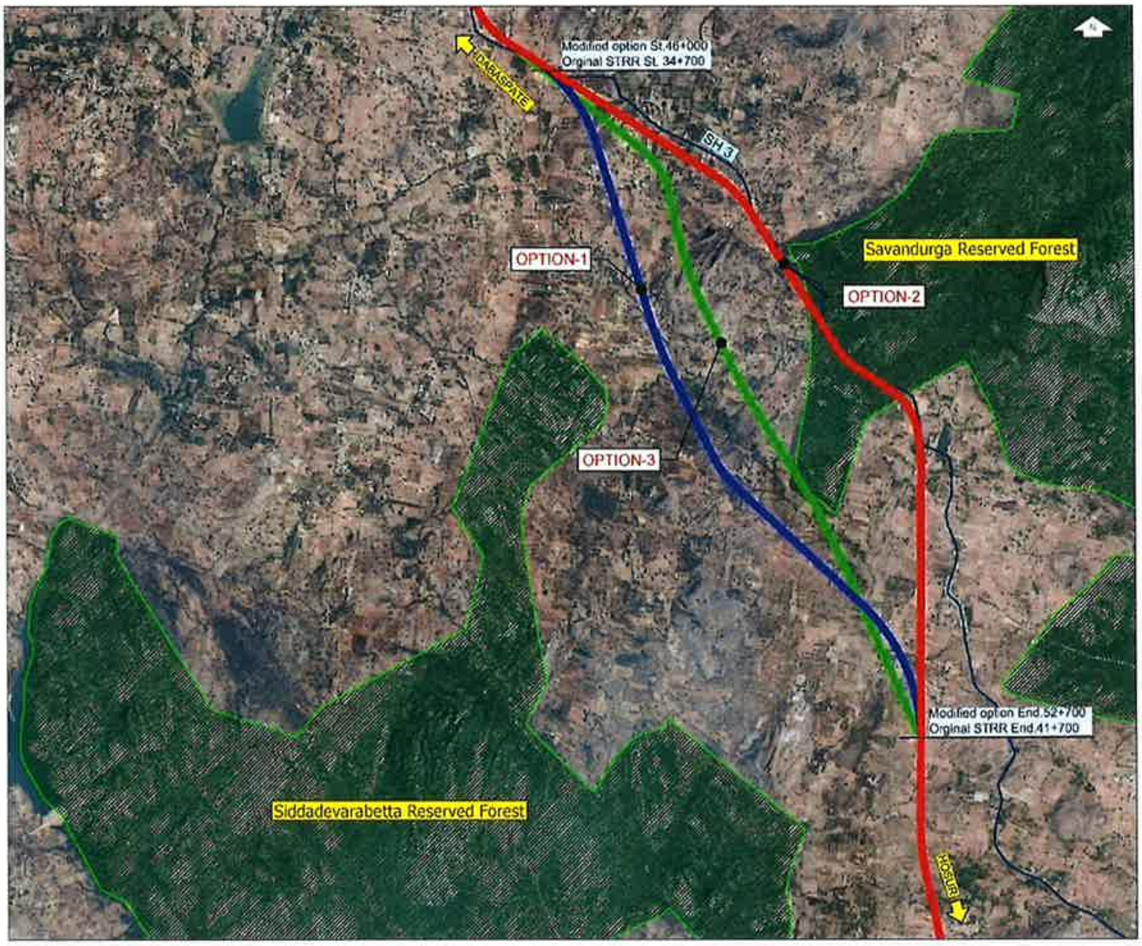
Comparative statement

The comparative statements of all four options of proposed modifications given below:

S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
1	Length of Alignment (km)	3.6	3.6	5.7
2	Built-up stretch	Nil	Nil	Nil
3	Terrain	Plain	Plain	Plain
4	Speed	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.
6	Existing Land use pattern through proposed alignment	Agricultural Land	Agricultural Land	Agricultural Land / Forest Land
7	Proposed ROW (m)	75	75	75
8	Total Additional land required in Hec.	27	27	42.75
9	No of affected Structures (tentative)	0	30	5
10	ROB	0	0	0
11	Bridge	0	0	0
12	Interchange	0	0	0
13	Environmental Impact	No significant environmental impact is envisaged	No significant environmental impact is envisaged	No significant environmental impact is envisaged
15	Tentative civil cost (INR in crores)	169.866	172.866	269.4545
16	Merits	1. Shorter alignment length 2. No built-up land is involved		
17	Demerits		1. More than 30 establishments would get affected 2.Comparatively poor alignment geometry	1. Passes through pond 2.Higher construction cost
18	Recommendation	Recommended	Not Recommended	Not Recommended

4 Avoiding Savanadurga forest Area
Chainage km 46.000 to km 52.700 (Original km 34.700 to km 41.700)

Alignment options



Comparative statement

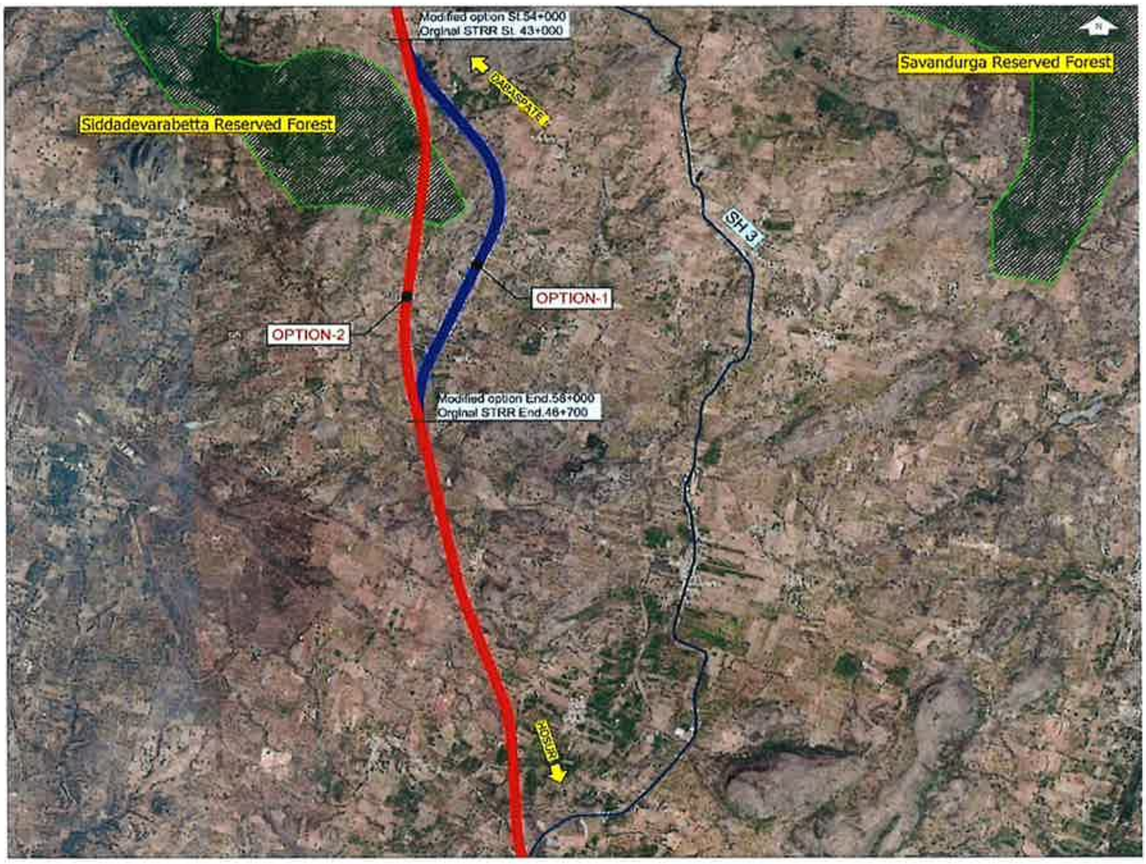
The comparative statements of all four options of proposed modifications given below

S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
1	Length of Alignment (km)	6.7	7	8.8
2	Built-up stretch	Nil	Nil	Nil
3	Terrain	Plain	Plain	Plain
4	Speed	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.

S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
6	Existing Land use pattern through proposed alignment	Mostly Barren Land	Barren Land / Forest Land	Barren Land / Forest Land
7	Proposed ROW (m)	75	75	75
8	Total Additional land required in Hec.	50.25	52.5	66
9	No of affected Structures (tentative)	0	0	0
10	ROB	0	0	0
11	Bridge	0	0	0
12	Interchange	0	0	0
13	Environmental Impact	No significant environmental impact is envisaged	The proposed alignment passes through Savanadurga Reserve Forest. Thus, Reserve forest clearances required.	The proposed alignment passes through Savanadurga Reserve Forest. Thus, Reserve forest clearances required.
15	Tentative civil cost (INR in crores)	316.1395	330.295	415.228
16	Merits	1. Away from forest land, resulting ease in construction 2.Better alignment geometry		
17	Demerits		The proposed alignment passes through Savanadurga Reserve Forest. Thus, Reserve forest clearances required. This will delay the project implementation	The proposed alignment passes through Savanadurga Reserve Forest. Thus, Reserve forest clearances required. This will delay the project implementation
18	Recommendation	Recommended	Not Recommended	Not Recommended

5. Siddadevarabetta Forest Area
Chainage km 54.000 to km 58.000 (Original km 43.000 to km 46.700)

Alignment options



Comparative statement

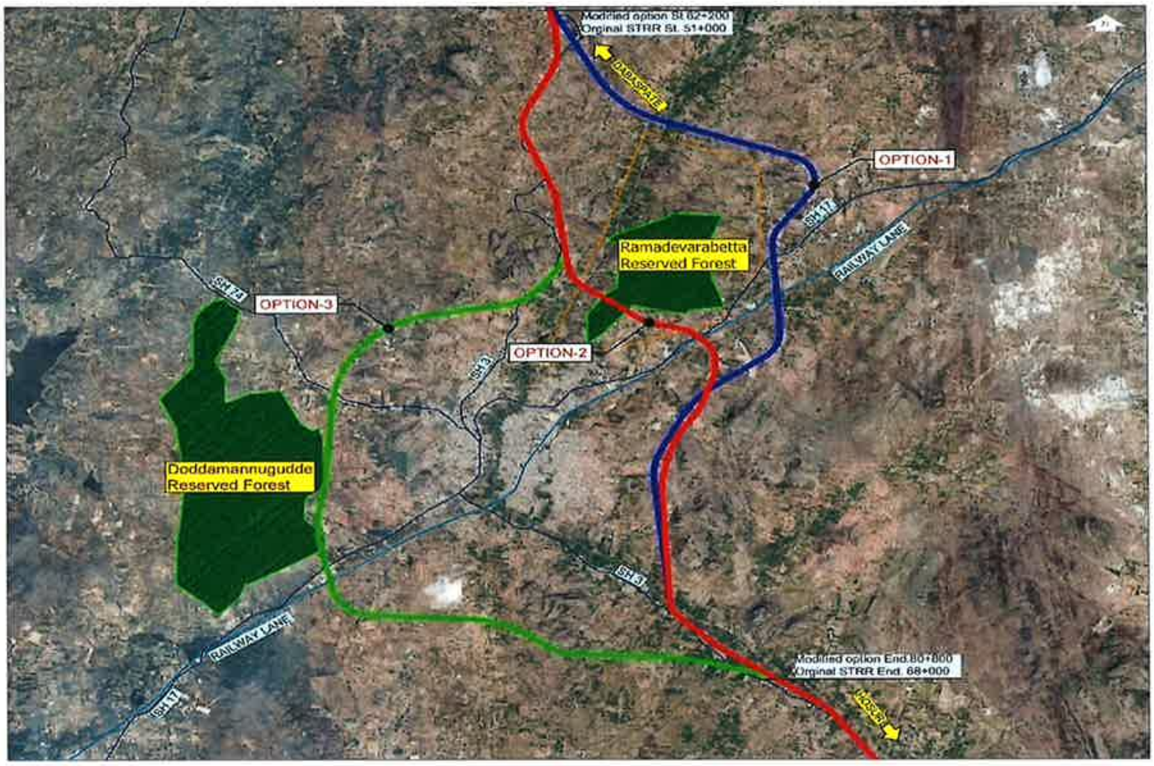
The comparative statements of all four options of proposed modifications given below

S. No.	Description	Option-1	Option-2 (original STRR)
1	Length of Alignment (km)	4	3.7
2	Built-up stretch	Nil	Nil
3	Terrain	Plain	Plain
4	Speed	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.
6	Existing Land use pattern through proposed alignment	Mostly Barren Land	Barren Land / Forest Land
7	Proposed ROW (m)	75	75
8	Total Additional land required in Hec.	30	27.75

S. No.	Description	Option-1	Option-2 (original STRR)
9	No of affected Structures (tentative)	0	0
10	ROB	0	0
11	Bridge	0	0
12	Interchange	0	0
13	Environmental Impact	No significant environmental impact is envisaged	The proposed alignment passes through Siddadevarabetta Reserve Forest. Thus, Reserve forest clearances required.
15	Tentative civil cost (INR in crores)	188.74	174.5845
16	Merits	Away from forest land, resulting ease in construction	
17	Demerits		The proposed alignment passes through Siddadevarabetta Reserve Forest. Thus, Reserve forest clearances required.
18	Recommendation	Recommended	Not Recommended

6. Ramanagara vulture Sanctuary area
Chainage km 62.200 to km 80.800 (Original km 51.000 to km 68.000)

Alignment options



Comparative statement

The comparative statements of all four options of proposed modifications given below

S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
1	Length of Alignment (km)	18.6	17	25.05
2	Built-up stretch	Nil	Nil	Nil
3	Terrain	Plain	Plain	Plain
4	Speed	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.
6	Existing Land use pattern through proposed alignment	Agricultural Land/Barren Land	Agricultural Land / Forest Land/Residential	Agricultural Land/Barren Land/Forest Land
7	Proposed ROW (m)	75	75	75
8	Total Additional land required in Hectare.	139.5	127.5	187.875

S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
9	No of affected Structures (tentative)	0	0	10
10	ROB	1	1	1
11	Bridge	1	1	1
12	Interchange	1	1	2
13	Environmental Impact	No significant environmental impact is envisaged	The alignment is passing through the Ramadevarabetta Reserve forest	The proposed alignment pass through close proximity of Doddamannugudde Reserve Forest
15	Tentative civil cost (INR in crores)	992.641	917.145	1347.98425
16	Merits	1.Not demolishing any major structure 2.No forest land is involved, resulting ease of construction		
17	Demerits		The alignment is passing through the mid of Ramadevarabetta Vulture Sanctuary	1. Larger alignment length 2. The proposed alignment pass through close proximity of Doddamannugudde Reserve Forest. 3. the existing railway line and the National highway are in close proximity (250m) therefore vertical geometry not suitable for ROB & interchange provision in NH 275
18	Recommendation	Recommended	Not Recommended	Not Recommended

7. Kanakapura
Chainage km 86.750 to km 106.000 (Original km 74.000 to km 99.000)

Alignment options

The comparative statements of all four options of proposed modifications given below:

S. No.	Description	Original STRR	Alt 1 (Modified)	Alt 2	Alt 3	Alt 4
1	Length of Alignment (km)	25	24.65	21.10	19.61	19.25
2	Built-up stretch	Nil	Nil	Nil	Nil	Nil
3	Terrain	Plain/rolling	Plain/rolling	Plain/rolling	Plain/rolling	Plain/rolling
4	Speed	100 kmph	100 kmph	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed.	Geometry is good, supports 100 kmph speed.
6	Existing Land use pattern through proposed alignment	Barren/Agricultural Land	Barren/Agricultural Land	Barren/Agricultural Land	Barren/Agricultural Land	Barren/Agricultural Land
7	Proposed ROW (m)	75	75	75	75	75
8	Total Additional land	172.5	176.25	148.125	141.75	138.75

S. No.	Description	Original STRR	Alt 1 (Modified)	Alt 2	Alt 3	Alt 4
	required in Hectare.					
9	No of affected Structures (tentative)	75	20	5	5	5
10	ROB	0	0	0	0	0
11	Major Bridge	1	1	1	1	1
12	Interchange	1	1	1	1	1
13	Environmental Impact	Pass through reserve forestland and heavily built up area.	No significant environmental impact is envisaged	No significant environmental impact is envisaged	No significant environmental impact is envisaged	No significant environmental impact is envisaged
15	Tentative civil cost (INR in crores)	1416.13	1390.54	1202.25	1150.86	1074.49
16	Merits	-	Improved geometry as compare to original, Avoid acquisition in built-up and reserve forest area	Length is shorter as compare to proposed & original, Avoid acquisition in built-up and reserve forest area. No significant environmental impact	Length is shorter as compare to proposed, original and Alt-1, Avoid acquisition in built-up and reserve forest area. No significant environmental impact	Good horizontal geometry. The length will be shorter compared to originally proposed alignment. Very fewer structures will be affect. No significant environmental impact
17	Demerits	Passes through large number of structures including religious structure, resulting higher land & social cost. The existing NH and proposed Kankapura bypass are at the distance of about 800m. This envisage a combined structure. Higher	The proposed flyover will be combine for both existing NH 209 and its newly proposed bypass resulting more length.	Comparatively poor horizontal geometry. Large amount of cutting involved. Pass through close to reserve forest area. There is major water pipe (2 no) line run parallel to NH 209. Interchange length will be more as they are at close proximity to road. The interchange proposal may encroach the	Comparatively poor horizontal geometry. Large amount of cutting involved. Pass through close to reserve forest area. There is major water pipe (2 no) line run parallel to NH 209. Interchange length will be more as they are at close proximity to road. The interchange proposal may encroach the	Some amount cutting expected due to rolling terrain.

S. No.	Description	Original STRR	Alt 1 (Modified)	Alt 2	Alt 3	Alt 4
		construction cost.		existing water body	existing water body	
18		Not Recommended	Not Recommended	Not Recommended	Not Recommended	Recommended

End point of Tamil Nadu/Karnataka

The end of STRR will need integration with the alignment under finalization for 4 lanes of Sarjapur, Karnataka/Tamil Nadu border near Bagalur town. In order to provide efficient connectivity it envisaged during the joint site visit with PD/NHAI/Bangalore during 8 to 10 January 2018 that bypass the Bagalur town is also vital. Thus, the alignment extended to cover Bagalur town and joining the alignment in Kalakunde. This section dealt with M/s Kerala Industrial and Technical Consultancy Organization Ltd (KITCO). Accordingly, the proposal modified after discussed with RO/NHAI/Bangalore. The alignment also slightly modified in few locations in Karnataka portion. The Modifications also further discussed with CGM/NHAI on 31/1/2018 and agreed.

Alignment Presentation in RO/NHAI/Bangalore

The updated alignment presented and discussed with RO/NHAI/Bangalore and PD/NHAI on 12/3/2018, 21/3/2018 04/04/2018 & 07/04/2018.

Final updated alignment incorporating all modifications given **Figure 3.7.** The final alignment drawings on google images given in separate volume.

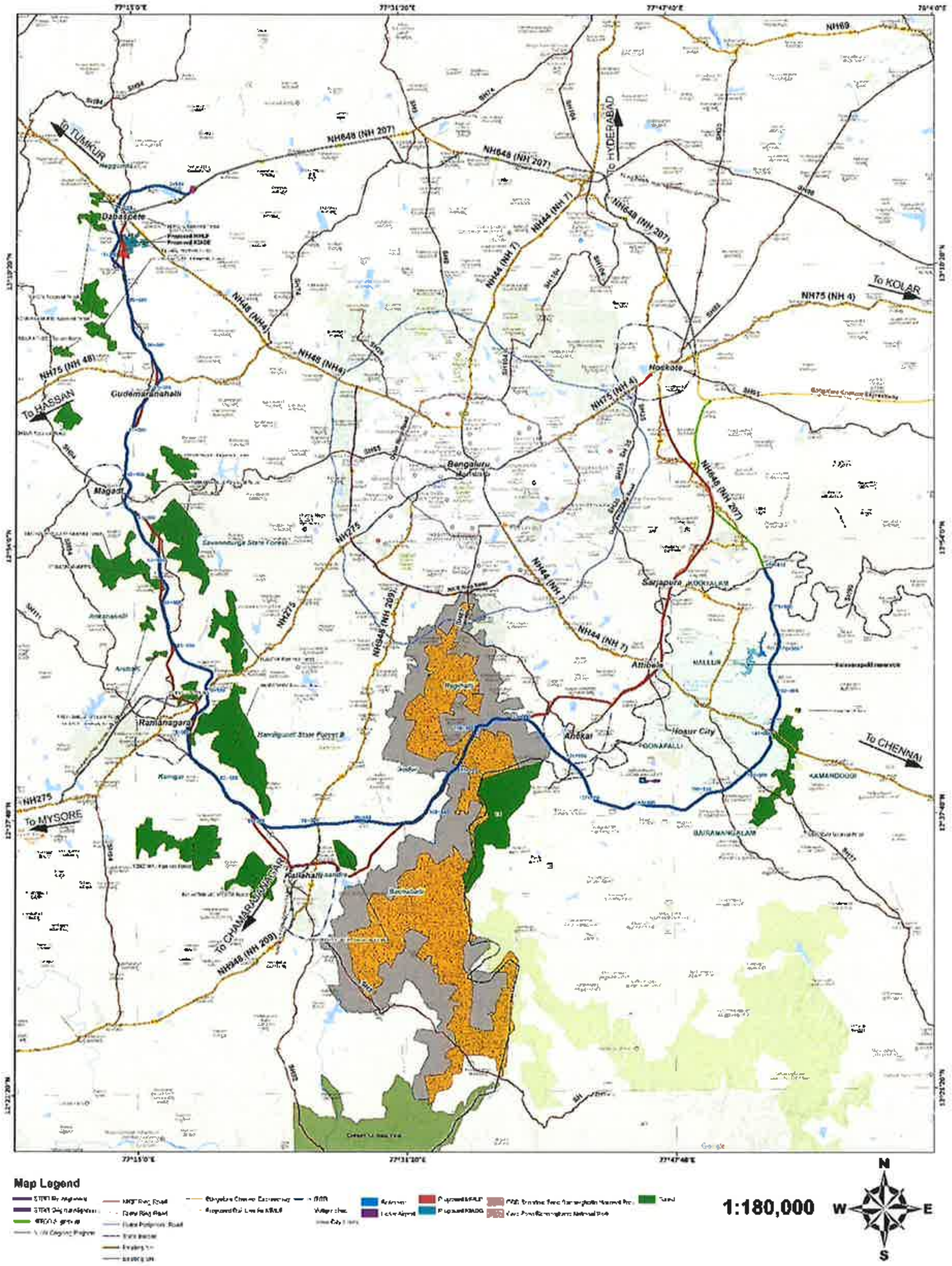


Figure 3.7: Final Alignment

3.6 SATELLITE TOWNS RING ROAD (STRR) BANGALORE WEST SIDE

Bangalore town is thickly populated and In order to ensure safe, smooth, efficient, and high-speed transport corridor to this city, it is impetus that the infrastructure of city and adjoining towns anticipated the development. National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of these traffic pass through the Bangalore city and resulting huge traffic jams. In addition, the NICE ring road currently has only four lanes configuration with very congested traffic level. Further, the toll rates are also exorbitant in comparison to NHAI toll rates due to private operator (about 4 times and without return passage).

The STRR will function as an alternative and there is huge potential for the traffic to get divert the proposed STRR facility. Provision of STTR will ensure high-speed connectivity primarily to Bangalore International airport and to the proposed Bangalore – Chennai Expressway.

Therefore, reviving the STRR project with considering current development in the region including development of STRR west side is absolute necessary on priority basis and it is propose to consider a 6lanes carriageway configuration throughout as minimum requirement.

3.6.1 Road under progress in STRR

Dobbaspet to Hoskote (80.20km)

The stretch of NH 207 from Dobbaspet to Hoskote (length 80.20km) on east side of STRR has taken up for implementation to 4lanes divided carriageway configuration with 45m land width by NHAI. However, the civil work currently held up due to contract complications. NHAI is currently reviving this project with 60m right of way and 6lanes project facilities.

Hoskote to Sarjapur/Bagalur

The portion from Hoskote to Sarjapur/Bagalur (length about 25km) is currently under detailed project report stage by KITCO consultants in NHAI. The alignment is already finalize by NHAI to this portion. This alignment will be integrate with our current study to complete the ring for entire STRR alignment.

Bangalore – Chennai Expressway

The Bangalore - Chennai Expressway is a proposed greenfield expressway between the cities of Bangalore (Karnataka) and Chennai (Tamil Nadu). This project formulated under NHDP Phase IV program and currently consider under Bharatmala Scheme. This high-speed travel corridor will run parallel to existing NH 4 and will be develop with total access control facility. The proposed expressway starts from Hoskote (the junction of NH 4 & NH 207) and ends in Sriperumbudur (just 40km away from Chennai) in Tamil Nadu. The total length of this proposed facility will be 262.3km. The expressway passes through Bangalore Rural & Kolar districts in Karnataka state (about 75.6km), Chittoor district of Andhra Pradesh (88.31km), and Vellore, Kanchipuram, Thiruvallur districts of Tamil Nadu (98.33km). The proposed configuration will be 4lanes carriageway with five major interchanges with fully access control facilities.

3.7 PROPOSED DESIGN FEATURES

3.7.1 Declaration of STRR (West Side) As NH

The proposed STRR declared as National highway with a serial number 462 and new National highway number 948A as per MORTH Gazette notification -6, dated 02/01/2018.

3.7.2 Project Road

The project road currently intends to connect Dobbaspet, Magadi, Ramanagara, Kankapura, Anekal, Hosur & Sarjapur. The proposed road passes through Bangalore Rural, Bangalore Urban, and Ramanagara districts in Karnataka state and Hosur town in Krishnagiri district of Tamil Nadu state. The total length of this alignment will 179.969km. The start point co-ordinate of STRR -750104.8329/1465840.4410 (near Dobbaspet). End coordinates of STRR merging with KITCO alignment at Tamil Nadu/Karnataka Border – 83614.6946/1424665.8098 (near Sampangere).

The section of Phase-2 falls in the State of Karnataka and Tamil Nadu, starts from km 79.000, and terminate in km 144.480.

Section	Geo-Coordinates		Design/ Proposed Chainage (km)		Length (km)
	Start Point	End Point	From	To	
Phase 2	E 750869.262 N 1403462.510	E 801810.826 N 1398631.353	79.000	144.480	65.480

Terrain

The project road stretch is passing through Plain and rolling terrain

Land use

The land use by the side of this road predominantly barren and agriculture

Proposed ROW

A 70m corridor is proposed for the entire Phase of project road except in Bannerghatta National Park. However, at Interchanges, Toll Plaza/Toll Booth, Wayside Amenities locations, where the proposed ROW will be more than 70m as per relevant drawings.

Road Configuration

The proposal envisages six lanes divided carriageway configuration with raised median as per the latest circular issued in Bharatmala program. All provisions of structure will be consider as per relevant IRC Manual. The proposed project road will be consider for fully access controlled facilities as per NHAI guidelines. All major cross roads will be provide with grade-separated structures to ensure uninterrupted free flow through traffic and to provide safety to local traffic. All minor crossroads will also ensure its connectivity by provision of suitable vehicular and light vehicular underpasses to ensure safe geometry standards. Service roads will envisage as per requirement for segregation of local traffic needs.

During the detailed field surveys and land acquisition process, it is note that the alignment at near Kambal Samsthana Mutt and Maruthi Educational trust (near km 45.100) need modification as the original alignment pass through in the mid property. Accordingly, following modifications are suggest.

3.7.3 Widening Scheme

The entire STRR road divided in 3 phases as follow. The proposed phases approved by NHAI vide its letter NHAI/KNT/DPR/STRR/BNG/2018/122791 dated 24/08/2018

1. Dobbaspet to Ramanagara (km 0 to km 82.200 – Length 82.20km)
2. Ramanagara to Belagondapalli (km 82.200 to km 140.000 – 57.80km)
3. Belagondapalli to TN/KNT border (km 140.000 to km 179.969 – 39.969km)

The Phases further divided in the following packages. The details recommended to competent authority by PIU/NHAI for approval vide letter MHAI/12012/STRR/Phasing/1/2018/ (PIU-BNG-EXP)/957 dated 26/02/2019.

Phase 2 : From km 79.0000 to km 144.480

3.7.3.1 **Horizontal/Vertical Geometry**

The horizontal geometry details for the proposed road given in **Annexure 3.1.** It is evident from the table that the entire corridor is cater for 100km per hour design speed. The vertical geometry profile details are furnish in **Annexure 3.2.**

3.7.3.2 **Proposed Design Standards**

The geometry design standard as per six lanes and Guidelines issued for Bharatmala program.

3.7.3.3 **Proposed Typical Cross Sections**

Based on traffic considerations, geometric standards and considering the site condition and economy following typical cross sections have been propose for different stretches of the project road. The main components are as given in **Table 3.3.**

Table 3.3: Details of proposed Cross sections

Cross Section Elements	Width (m)	Total Width (m)
Main Carriage way	3 x 3.50	10.50
Paved shoulder	2 x 1.50	3.00
Earthen Shoulder	2 x 2.00	4.00
Raised Median	0.5+4+0.5	5.00

The Typical Cross Sections of the package worked out based on geometry design, the typical cross section schedule, and its drawing given below:

Table 3.4: Typical Cross section Schedule

S. No.	Design Chainage (m)		Design Length (m)	TCS Type
	From	To		
1.	79000	79100	100	TCS 10
2.	79100	79500	400	TCS 9
3.	79500	79550	50	TCS 10
4.	79550	79960	410	TCS 1
5.	79960	80010	50	TCS 9
6.	80010	80150	140	TCS 10
7.	80150	81320	1170	TCS 1
8.	81320	81380	60	TCS 10
9.	81380	81660	280	TCS 9
10.	81660	81830	170	TCS 13
11.	81830	82050	220	TCS 13A
12.	82050	83050	1000	TCS 1
13.	83050	83110	60	TCS 3
14.	83110	83450	340	TCS 13
15.	83450	83660	210	TCS 3
16.	83660	83970	310	TCS 5
17.	83970	84190	220	TCS 17
18.	84190	84370	180	TCS 1
19.	84370	84480	110	TCS 9
20.	84480	84745	265	TCS 1
21.	84745	84860	115	TCS 2
22.	84860	84970	110	TCS 14
23.	84970	85025	55	TCS 2
24.	85025	85390	365	TCS 1
25.	85390	85720	330	TCS 9
26.	85720	86010	290	TCS 1
27.	86010	86090	80	TCS 11
28.	86090	89350	3260	TCS 1
29.	89350	89795	445	TCS 11
30.	89795	90005	210	TCS 19
31.	90005	90310	305	TCS 9
32.	90310	91020	710	TCS 1
33.	91020	91140	120	TCS 6
34.	91140	91380	240	TCS 7
35.	91380	91620	240	TCS 8
36.	91620	91850	230	TCS 7
37.	91850	92070	220	TCS 6
38.	92070	92750	680	TCS 9
39.	92750	93080	330	TCS 1
40.	93080	93270	190	TCS 17
41.	93270	93465	195	TCS 1
42.	93465	93545	80	TCS 6

S. No.	Design Chainage (m)		Design Length (m)	TCS Type
	From	To		
43.	93545	93610	65	TCS 1
44.	93610	93760	150	TCS 17
45.	93760	94090	330	TCS 1
46.	94090	94160	70	TCS 10
47.	94160	94270	110	TCS 1
48.	94270	94455	185	TCS 17
49.	94455	94500	45	TCS 8
50.	94500	94550	50	TCS 7
51.	94550	94820	270	TCS 6
52.	94820	94880	60	TCS 12
53.	94880	95060	180	TCS 19
54.	95060	95330	270	TCS 12
55.	95330	95390	60	TCS 19
56.	95390	95490	100	TCS 12
57.	95490	96030	540	TCS 19
58.	96030	96070	40	TCS 12
59.	96070	96140	70	TCS 6
60.	96140	96200	60	TCS 7
61.	96200	96370	170	TCS 8
62.	96370	96470	100	TCS 17
63.	96470	96620	150	TCS 1
64.	96620	97060	440	TCS 17
65.	97060	97280	220	TCS 1
66.	97280	97345	65	TCS 10
67.	97345	97385	40	TCS 9
68.	97385	97490	105	TCS 10
69.	97490	97565	75	TCS 1
70.	97565	97830	265	TCS 4
71.	97830	98370	540	TCS 17
72.	98370	98665	295	TCS 1
73.	98665	98880	215	TCS 12
74.	98880	99220	340	TCS 6
75.	99220	99430	210	TCS 1
76.	99430	99590	160	TCS 9
77.	99590	99680	90	TCS 1
78.	99680	99790	110	TCS 9
79.	99790	99840	50	TCS 6
80.	99840	99875	35	TCS 7
81.	99875	99950	75	TCS 17
82.	99950	100260	310	TCS 1
83.	100260	100295	35	TCS 17
84.	100295	100320	25	TCS 7
85.	100320	100350	30	TCS 8
86.	100350	100420	70	TCS 7
87.	100420	100590	170	TCS 6

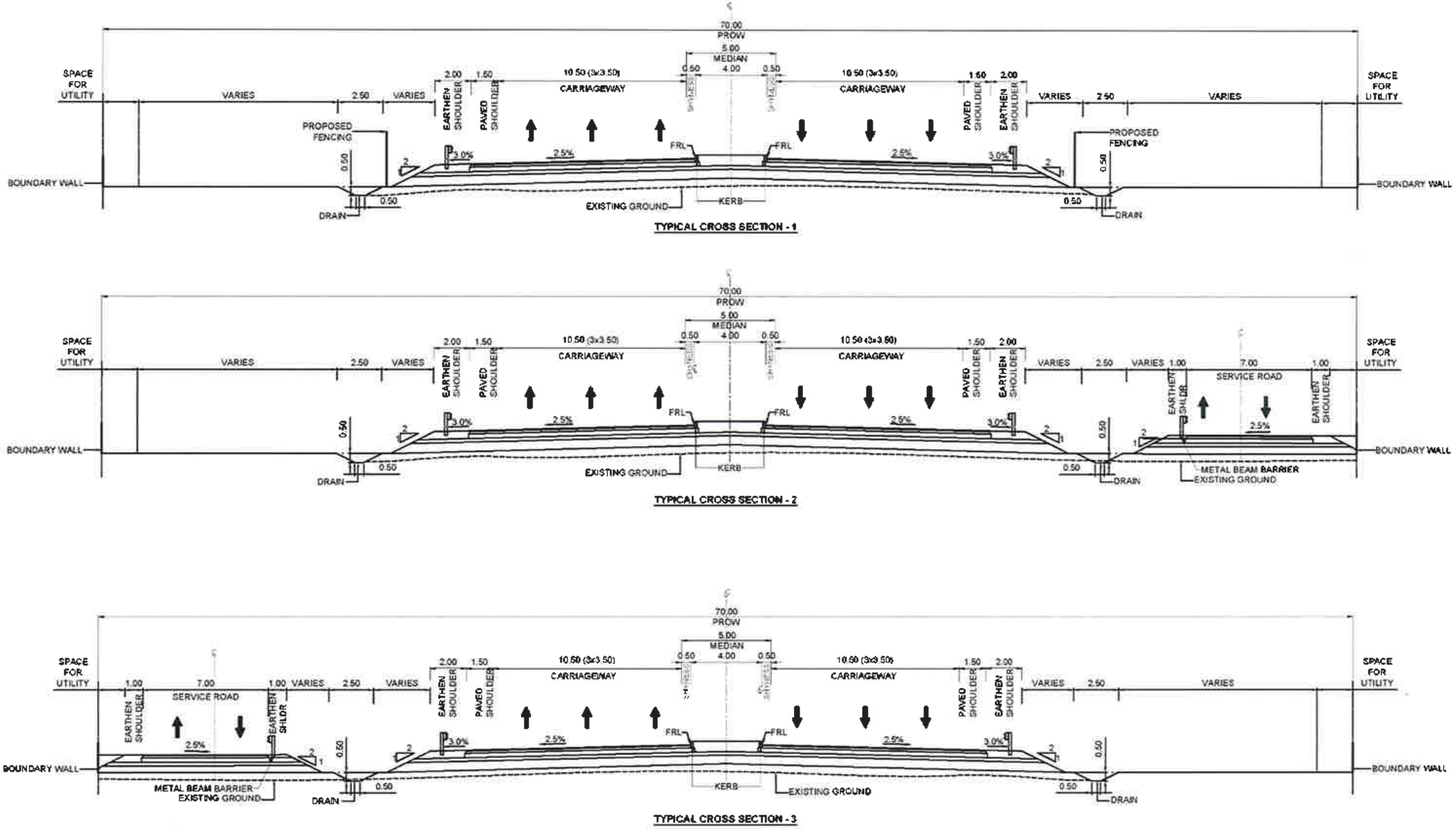
S. No.	Design Chainage (m)		Design Length (m)	TCS Type
	From	To		
88.	100590	100785	195	TCS 12
89.	100785	101050	265	TCS 14
90.	101050	101230	180	TCS 9
91.	101230	101370	140	TCS 1
92.	101370	101500	130	TCS 17
93.	101500	101880	380	TCS 1
94.	101880	102070	190	TCS 9
95.	102070	103200	1130	TCS 1
96.	103200	103390	190	TCS 9
97.	103390	104100	710	TCS 1
98.	104100	104235	135	TCS 17
99.	104235	104315	80	TCS 5
100.	104315	104550	235	TCS 17
101.	104550	104710	160	TCS 1
102.	104710	104960	250	TCS 9
103.	104960	105090	130	TCS 1
104.	105090	105360	270	TCS 17
105.	105360	105380	20	TCS 1
106.	105380	105465	85	TCS 6
107.	105465	105500	35	TCS 14A
108.	105500	105580	80	TCS 9
109.	105580	105690	110	TCS 1
110.	105690	106030	340	TCS 17
111.	106030	106200	170	TCS 1
112.	106200	106220	20	TCS 11
113.	106220	106540	320	TCS 9
114.	106540	106820	280	TCS 1
115.	106820	107800	980	TCS 9
116.	107800	109495	1695	TCS 1
117.	109495	109700	205	TCS 13A
118.	109700	110120	420	TCS 3
119.	110120	110290	170	TCS 1
120.	110290	110550	260	TCS 9
121.	110550	110610	60	TCS 11
122.	110610	111070	460	TCS 1
123.	111070	111280	210	TCS 9
124.	111280	111670	390	TCS 1
125.	111670	111700	30	TCS 11
126.	111700	111750	50	TCS 9
127.	111750	112825	1075	TCS 1
128.	112825	113000	175	TCS 6
129.	113000	113265	265	TCS 20
130.	113265	119750	6485	TCS 21
131.	119750	119830	80	TCS 1
132.	119830	119940	110	TCS 17

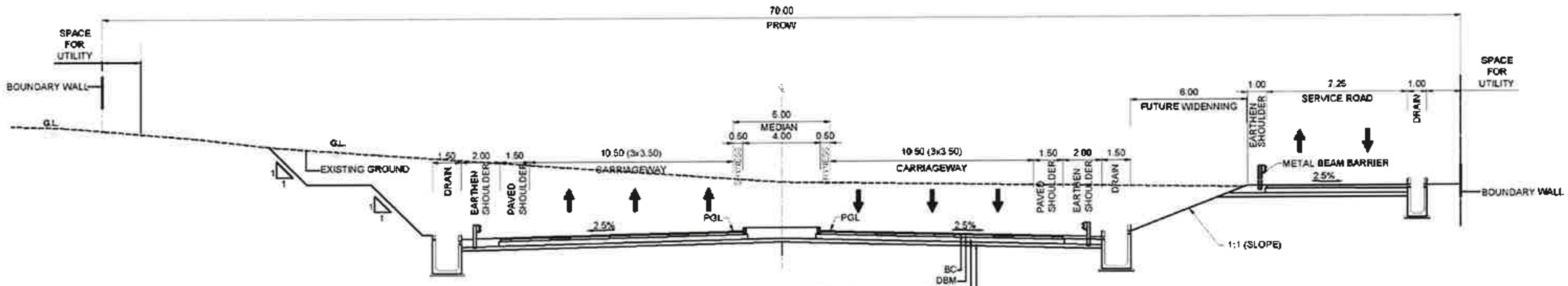
S. No.	Design Chainage (m)		Design Length (m)	TCS Type
	From	To		
133.	119940	120110	170	TCS 1
134.	120110	120700	590	TCS 17
135.	120700	120895	195	TCS 1
136.	120895	121180	285	TCS 3
137.	121180	121250	70	TCS 13A
138.	121250	121420	170	TCS 3
139.	121420	121570	150	TCS 13A
140.	121570	121715	145	TCS 3
141.	121715	121900	185	TCS 1
142.	121900	121960	60	TCS 9
143.	121960	122060	100	TCS 1
144.	122060	122150	90	TCS 17
145.	122150	122300	150	TCS 1
146.	122300	122390	90	TCS 9
147.	122390	122510	120	TCS 1
148.	122510	122880	370	TCS 17
149.	122880	122970	90	TCS 5
150.	122970	123110	140	TCS 1
151.	123110	123220	110	TCS 9
152.	123220	123355	135	TCS 3
153.	123355	123660	305	TCS 1
154.	123660	123860	200	TCS 17
155.	123860	124070	210	TCS 1
156.	124070	124530	460	TCS 17
157.	124530	125190	660	TCS 1
158.	125190	125300	110	TCS 9
159.	125300	125490	190	TCS 1
160.	125490	125700	210	TCS 17
161.	125700	126160	460	TCS 1
162.	126160	126325	165	TCS 17
163.	126325	126450	125	TCS 7
164.	126450	126590	140	TCS 6
165.	126590	126730	140	TCS 12
166.	126730	126790	60	TCS 6
167.	126790	126970	180	TCS 1
168.	126970	127130	160	TCS 9
169.	127130	127360	230	TCS 1
170.	127360	128040	680	TCS 17
171.	128040	128200	160	TCS 1
172.	128200	128340	140	TCS 9
173.	128340	128740	400	TCS 1
174.	128740	128910	170	TCS 9
175.	128910	129040	130	TCS 1
176.	129040	129415	375	TCS 17
177.	129415	129470	55	TCS 5

S. No.	Design Chainage (m)		Design Length (m)	TCS Type
	From	To		
178.	129470	129710	240	TCS 8
179.	129710	129785	75	TCS 5
180.	129785	129810	25	TCS 17
181.	129810	129910	100	TCS 1
182.	129910	130050	140	TCS 17
183.	130050	130290	240	TCS 1
184.	130290	130410	120	TCS 17
185.	130410	130660	250	TCS 1
186.	130660	130990	330	TCS 17
187.	130990	131280	290	TCS 1
188.	131280	131730	450	TCS 6
189.	131730	131860	130	TCS 7
190.	131860	131960	100	TCS 8
191.	131960	132020	60	TCS 19
192.	132020	132110	90	TCS 8
193.	132110	132240	130	TCS 7
194.	132240	132580	340	TCS 6
195.	132580	132670	90	TCS 1
196.	132670	132780	110	TCS 6
197.	132780	132910	130	TCS 7
198.	132910	133030	120	TCS 8
199.	133030	133400	370	TCS 17
200.	133400	135860	2460	TCS 1
201.	135860	135960	100	TCS 9
202.	135960	136020	60	TCS 1
203.	136020	136420	400	TCS 9
204.	136420	136510	90	TCS 10
205.	136510	136570	60	TCS 9
206.	136570	136590	20	TCS 10
207.	136590	137200	610	TCS 1
208.	137200	137250	50	TCS 11
209.	137250	137390	140	TCS 1
210.	137390	137940	550	TCS 17
211.	137940	138340	400	TCS 1
212.	138340	138660	320	TCS 17
213.	138660	138760	100	TCS 6
214.	138760	138785	25	TCS 12
215.	138785	139055	270	TCS 19
216.	139055	139230	175	TCS 12
217.	139230	139290	60	TCS 19
218.	139290	139620	330	TCS 12
219.	139620	139740	120	TCS 6
220.	139740	139880	140	TCS 7
221.	139880	140120	240	TCS 17
222.	140120	140610	490	TCS 1

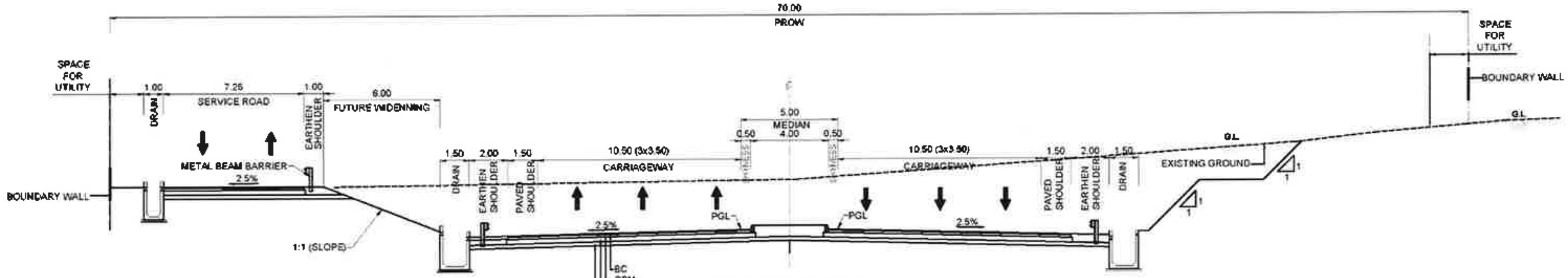
S. No.	Design Chainage (m)		Design Length (m)	TCS Type
	From	To		
223.	140610	140680	70	TCS 11
224.	140680	140760	80	TCS 9
225.	140760	140810	50	TCS 11
226.	140810	141540	730	TCS 1
227.	141540	141790	250	TCS 17
228.	141790	142030	240	TCS 1
229.	142030	142060	30	TCS 10
230.	142060	142280	220	TCS 9
231.	142280	143100	820	TCS 1
232.	143100	143340	240	TCS 17
233.	143340	143510	170	TCS 1
234.	143510	143800	290	TCS 9
235.	143800	143940	140	TCS 1
236.	143940	144020	80	TCS 10
237.	144020	144170	150	TCS 1

Figure 3.8: Typical Cross Sections





TYPICAL CROSS SECTION - 4



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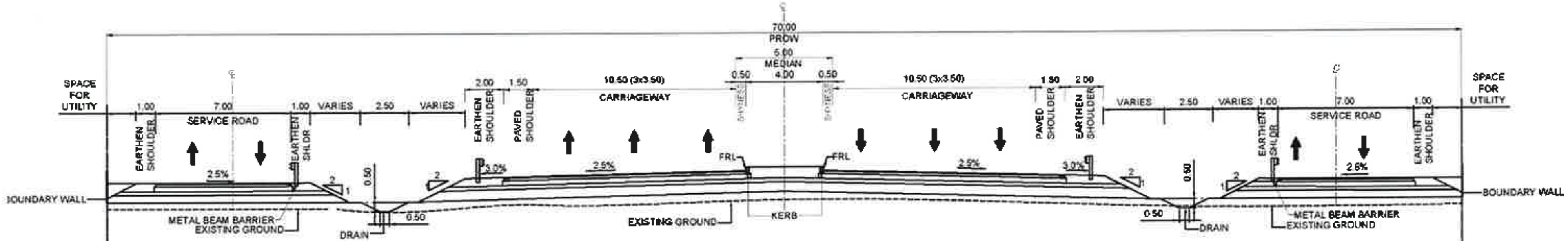

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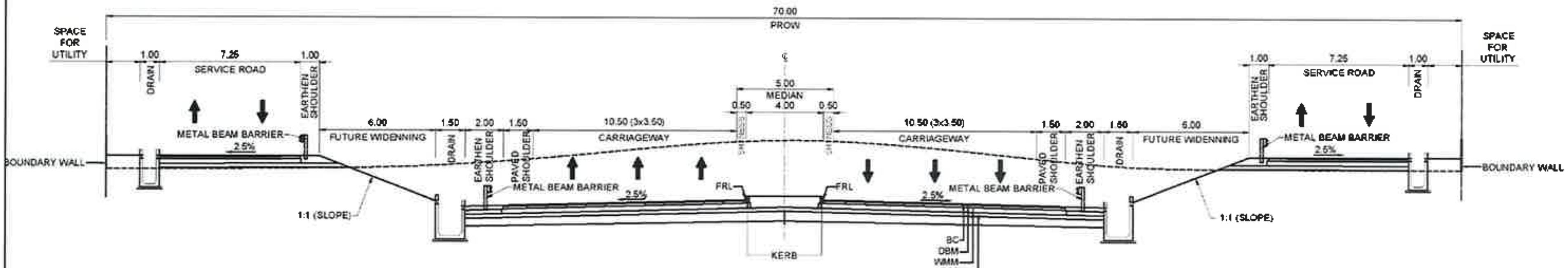
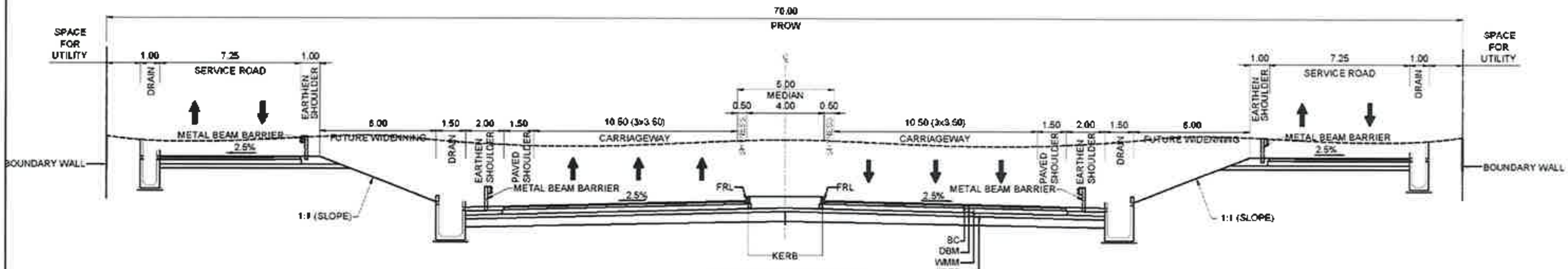
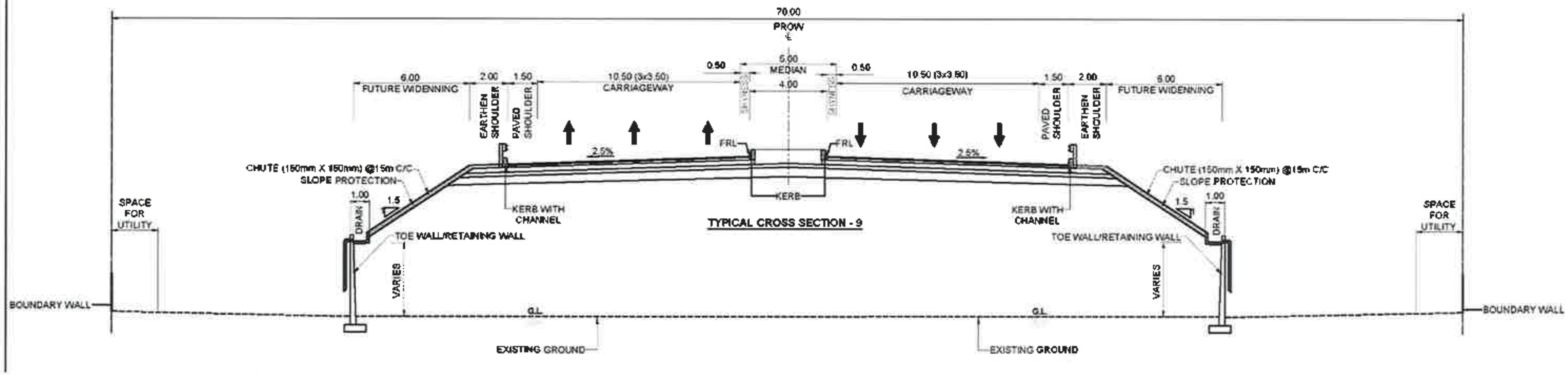


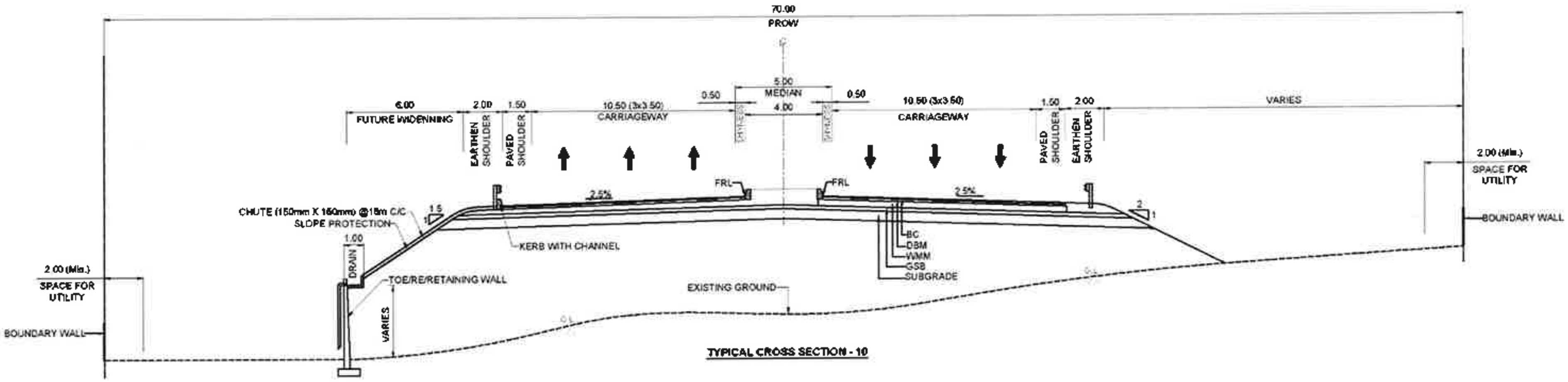
TYPICAL CROSS SECTION - 7



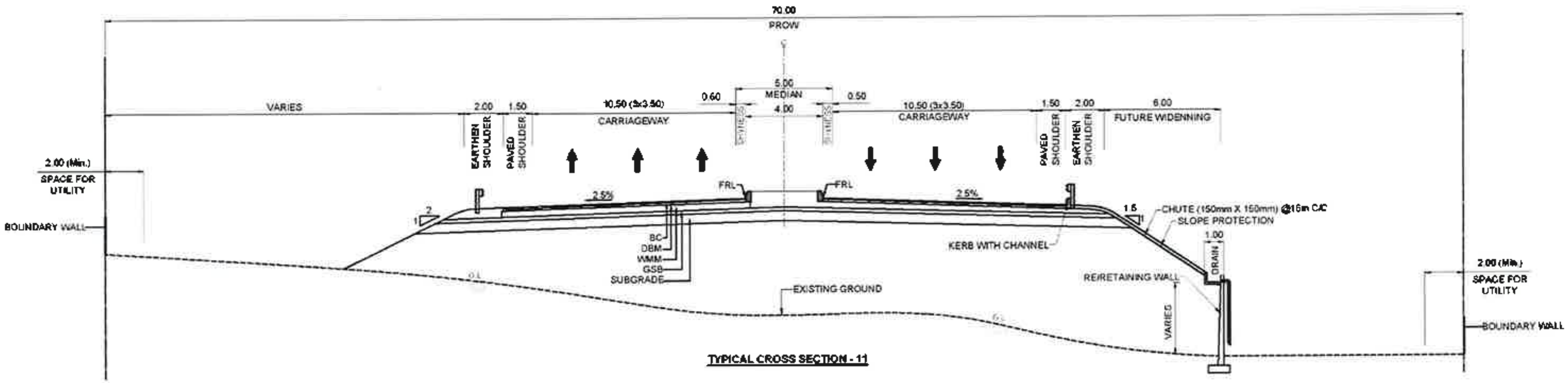
TYPICAL CROSS SECTION - 8



TYPICAL CROSS SECTION - 9

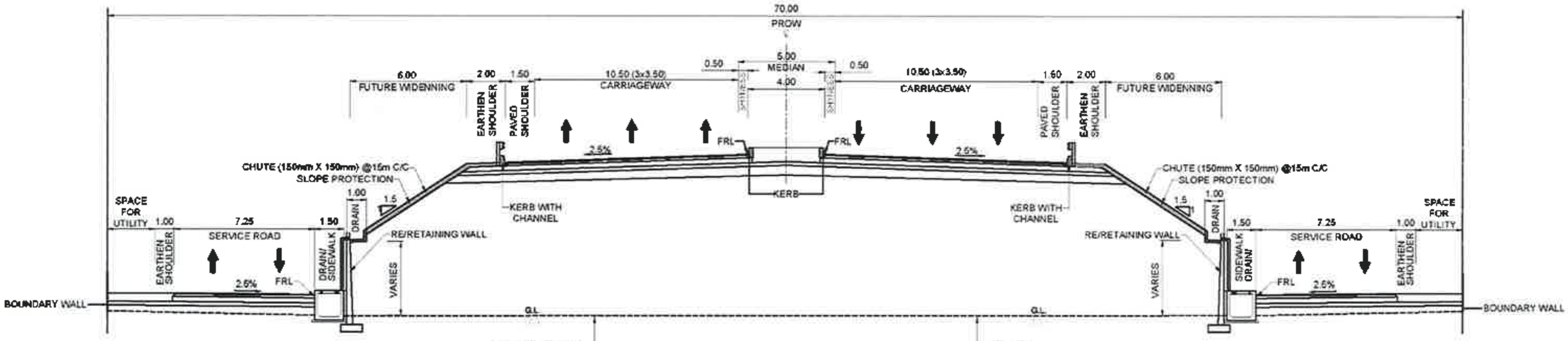


TYPICAL CROSS SECTION - 10

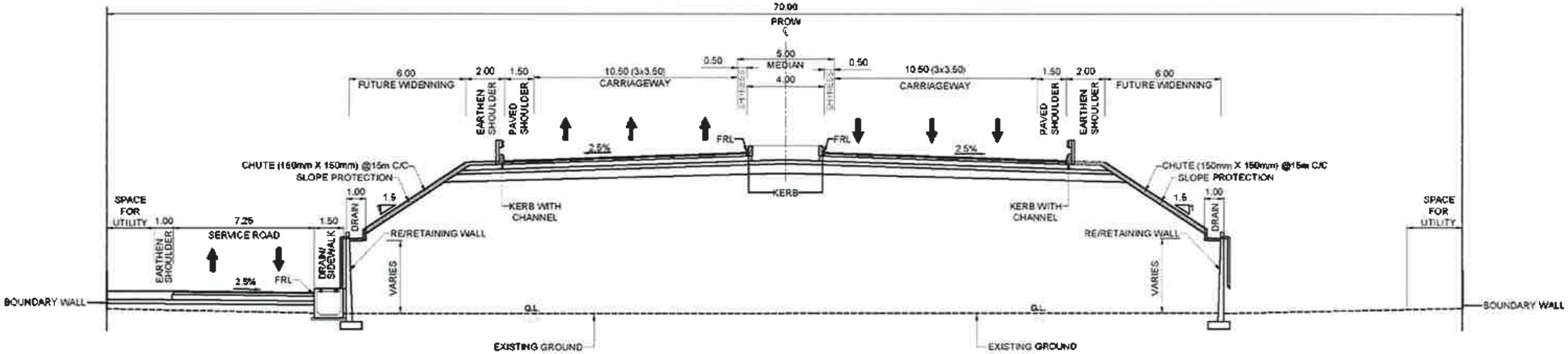


TYPICAL CROSS SECTION - 11

NOTE:
1. ALL DIMENSIONS ARE METERS.
2. PROW - PROPOSED RIGHT OF WAY.
3. EARTHEN SHOULDER WITH 150mm GRANULAR ON TOP LAYER.
4. DESIGN OF RE / RETAINING WALL SHALL BE CONSIDER FOR TOTAL HEIGHT FROM FRL CONSIDERING FUTURE WIDENNING.

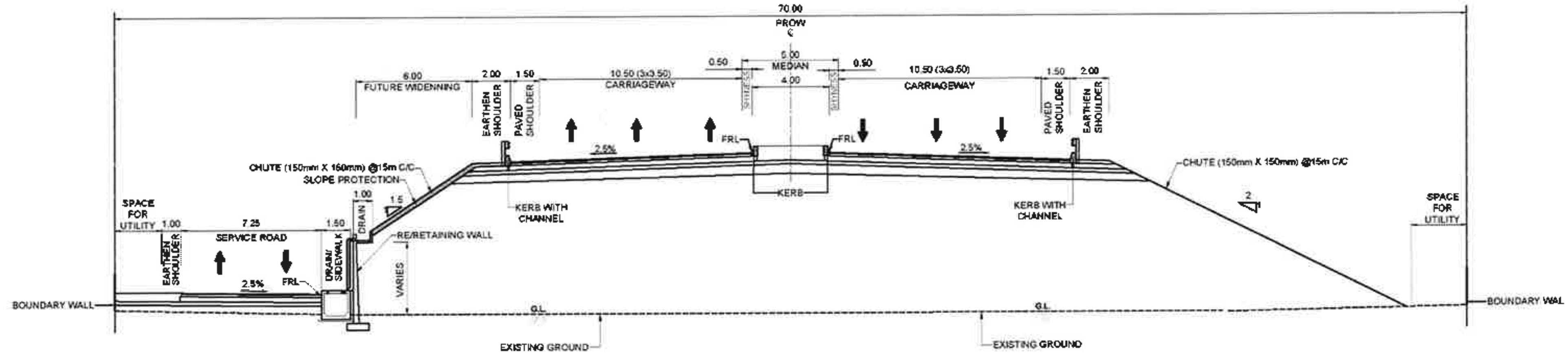


TYPICAL CROSS SECTION - 12

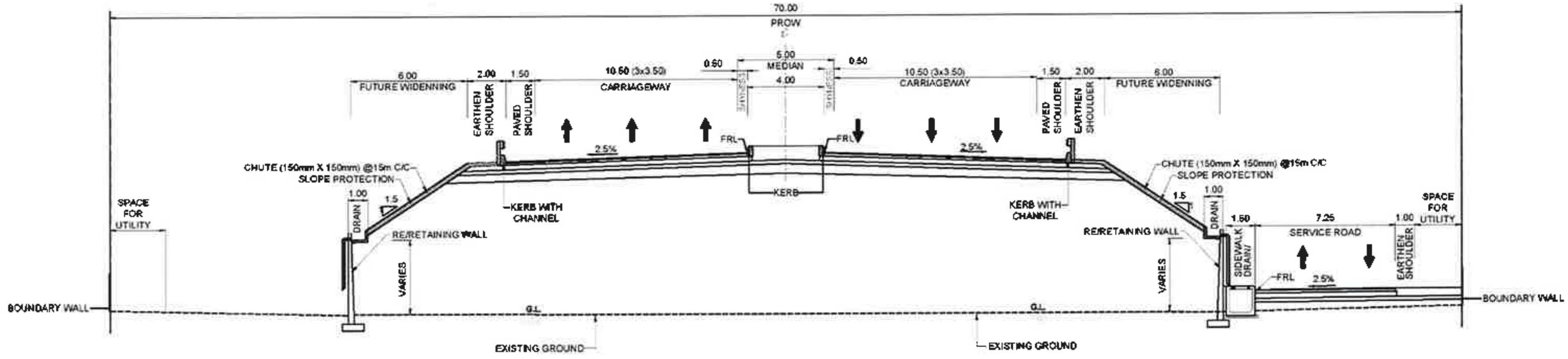


TYPICAL CROSS SECTION - 13

1. ALL DIMENSIONS ARE METERS
2. PROW- PROPOSED RIGHT OF WAY
3. EARTHEN SHOULDER WITH 150MM GRANULAR ON TOP LAYER

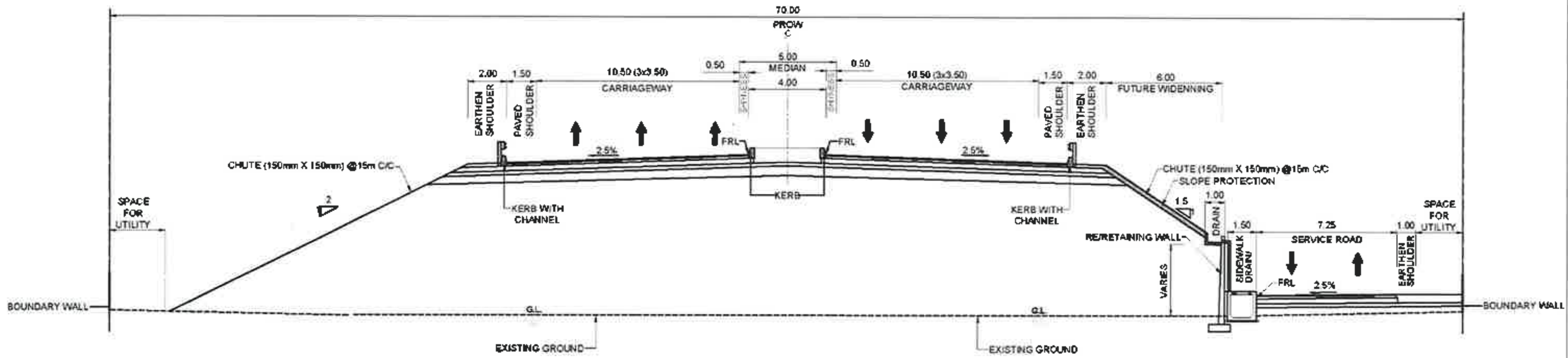


TYPICAL CROSS SECTION - 13A

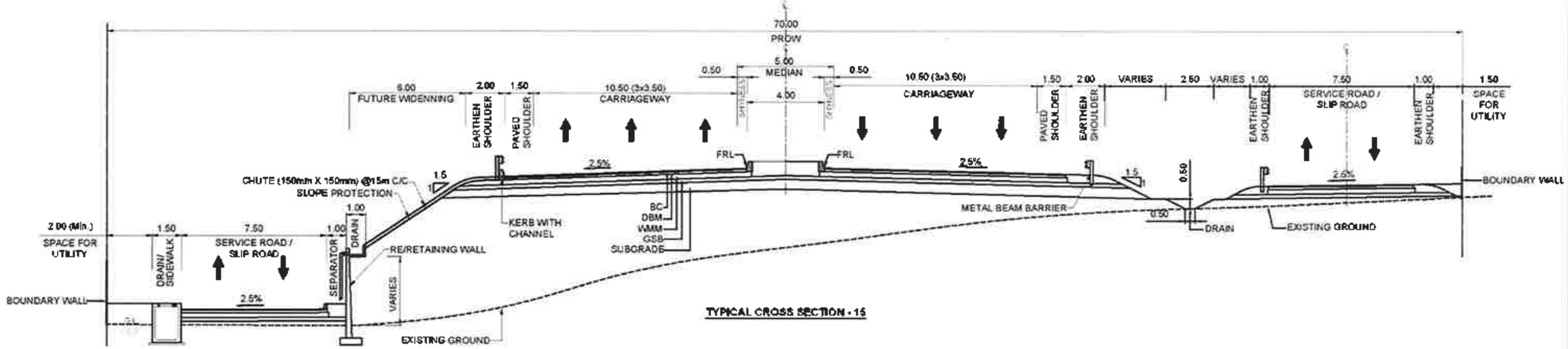


TYPICAL CROSS SECTION - 14

1 ALL DIMENSIONS ARE METERS
2 PROW - PROPOSED RIGHT OF WAY
3 EARTHEN SHOULDER WITH 150MM GRANULAR ON TOP LAYER

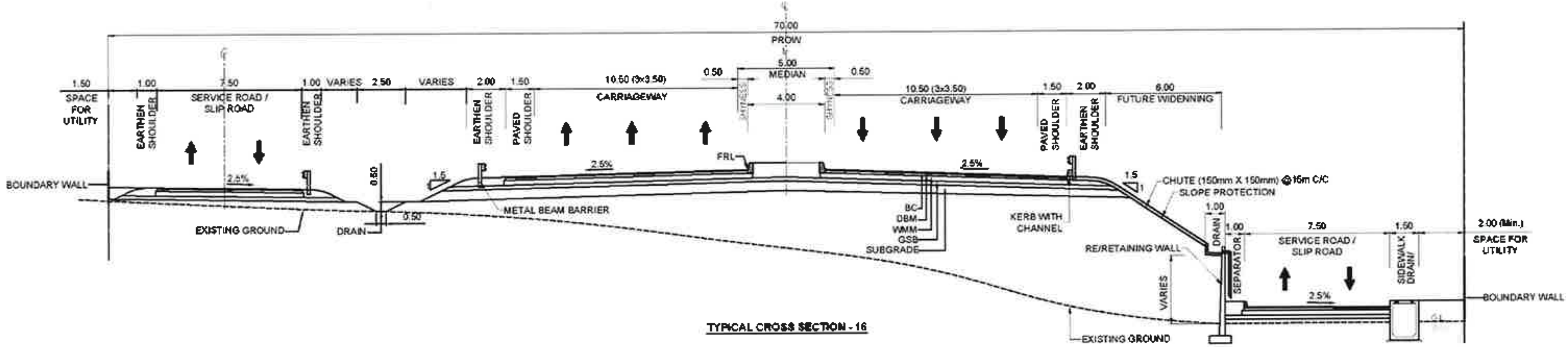


TYPICAL CROSS SECTION - 14A

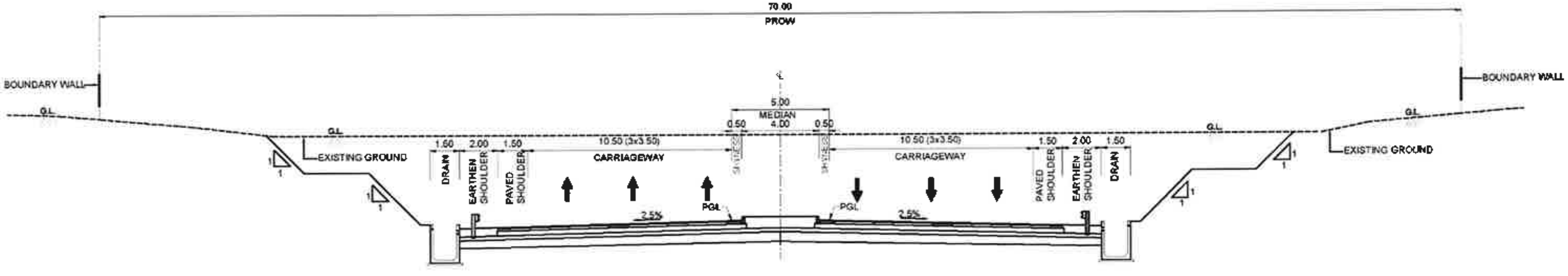


TYPICAL CROSS SECTION - 15

1. ALL DIMENSIONS ARE METERS
2. PROW - PROPOSED RIGHT OF WAY
3. EARTHEN SHOULDER WITH 150MM GRANULAR ON TOP LAYER

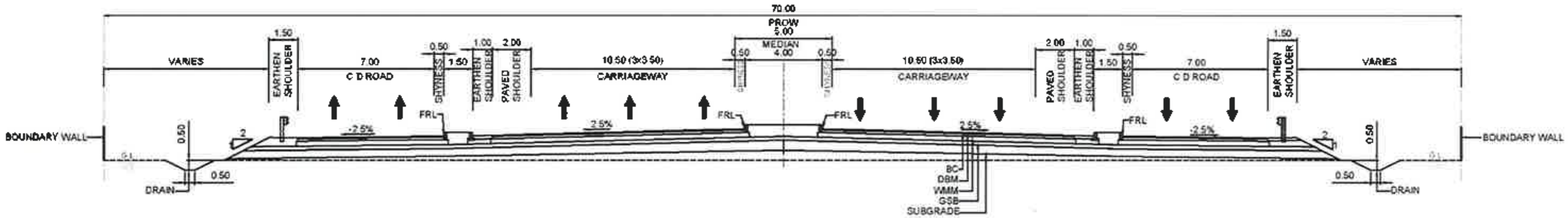


TYPICAL CROSS SECTION - 16

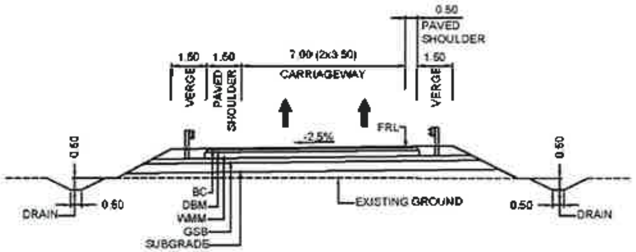


TYPICAL CROSS SECTION - 17

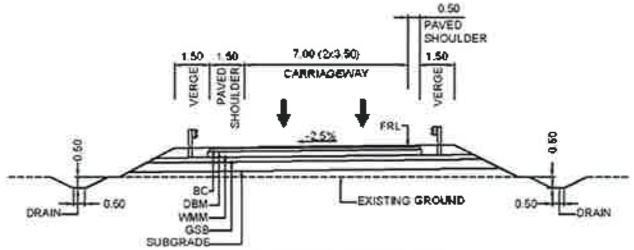
1.ALL DIMENSIONS ARE METERS
2.PROW - PROPOSED RIGHT OF WAY
3.EARTHEN SHOULDER WITH 150MM GRANULAR ON TOP LAYER



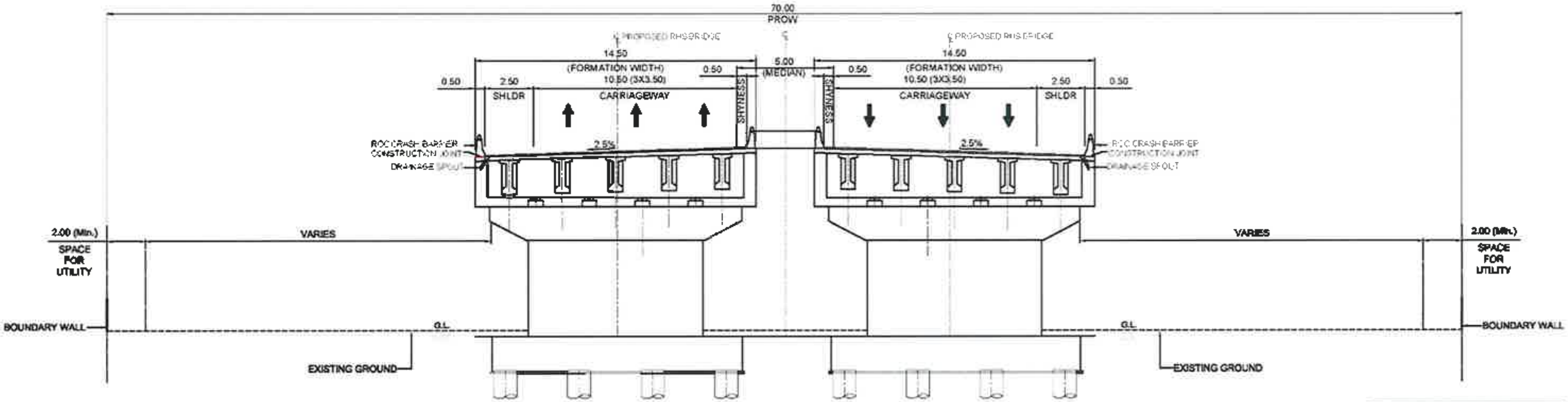
TYPICAL CROSS SECTION - 18



TYPICAL CROSS SECTION OF RAMP

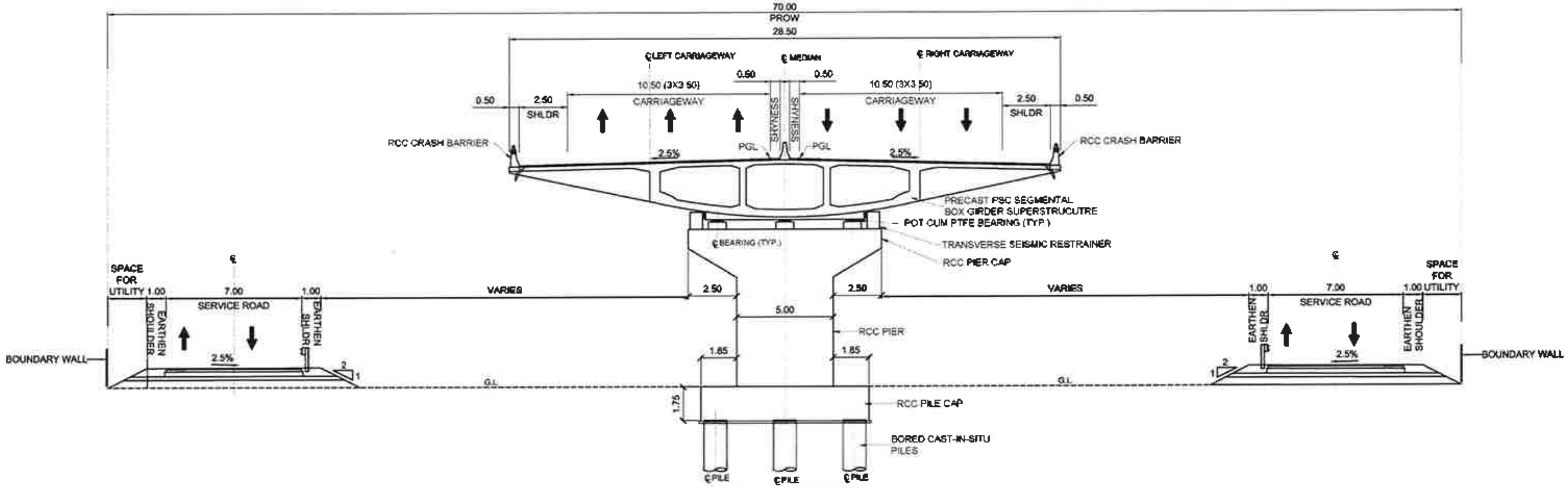


TYPICAL CROSS SECTION OF LOOP

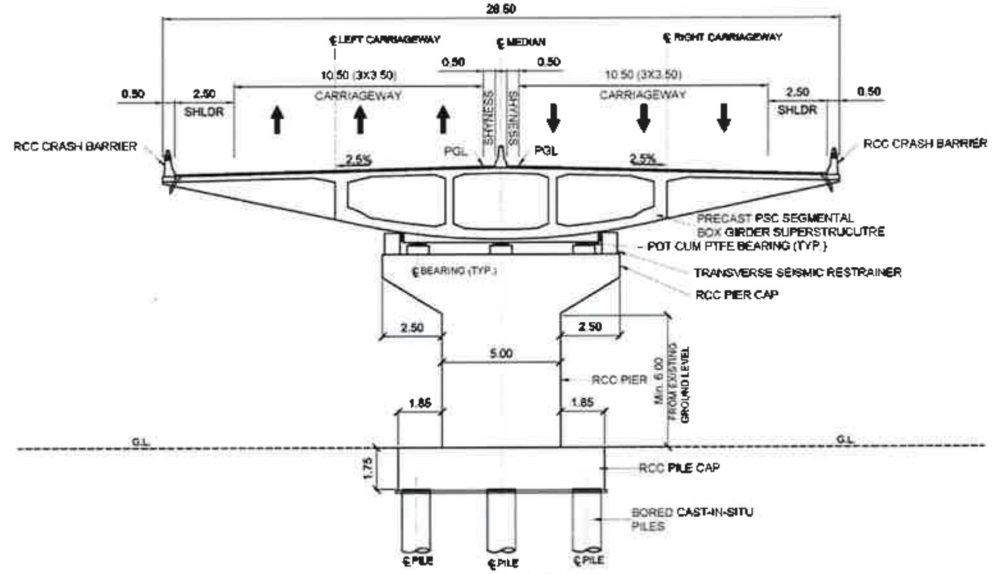


TYPICAL CROSS SECTION - 19

1. ALL DIMENSIONS ARE METERS
2. PROW - PROPOSED RIGHT OF WAY
3. EARTHEN SHOULDER WITH 150MM GRANULAR ON TOP LAYER



TYPICAL CROSS SECTION - 20



TYPICAL CROSS SECTION - 21

1. ALL DIMENSIONS ARE METERS
2. PROW - PROPOSED RIGHT OF WAY
3. EARTHEN SHOULDER WITH 150MM GRANULAR ON TOP LAYER

3.7.4 Major and Minor Junctions

The proposed alignment crisscrosses the NH and SH at three locations. Different options of interchanges are propose in these locations. The options with its merits and demerits including amount of land needs and cost aspects discussed and the details as below. The options also submitted to NHAI with recommendation for further consideration and approval.

Table 3.5: Major Cross road locations

S. No.	Road	Chainage of Cross road Cross point (km)	Proposed STRR (km)	Description
1	NH 209	431.310	95.360	NH-209 (Bengaluru – Coimbatore road)
2	SH 35	51.500	131.990	SH-35 (Sidlaghatta to Karnataka/Tamil Nadu State Border via Anekal road)
3	SH 17B	14.790	139.260	SH-17B (Nanjanagud to Karnataka/Tamil Nadu State Border via Chamarajanagar road)

3.7.5 Interchanges options proposed

Phase 2

Interchange at km 95.360 (NH 209)

The project road crosses NH 209 at km 95.360. The proposed STRR is Greenfield alignment and so it is propose to provide an Interchange with uninterrupted turning facilities from all directions considering the future growth of traffic and considering traffic safety. Two options are propose considering the land requirements and its acquisition cost. It is also pertinent to mention that the grade-separated facilities with designated entry- exit points are foresee considering the type of tolling system adopted, its design speed and level of services and traffic safety. The details of all the options are as below.

Option-1

The proposed STRR through traffic will ply on flyover and directional ramps have proposed on all the four sides including 4-lane tollbooths on both sides and in both directions of STRR considering the future traffic requirements. Two at grade rotary type intersections (with 20m Internal Diameter) have proposed on NH 209 to the left and right side of STRR connecting the directional ramps for smooth circulation of traffic in all the directions.

The proposed Interchange require total area of 25.21hectares and the net additional area requirement is 10.80hectares. The land cost for interchange will be (land cost considered @ INR 6.5crores per hectare) INR 70.20Crores. Civil cost for additional area in interchange location except for main carriageway, structure and toll plaza arrangements will be INR 14crores and the total cost will be INR 84.20crores

The details given in drawing: 04A

Option-2

Interchange options are capable of dispersing all direction traffic in efficient manner. However, considering the land requirement, land cost in the junction locality and additional acquisition of structures abutting junction location, full Cloverleaf type Interchange with loop ramp of 60m radius and outer ramp has proposed at this location including with 4-lane toll collection arrangement on both sides of STRR.

The proposed interchange require total area of 37.32hectares and the net additional area requirement is about 12.72hectares after deducting the land along proposed STRR and existing NH 209. The land cost for interchange will be (land cost considered @ INR 6.5crores per hectare) INR 82.68Crores. Civil cost for additional area in interchange location except for main carriageway, structure and toll plaza arrangements will be INR 24.80crores and the total cost will be INR 107.48crores

The details given in drawing: 05A

Option-3

The proposed STRR through traffic will ply on flyover and directional ramps have proposed on all the four sides including with 4-lane tollbooths on both sides and both directions of STRR, considering the future traffic requirements. U turn facility are propose in level 1 on both directions on NH 209 at about 600m away from the cross point to facilitate all directional traffic flow. Four at- grade, free left turn facilities are propose on NH 209 for converging and diverging traffic on all directions. As the turning traffic are in the range of 600 in peak hour (in design life) these arrangement may function efficiently as per current and future traffic however, proposal require acquisition of about 20 structures along the NH 209 towards Bangalore direction

The proposed Interchange require total area of 34.85 hectares and the net additional area requirement is 7.15 hectares after deducting the land along proposed STRR and existing NH 209. The land cost for interchange will be (land cost considered @ INR 6.5crores per hectare) INR 46.48Crores. Civil cost for additional area in interchange location except for main carriageway, structure and toll plaza arrangements will be INR 52.99crores and the total cost will be INR 99.47crores

The details given in drawing: 09A

Conclusion

It recommended that option 2 is suitable for consideration with optimal geometry requirement. This option require approximately 5 hectare more land area in comparison to Option 3, but considering better traffic circulation and efficient operations, Option 2 is recommend.

Interchange at km 131.990 (SH 35)

The project road crosses SH 85 at km 131.990. The proposed STRR is Greenfield alignment and so it is propose to provide an Interchange with uninterrupted turning facilities from all directions considering the future growth of traffic and considering traffic safety. It is also pertinent to mention that the grade-separated facilities with designated entry- exit points are foresee considering the type of tolling system adopted, its design speed and level of services and traffic safety. The details of alternative is as below.

Option-1

The proposed STRR through traffic will ply on flyover and directional ramps have proposed on all the four sides including with 4-lane tollbooths on all the ramps, considering the future traffic requirements. Two at grade rotary type intersections (with 20m Internal Diameter) have proposed on SH-35 to the left and right side of STRR connecting the directional ramps and SH-35 for smooth circulation of traffic in all the directions and to avoid points of conflict of traffic.

The proposed Interchange require total area of 22.18hectares and the net additional area requirement is 8.35hectares. The land cost for interchange will be (land cost considered @ INR 6.5crores per hectare) INR 54.275Crores. Civil cost for additional area in interchange location except for main carriageway, structure and toll plaza arrangements will be INR 10.52crores and the total cost will be INR 64.795crores

The details given in drawing: 04

Option-2

The proposed STRR through traffic will ply on flyover and directional ramps have proposed on all the four sides including with 4-lane tollbooths on all the ramps, considering the future traffic requirements. The turning traffic in all legs are in the range of 200 vehicles per hour in peak hour. A roundabout (with 160m Internal Diameter) is also propose to disperse the traffic in efficient manner on ground. The ID of roundabout is increase due to existing position of SH 35 junction in skew

The proposed Interchange require total area of 20.31hectares and the net additional area requirement is 6.48hectares. The land cost for interchange will be (land cost considered @ INR 6.5crores per hectare) INR 42.12Crores. Civil cost for additional area in interchange location except for main carriageway, structure and toll plaza arrangements will be INR 7.38crores and the total cost will be INR 49.50Crores

The details given in drawing: 05

Conclusion

Considering the traffic safety and traffic circulation, land cost in the junction locality along SH 35, considering the geometry of SH 35 and social impact this is apt recommend option 2 suitable for consideration.

Interchange at km 139.260 (SH 17B)

The project road crosses SH 17B at km 139.260. The proposed STRR is Greenfield alignment and so it is propose to provide an Interchange with uninterrupted turning facilities from all directions considering the future growth of traffic and considering traffic safety. Two options are propose considering the land requirements and its acquisition cost. It is also pertinent to mention that the grade-separated facilities with designated entry- exit points are foresee considering the type of tolling system adopted, its design speed and level of services and traffic safety. The details for both options are as below.

Option-1

The proposed STRR through traffic will ply on flyover and directional ramps have proposed on all the four sides including with 4-lane tollbooths on all the ramps, considering the future traffic requirements. The turning traffic in all legs are in the range of 200 vehicles per hour in peak hour. A roundabout (with 100m Internal Diameter) is also propose to disperse the traffic in efficient manner on ground. The civil cost for option 1 is about INR 38.5 Crores.

The proposed Interchange require total area of 20.25hectares and the net additional area requirement is 6.75hectares. The land cost will be (land cost considered @ INR 3.5crores per hectare) INR 70.875 Crores. Thus, the total cost of this option will be about INR 109.375 Crores

The details given in drawing: 01C

Option-2

The proposed STRR through traffic will ply on flyover and directional ramps have proposed on all the four sides including with 4-lane tollbooths on all the ramps, considering the future traffic requirements. In addition, two at grade rotary type intersections (with 40m Internal Diameter) have proposed on SH-17B to the left and right side of STRR connecting the directional ramps and SH-17B for smooth circulation of traffic in all the directions and to avoid points of conflict of traffic. The civil cost is INR 31.8croroes.

The proposed Interchange require total area of 20.40hectares and the net additional area requirement is 6.69hectares. The land cost will be (land cost considered @ INR 3.5crores per hectare) INR 71.40 Crores. Thus, the total cost of this option will be about INR 103.200 Crores

The details given in drawing: 02C

Conclusion

Both the proposed Interchange options are capable of dispersing all direction traffic in efficient manner. However, considering the traffic safety and traffic circulation, land cost in the prime junction locality and additional large-scale acquisition of residential/commercial structures along SH-17B to the left side of STRR and social impact it is recommend option 1 is suitable for consideration. It is also pertinent to mention that the cost difference will be about INR 6 Crores more in this option.

Interchange drawings are provided in Annexure 3.3

3.7.6 Service road

The service roads are provide as per the local requirements either or one side or on both sides. Also to provide uninterrupted free flow in the existing SH 3 as at some locations the proposed STRR passes over the existing state highway. The details of service roads are as follow.

Table 3.6: Details of Service road

S No	From (km)	To (km)	Length (m)	Sides
1.	81.660	82.050	390	LHS
2.	83.055	83.975	920	LHS
3.	84.745	85.025	280	RHS
4.	91.020	92.070	1050	Both
5.	93.465	93.545	80	Both
6.	94.455	96.370	1915	Both
7.	97.565	97.835	270	RHS
8.	98.665	99.220	555	Both
9.	99.790	99.875	85	Both
10.	100.295	100.785	490	Both
11.	100.785	101.050	265	RHS
12.	104.235	104.315	80	LHS
13.	105.380	105.465	85	Both
14.	109.495	110.115	620	LHS
15.	112.950	113.265	315	Both
16.	120.895	121.715	820	LHS
17.	122.885	123.355	470	LHS

S No	From (km)	To (km)	Length (m)	Sides
18.	126.325	126.790	465	Both
19.	129.415	129.470	55	LHS
20.	129.470	129.710	240	Both
21.	129.710	129.785	75	LHS
22.	131.280	132.580	1300	Both
23.	132.670	133.030	360	Both
24.	138.660	139.880	1220	Both

3.7.7 Other Grade Separated Structures (VUP/LVUP/Overpasses)

In order to facilitate the uninterrupted free flow traffic in all other minor roads, following grade separated structures provided.

- Sixteen vehicular underpass with 5.5m clear vertical height and 20m span (except one with 25m span).
- Eighteen light vehicular underpasses with 4.0m clear vertical height and 12m span
- Ten overpasses

The details of provisions given in **Table 3.7a to 3.7c**.

Table 3.7a: Location of Vehicular Underpasses (VUP)

S No	Chainage (km)	Span
1	79.380	1x20
2	79.995	1x25
3	81.660	1x20
4	90.070	1x20
5	92.740	1x20
6	98.665	1x20
7	100.785	1x20
8	106.603	1x20
9	107.345	1x20
10	109.645	1x20
11	110.540	1x20
12	121.895	1x20
13	126.720	1x20
14	128.860	1x20
15	135.850	1x20
16	142.285	1x20

Table 3.7b: Location of Light Vehicular Underpasses (LVUP)

S No	Chainage (km)	Span
1	84.960	1x12
2	85.710	1x12
3	87.715	1x12
4	89.360	1x12
5	92.070	1x12

S No	Chainage (km)	Span
6	93.465	1x12
7	97.245	1x12
8	99.225	1x12
9	99.790	1x12
10	103.020	1x12
11	105.015	1x12
12	105.465	1x12
13	107.875	1x12
14	108.675	1x12
15	111.670	1x12
16	125.310	1x12
17	137.310	1x12
18	140.895	1x12

Table 3.7c: Location of Vehicular Overpasses (VOP)

S No	Chainage (km)	Span (m)
1	83.975	2x23.5
2	91.513	2x23.5
3	96.380	4x23.5
4	97.825	2x23.5
5	104.315	2x23.5
6	122.880	2x23.5
7	124.280	2x23.5
8	127.845	2x23.5
9	129.710	2x23.5
10	133.030	2x23.5

The other structures provided across streams/water bodies and ROBs are as follow.

Table 3.8 a: Minor Bridges

S No	Chainage (km)	Span(no x m)
1	83.310	1 X 15
2	88.265	1 X 15
3	101.150	3 X 27
4	101.935	1 X 20
5	107.495	1 X 33
6	111.065	1 X 30
7	128.122	1 X 15
8	129.855	1 X 12

Table 3.8 b: Major Bridges

S No	Chainage (km)	Span(no x m)
1	92.640	3 X 27

Table 3.9: ROBs

S No	Chainage (km)	Span (number x m)	Remark
NIL			

Table 3.10: Viaducts

Chainage (km)	Span (number x m)	Remark
89.900	7 X 30	
94.960	2 X 30	Additional Spans on Slip Lane on both sides with 16.0m width is also required
95.660	5 X 30	Additional Spans on Slip Lane on both sides with 16.0m width is also required
116.315	221 X 30	

3.7.8 Culverts

The project is completely Greenfield and thus 80 number of box culverts (details given below) plus one additional box culvert on canal proposed for cross-drainage purposes.

Table 3.11: Culverts

Sl. No	Chainage	Structure	Span
1.	79.090	Box Culvert	3 X 2.5
2.	79.300	Box Culvert	3 X 2.5
3.	79.500	Box Culvert	3 X 2.5
4.	79.950	Box Culvert	3 X 2.5
5.	80.050	Box Culvert	3 X 2.5
6.	80.180	Box Culvert	3 X 2.5
7.	80.540	Box Culvert	3 X 2.5
8.	80.990	Box Culvert	3 X 2.5
9.	81.250	Box Culvert	3 X 2.5
10.	82.485	Box Culvert	2 X 2
11.	82.840	Box Culvert	2 X 2
12.	83.183	Box Culvert	3 X 2.5
13.	84.420	Box Culvert	4 X 2.5
14.	84.910	Box Culvert	2 X 2
15.	85.000	Box Culvert	2 X 2
16.	85.190	Box Culvert	3 X 2.5
17.	85.440	Box Culvert	3 X 2.5
18.	85.523	Box Culvert	2 X 2
19.	86.075	Box Culvert	6 X 2.5

Sl. No	Chainage	Structure	Span
20.	86.265	Box Culvert	3 X 2.5
21.	86.430	Box Culvert	3 X 2.5
22.	86.700	Box Culvert	3 X 2.5
23.	87.100	Box Culvert	6 X 2.5
24.	87.817	Box Culvert	3 X 2.5
25.	88.900	Box Culvert	6 X 2.5
26.	90.800	Box Culvert	6 X 2.5
27.	92.230	Box Culvert	3 X 2.5
28.	93.410	Box Culvert	2 X 2
29.	93.880	Box Culvert	3 X 2.5
30.	96.582	Box Culvert	3 X 2.5
31.	97.475	Box Culvert	3 X 2.5
32.	98.860	Box Culvert	2 X 2
33.	99.560	Box Culvert	2 X 2
34.	99.765	Box Culvert	2 X 2
35.	100.060	Box Culvert	3 X 2.5
36.	103.300	Box Culvert	3 X 2.5
37.	104.025	Box Culvert	2 X 2
38.	104.830	Box Culvert	3 X 2.5
39.	104.925	Box Culvert	3 X 2.5
40.	105.517	Box Culvert	2 X 2
41.	105.594	Box Culvert	2 X 2
42.	106.300	Box Culvert	3 X 2.5
43.	107.105	Box Culvert	3 X 2.5
44.	107.685	Box Culvert	3 X 2.5
45.	108.090	Box Culvert	2 X 2
46.	108.890	Box Culvert	3 X 2.5
47.	109.555	Box Culvert	3 X 2.5
48.	109.990	Box Culvert	3 X 2.5
49.	110.700	Box Culvert	3 X 2.5
50.	110.850	Box Culvert	3 X 2.5
51.	111.700	Box Culvert	3 X 2.5
52.	111.805	Box Culvert	2 X 2
53.	112.135	Box Culvert	4 X 2.5
54.	112.518	Box Culvert	3 X 2.5
55.	121.990	Box Culvert	2 X 2
56.	122.385	Box Culvert	3 X 2.5
57.	123.150	Box Culvert	4 X 2.5
58.	123.965	Box Culvert	3 X 2.5
59.	124.642	Box Culvert	3 X 2.5
60.	125.180	Box Culvert	3 X 2.5
61.	126.640	Box Culvert	3 X 2.5
62.	127.130	Box Culvert	3 X 2.5
63.	128.240	Box Culvert	2 X 2
64.	131.490	Box Culvert	3 X 2.5

Sl. No	Chainage	Structure	Span
65.	132.420	Box Culvert	3 X 2.5
66.	133.555	Box Culvert	3 X 2.5
67.	134.625	Box Culvert	2 X 2
68.	136.120	Box Culvert	3 X 2.5
69.	136.800	Box Culvert	3 X 2.5
70.	137.305	Box Culvert	3 X 2.5
71.	138.070	Box Culvert	2 X 2
72.	138.150	Box Culvert	2 X 2
73.	139.475	Box Culvert	3 X 2.5
74.	140.300	Box Culvert	3 X 2.5
75.	140.800	Box Culvert	3 X 2.5
76.	141.370	Box Culvert	2 X 2
77.	142.200	Box Culvert	3 X 2.5
78.	142.760	Box Culvert	2 X 2
79.	143.048	Box Culvert	2 X 2
80.	144.000	Box Culvert	2 X 2

3.7.9 Other Structures

One Water Pipeline protection portal is proposed as per the details below:

Chainage (km)	Span (m)	Remark
95.300	40 + 30 + 125 + 50	Water Pipeline Protection Portal

Annexure 3.1: Horizontal Curve Details

HIP / Curve No.	HIP		Deflection			Element	Start			End			Length (m)	Bearing (dd mm ss)	Hand of Arc	Design Speed (KM/H)	Radius (m)	Superelevation (%)
	Easting	Northing	Deg	Min	Sec		Chainage (m)	Easting	Northing	Chainage (m)	Easting	Northing						
						Start	78900.000	750796.073	1403530.662	79114.854	750953.312	1403384.244	214.854					
1	751063.186	1403281.933	351	24	50.8	Arc	79114.854	750953.312	1403384.244	79414.558	751187.103	1403197.171	299.704		Left	100	-2000	-2.500%
						Straight	79414.558	751187.103	1403197.171	81312.665	752753.762	1402125.541	1898.107	124 22 22.8				
						Transition	81312.665	752753.762	1402125.541	81412.665	752835.009	1402067.274	100.000					
2	752896.747	1402027.735	18	38	59.6	Arc	81412.665	752835.009	1402067.274	81556.792	752939.051	1401967.857	144.127		Right	100	750	5.000%
						Transition	81556.792	752939.051	1401967.857	81656.792	753000.948	1401889.341	100.000					
						Straight	81656.792	753000.948	1401889.341	82837.011	753710.845	1400946.493	1180.219	143 1 22.4				
						Transition	82837.011	753710.845	1400946.493	82937.011	753768.911	1400865.111	100.000					
3	753788.904	1400842.818	13	58	55.5	Arc	82937.011	753768.911	1400865.111	82995.632	753798.200	1400814.353	58.621		Right	100	650	5.000%
						Transition	82995.632	753798.200	1400814.353	83095.632	753839.601	1400723.355	100.000					
						Straight	83095.632	753839.601	1400723.355	83595.829	754035.004	1400262.904	500.197	157 0 17.9				
						Transition	83595.829	754035.004	1400262.904	83645.829	754054.918	1400217.043	50.000					
4	754077.307	1400163.220	350	28	43	Arc	83645.829	754054.918	1400217.043	83762.008	754108.993	1400114.289	116.179		Left	100	-1000	4.444%
						Transition	83762.008	754108.993	1400114.289	83812.008	754135.517	1400071.906	50.000					
						Straight	83812.008	754135.517	1400071.906	84542.519	754528.197	1399455.911	730.511	147 29 1				
						Transition	84542.519	754528.197	1399455.911	84632.519	754578.303	1399381.172	90.000					
5	754679.840	1399218.030	319	56	48.4	Arc	84632.519	754578.303	1399381.172	84996.909	754863.786	1399162.453	364.390		Left	100	-650	5.000%
						Transition	84996.909	754863.786	1399162.453	85086.909	754948.990	1399133.526	90.000					
						Straight	85086.909	754948.990	1399133.526	85783.185	755613.295	1398924.959	696.276	107 25 49.4				
						Transition	85783.185	755613.295	1398924.959	85833.185	755660.871	1398909.585	50.000					
6	755808.565	1398863.651	20	22	8.8	Arc	85833.185	755660.871	1398909.585	86138.694	755930.525	1398768.524	305.509		Right	100	1000	4.444%
						Transition	86138.694	755930.525	1398768.524	86188.694	755970.286	1398738.210	50.000					
						Straight	86188.694	755970.286	1398738.210	87420.036	756943.244	1397983.520	1231.342	127 47 58.2				
7	757077.887	1397879.082	9	44	22.6	Arc	87420.036	756943.244	1397983.520	87760.013	757192.921	1397753.373	339.977		Right	100	2000	-2.500%
						Straight	87760.013	757192.921	1397753.373	87862.845	757262.342	1397677.509	102.832	137 32 20.8				
8	757488.385	1397430.488	358	4	54.2	Arc	87862.845	757262.342	1397677.509	88532.454	757722.570	1397191.172	669.609		Left	100	-20000	-2.500%
						Straight	88532.454	757722.570	1397191.172	89124.522	758136.665	1396768.005	592.068	135 37 15				
9	758786.973	1396103.449	310	7	56.5	Arc	89124.522	758136.665	1396768.005	90865.231	759714.224	1396172.303	1740.709		Left	100	-2000	-2.500%
						Straight	90865.231	759714.224	1396172.303	91912.468	760758.586	1396249.854	1047.237	85 45 11.5				
10	760836.145	1396255.614	1	46	56.2	Arc	91912.468	760758.586	1396249.854	92068.001	760913.846	1396258.958	155.533		Right	100	5000	-2.500%
						Straight	92068.001	760913.846	1396258.958	93908.572	762752.715	1396338.104	1840.571	87 32 7.7				
11	762910.332	1396344.888	350	58	46.3	Arc	93908.572	762752.715	1396338.104	94223.446	763064.936	1396376.300	314.874		Left	100	-2000	-2.500%
						Straight	94223.446	763064.936	1396376.300	95241.887	764062.984	1396579.083	1018.441	78 30 54				
12	764242.282	1396615.513	10	27	13.8	Arc	95241.887	764062.984	1396579.083	95606.794	764425.214	1396618.805	364.907		Right	100	2000	-2.500%
						Straight	95606.794	764425.214	1396618.805	97223.881	766042.039	1396647.907	1617.087	88 58 7.8				
13	766376.879	1396653.934	352	20	10.5	Arc	97223.881	766042.039	1396647.907	97892.669	766707.923	1396704.561	668.788		Left	100	-5000	-2.500%
						Straight	97892.669	766707.923	1396704.561	99631.418	768426.689	1396967.413	1738.749	81 18 18.3				

HIP / Curve No.	HIP		Deflection			Element	Start			End			Length (m)	Bearing (dd mm ss)	Hand of Arc	Design Speed (KM/H)	Radius (m)	Superelevation (%)
	Easting	Northing	Deg	Min	Sec		Chainage (m)	Easting	Northing	Chainage (m)	Easting	Northing						
14	769153.026	1397078.492	16	43	13	Arc	99631.418	768426.689	1396967.413	101090.538	769880.612	1396975.908	1459.120		Right	100	5000	-2.500%
						Straight	101090.538	769880.612	1396975.908	103287.947	772056.501	1396669.124	2197.409	98 1 31.3				
15	772864.304	1396555.230	341	28	0.1	Arc	103287.947	772056.501	1396669.124	104905.282	773666.416	1396704.008	1617.335		Left	100	-5000	-2.500%
						Straight	104905.282	773666.416	1396704.008	105175.519	773932.120	1396753.291	270.237	79 29 31.5				
16	774056.052	1396776.278	7	12	44.3	Arc	105175.519	773932.120	1396753.291	105427.276	774181.889	1396783.524	251.757		Right	100	2000	-2.500%
						Straight	105427.276	774181.889	1396783.524	105934.658	774688.431	1396812.692	507.382	86 42 15.8				
						Transition	105934.658	774688.431	1396812.692	105999.658	774753.266	1396817.255	65.000					
17	774968.928	1396828.844	327	25	9.3	Arc	105999.658	774753.266	1396817.255	106418.003	775143.440	1396956.082	418.345		Left	100	-850	5.000%
						Transition	106418.003	775143.440	1396956.082	106483.003	775196.586	1396993.498	65.000					
						Straight	106483.003	775196.586	1396993.498	107440.522	775972.448	1397554.641	957.519	54 7 25.1				
						Transition	107440.522	775972.448	1397554.641	107475.522	776000.728	1397575.263	35.000					
18	776302.922	1397793.657	330	49	37.9	Arc	107475.522	776000.728	1397575.263	108204.264	776460.081	1398131.766	728.742		Left	100	-1500	2.963%
						Transition	108204.264	776460.081	1398131.766	108239.264	776474.969	1398163.441	35.000					
						Straight	108239.264	776474.969	1398163.441	109243.723	776898.690	1399074.154	1004.459	24 57 3				
						Transition	109243.723	776898.690	1399074.154	109278.723	776913.578	1399105.830	35.000					
19	777040.804	1399379.601	24	2	23.9	Arc	109278.723	776913.578	1399105.830	109873.089	777268.700	1399577.592	594.366		Right	100	1500	2.963%
						Transition	109873.089	777268.700	1399577.592	109908.089	777295.022	1399600.661	35.000					
						Straight	109908.089	777295.022	1399600.661	110393.149	777661.050	1399918.948	485.060	48 59 27				
						Transition	110393.149	777661.050	1399918.948	110483.149	777727.836	1399979.259	90.000					
20	777853.566	1400086.353	330	34	53	Arc	110483.149	777727.836	1399979.259	110803.910	777907.300	1400242.525	320.761		Left	100	-800	5.000%
						Transition	110803.910	777907.300	1400242.525	110893.910	777939.030	1400326.733	90.000					
						Straight	110893.910	777939.030	1400326.733	111129.856	778018.071	1400549.046	235.946	19 34 20				
						Transition	111129.856	778018.071	1400549.046	111219.856	778049.800	1400633.254	90.000					
21	778066.29	1400684.67	14	5	38.2	Arc	111219.856	778049.800	1400633.254	111326.644	778097.612	1400728.652	106.788		Right	100	800	5.000%
						Transition	111326.644	778097.612	1400728.652	111416.644	778146.084	1400804.469	90.000					
						Straight	111416.644	778146.084	1400804.469	111948.808	778441.090	1401247.379	532.164	33 39 58.1				
22	778507.113	1401346.502	353	11	3.3	Arc	111948.808	778441.090	1401247.379	112186.723	778560.905	1401452.760	237.915		Left	100	-2000	-2.500%
						Straight	112186.723	778560.905	1401452.760	112791.393	778834.012	1401992.240	604.670	26 51 1.4				
						Transition	112791.393	778834.012	1401992.240	112871.393	778871.595	1402062.848	80.000					
23	778918.186	1402158.514	25	21	56.2	Arc	112871.393	778871.595	1402062.848	113079.157	779003.279	1402222.405	207.764		Right	100	650	5.000%
						Transition	113079.157	779003.279	1402222.405	113159.157	779065.476	1402272.698	80.000					
						Straight	113159.157	779065.476	1402272.698	113797.763	779570.183	1402663.963	638.606	52 12 57.7				
						Transition	113797.763	779570.183	1402663.963	113887.763	779640.006	1402720.719	90.000					
24	779729.943	1402787.814	332	50	15.2	Arc	113887.763	779640.006	1402720.719	114105.911	779775.570	1402890.325	218.148		Left	100	-650	5.000%
						Transition	114105.911	779775.570	1402890.325	114195.911	779815.544	1402970.939	90.000					
						Straight	114195.911	779815.544	1402970.939	114225.366	779828.017	1402997.623	29.455	25 3 12.9				
						Transition	114225.366	779828.017	1402997.623	114315.366	779868.326	1403078.062	90.000					

HIP / Curve No.	HIP		Deflection			Element	Start			End			Length (m)	Bearing (dd mm ss)	Hand of Arc	Design Speed (KM/H)	Radius (m)	Superelevation (%)
	Easting	Northing	Deg	Min	Sec		Chainage (m)	Easting	Northing	Chainage (m)	Easting	Northing						
25	779878.511	1403105.643	15	21	34.7	Arc	114315.366	779868.326	1403078.062	114372.808	779899.373	1403126.360	57.442		Right	100	550	5.000%
						Transition	114372.808	779899.373	1403126.360	114462.808	779955.813	1403196.429	90.000					
						Straight	114462.808	779955.813	1403196.429	114603.783	780047.206	1403303.766	140.975	40 24 47.6				
						Transition	114603.783	780047.206	1403303.766	114703.783	780109.435	1403381.988	100.000					
26	780149.366	1403423.747	335	44	59.4	Arc	114703.783	780109.435	1403381.988	114815.406	780162.224	1403480.077	111.623		Left	100	-500	5.000%
						Transition	114815.406	780162.224	1403480.077	114915.406	780193.232	1403575.101	100.000					
						Straight	114915.406	780193.232	1403575.101	115137.119	780254.951	1403788.050	221.713	16 9 47				
						Transition	115137.119	780254.951	1403788.050	115227.119	780284.906	1403872.792	90.000					
27	780287.856	1403901.585	31	19	13.4	Arc	115227.119	780284.906	1403872.792	115279.247	780312.347	1403917.010	52.128		Right	80	260	5.000%
						Transition	115279.247	780312.347	1403917.010	115369.247	780374.984	1403981.469	90.000					
						Straight	115369.247	780374.984	1403981.469	115375.927	780379.909	1403985.984	6.680	47 29 0.5				
						Transition	115375.927	780379.909	1403985.984	115465.927	780442.546	1404050.443	90.000					
28	780458.37	1404057.922	333	30	50	Arc	115465.927	780442.546	1404050.443	115496.118	780459.523	1404075.387	30.191		Left	80	-260	-2.500%
						Transition	115496.118	780459.523	1404075.387	115586.118	780496.513	1404157.303	90.000					
						Straight	115586.118	780496.513	1404157.303	115617.080	780507.608	1404186.209	30.962	20 59 50.5				
29	780568.184	1404344.036	350	20	13.2	Arc	115617.080	780507.608	1404186.209	115954.382	780601.408	1404509.791	337.302		Left	80	-2000	-2.500%
						Straight	115954.382	780601.408	1404509.791	116160.867	780641.989	1404712.248	206.485	11 20 3.7				
						Transition	116160.867	780641.989	1404712.248	116220.867	780655.245	1404770.750	60.000					
30	780669.514	1404849.569	30	44	25.3	Arc	116220.867	780655.245	1404770.750	116375.475	780724.293	1404908.009	154.608		Right	80	400	-2.500%
						Transition	116375.475	780724.293	1404908.009	116435.475	780763.363	1404953.525	60.000					
						Straight	116435.475	780763.363	1404953.525	116458.631	780778.880	1404970.713	23.156	42 4 29				
						Transition	116458.631	780778.880	1404970.713	116518.631	780817.950	1405016.229	60.000					
31	780875.622	1405077.875	328	6	48.6	Arc	116518.631	780817.950	1405016.229	116681.241	780889.076	1405161.214	162.610		Left	80	-400	-2.500%
						Transition	116681.241	780889.076	1405161.214	116741.241	780901.159	1405219.970	60.000					
						Straight	116741.241	780901.159	1405219.970	116814.362	780914.093	1405291.938	73.121	10 11 17.6				
						Transition	116814.362	780914.093	1405291.938	116874.362	780926.176	1405350.694	60.000					
32	780931.997	1405391.559	20	10	24.5	Arc	116874.362	780926.176	1405350.694	116955.199	780954.140	1405426.393	80.837		Right	80	400	-2.500%
						Transition	116955.199	780954.140	1405426.393	117015.199	780983.157	1405478.893	60.000					
						Straight	117015.199	780983.157	1405478.893	117245.615	781099.622	1405677.708	230.416	30 21 42.2				
						Transition	117245.615	781099.622	1405677.708	117280.615	781117.136	1405708.010	35.000					
33	781189.6	1405831.306	341	45	47.1	Arc	117280.615	781117.136	1405708.010	117563.909	781219.439	1405971.172	283.294		Left	80	-1000	-2.500%
						Transition	117563.909	781219.439	1405971.172	117598.909	781226.990	1406005.348	35.000					
						Straight	117598.909	781226.990	1406005.348	117604.333	781228.129	1406010.650	5.424	12 7 29.2				
						Transition	117604.333	781228.129	1406010.650	117664.333	781242.190	1406068.964	60.000					
34	781250.03	1406112.595	21	1	11.2	Arc	117664.333	781242.190	1406068.964	117751.078	781275.509	1406148.871	86.745		Right	80	400	-2.500%
						Transition	117751.078	781275.509	1406148.871	117811.078	781307.041	1406199.900	60.000					
						Straight	117811.078	781307.041	1406199.900	117843.822	781324.943	1406227.316	32.744	33 8 40.4				

HIP / Curve No.	HIP		Deflection			Element	Start			End			Length (m)	Bearing (dd mm ss)	Hand of Arc	Design Speed (KM/H)	Radius (m)	Superelevation (%)
	Easting	Northing	Deg	Min	Sec		Chainage (m)	Easting	Northing	Chainage (m)	Easting	Northing						
						Transition	117843.822	781324.943	1406227.316	117893.822	781352.972	1406268.715	50.000					
35	781370.842	1406297.606	13	26	34.1	Arc	117893.822	781352.972	1406268.715	117961.132	781396.085	1406320.340	67.310		Right	80	500	-2.500%
						Transition	117961.132	781396.085	1406320.340	118011.132	781431.824	1406355.299	50.000					
						Straight	118011.132	781431.824	1406355.299	118077.504	781480.038	1406400.913	66.372	46 35 14.5				
						Transition	118077.504	781480.038	1406400.913	118137.504	781522.569	1406443.214	60.000					
36	781627.4	1406540.328	313	17	40.4	Arc	118137.504	781522.569	1406443.214	118403.570	781625.607	1406683.218	266.066		Left	80	-400	-2.500%
						Transition	118403.570	781625.607	1406683.218	118463.570	781626.982	1406743.187	60.000					
						Straight	118463.570	781626.982	1406743.187	118769.058	781626.353	1407048.675	305.488	359 52 54.8				
						Transition	118769.058	781626.353	1407048.675	118849.058	781629.739	1407128.540	80.000					
37	781625.691	1407369.741	86	6	11.9	Arc	118849.058	781629.739	1407128.540	119219.894	781866.556	1407383.087	370.836		Right	80	300	-2.500%
						Transition	119219.894	781866.556	1407383.087	119299.894	781945.970	1407392.220	80.000					
						Straight	119299.894	781945.970	1407392.220	119478.505	782124.142	1407404.726	178.611	85 59 6.7				
						Transition	119478.505	782124.142	1407404.726	119513.505	782159.030	1407407.515	35.000					
38	782193.928	1407409.624	350	0	28.9	Arc	119513.505	782159.030	1407407.515	119583.140	782227.767	1407418.416	69.635		Left	80	-600	-2.500%
						Transition	119583.140	782227.767	1407418.416	119618.140	782261.806	1407426.556	35.000					
						Straight	119618.140	782261.806	1407426.556	119808.797	782446.794	1407472.702	190.657	75 59 35.7				
						Transition	119808.797	782446.794	1407472.702	119863.797	782500.439	1407484.785	55.000					
39	782569.424	1407503.292	27	45	8.8	Arc	119863.797	782500.439	1407484.785	120002.546	782638.492	1407485.100	138.749		Right	80	400	-2.500%
						Transition	120002.546	782638.492	1407485.100	120057.546	782692.191	1407473.261	55.000					
						Straight	120057.546	782692.191	1407473.261	120193.057	782823.821	1407441.062	135.511	103 44 44.5				
						Transition	120193.057	782823.821	1407441.062	120283.057	782912.213	1407424.774	90.000					
40	783031.002	1407390.382	294	25	6.6	Arc	120283.057	782912.213	1407424.774	120490.656	783103.278	1407490.731	207.599		Left	80	-260	-2.500%
						Transition	120490.656	783103.278	1407490.731	120580.656	783162.798	1407558.079	90.000					
						Straight	120580.656	783162.798	1407558.079	120931.807	783379.780	1407834.169	351.151	38 9 51				
						Transition	120931.807	783379.780	1407834.169	121021.807	783436.625	1407903.930	90.000					
41	783682.484	1408219.333	55	13	56.6	Arc	121021.807	783436.625	1407903.930	121751.196	784081.592	1408194.055	729.389		Right	100	850	-2.500%
						Transition	121751.196	784081.592	1408194.055	121841.196	784171.502	1408190.310	90.000					
						Straight	121841.196	784171.502	1408190.310	122354.263	784683.668	1408159.912	513.067	93 23 47.7				
42	784862.508	1408149.298	353	9	53.6	Arc	122354.263	784683.668	1408159.912	122712.148	785041.340	1408160.043	357.885		Left	100	-3000	-2.500%
						Straight	122712.148	785041.340	1408160.043	124066.149	786392.904	1408241.253	1354.001	86 33 41.3				
43	787800.494	1408325.829	58	51	1.7	Arc	124066.149	786392.904	1408241.253	126633.985	788600.984	1407164.934	2567.836		Right	100	2500	-2.500%
						Straight	126633.985	788600.984	1407164.934	128919.008	789898.129	1405283.778	2285.023	145 24 43				
44	790296.287	1404706.357	340	6	32.1	Arc	128919.008	789898.129	1405283.778	130307.667	790867.149	1404298.851	1388.659		Left	100	-4000	-2.500%
						Straight	130307.667	790867.149	1404298.851	131971.194	792221.101	1403332.343	1663.527	125 31 15.1				
45	793499.543	1402419.736	34	52	49	Arc	131971.194	792221.101	1403332.343	135015.073	794026.425	1400939.986	3043.879		Right	100	5000	-2.500%

Annexure 3.2: Vertical Curve Details

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
1				Grade	78900.000	672.042	78962.862	673.613	2.500				62.862
2	79295.362	681.926	-4.900	Hog Curve	78962.862	673.613	79627.862	673.946		-13571	-0.737	135.713	665.000
3				Grade	79627.862	673.946	79736.779	671.332	-2.400				108.917
4	79796.779	669.892	1.600	Sag Curve	79736.779	671.332	79856.779	669.412		7500	1.333	74.999	120.000
5				Grade	79856.779	669.412	80880.127	661.225	-0.800				1023.348
6	80930.127	660.825	1.534	Sag Curve	80880.127	661.225	80980.127	661.192		6519	1.534	65.195	100.000
7				Grade	80980.127	661.192	81468.346	664.775	0.734				488.219
8	81653.346	666.133	-2.688	Hog Curve	81468.346	664.775	81838.346	662.517		-13763	-0.727	137.633	370.000
9				Grade	81838.346	662.517	82037.200	658.630	-1.954				198.854
10	82137.199	656.676	2.454	Sag Curve	82037.200	658.630	82237.200	657.176		8149	1.227	81.485	200.000
11				Grade	82237.200	657.176	83529.522	663.638	0.500				1292.322
12	83629.523	664.138	-1.200	Hog Curve	83529.522	663.638	83729.522	663.438		-16667	-0.600	166.667	200.000
13				Grade	83729.522	663.438	84111.195	660.766	-0.700				381.673
14	84211.195	660.066	2.200	Sag Curve	84111.195	660.766	84311.195	661.566		9091	1.100	90.909	200.000
15				Grade	84311.195	661.566	84497.865	664.366	1.500				186.670
16	84772.865	668.491	-4.000	Hog Curve	84497.865	664.366	85047.865	661.616		-13750	-0.727	137.497	550.000
17				Grade	85047.865	661.616	85181.970	658.263	-2.500				134.105
18	85291.970	655.513	4.500	Sag Curve	85181.970	658.263	85401.970	657.713		4889	2.046	48.888	220.000
19				Grade	85401.970	657.713	85441.021	658.494	2.000				39.051
20	85716.021	663.994	-4.000	Hog Curve	85441.021	658.494	85991.021	658.494		-13750	-0.727	137.501	550.000
21				Grade	85991.021	658.494	86164.284	655.028	-2.000				173.263
22	86214.284	654.028	1.500	Sag Curve	86164.284	655.028	86264.284	653.778		6667	1.500	66.667	100.000
23				Grade	86264.284	653.778	87362.559	648.287	-0.500				1098.275

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
24	87412.559	648.037	1.500	Sag Curve	87362.559	648.287	87462.559	648.537		6667	1.500	66.667	100.000
25				Grade	87462.559	648.537	87606.335	649.975	1.000				143.776
26	87716.335	651.075	-1.552	Hog Curve	87606.335	649.975	87826.335	650.468		-14175	-0.705	141.749	220.000
27				Grade	87826.335	650.468	88720.437	645.532	-0.552				894.102
28	88820.437	644.980	1.225	Sag Curve	88720.437	645.532	88920.437	645.653		16326	0.613	163.260	200.000
29				Grade	88920.437	645.653	89822.104	651.721	0.673				901.667
30	90072.103	653.403	-2.076	Hog Curve	89822.104	651.721	90322.104	649.895		-24082	-0.415	240.819	500.000
31				Grade	90322.104	649.895	90698.269	644.617	-1.403				376.165
32	90798.270	643.214	2.922	Sag Curve	90698.269	644.617	90898.269	644.732		6845	1.461	68.451	200.000
33				Grade	90898.269	644.732	91328.335	651.263	1.519				430.066
34	91513.335	654.072	-2.341	Hog Curve	91328.335	651.263	91698.335	652.550		-15803	-0.633	158.035	370.000
35				Grade	91698.335	652.550	92361.213	647.097	-0.823				662.878
36	92451.213	646.357	1.823	Sag Curve	92361.213	647.097	92541.213	647.257		9875	1.013	98.755	180.000
37				Grade	92541.213	647.257	92884.686	650.691	1.000				343.473
38	92934.686	651.191	1.062	Sag Curve	92884.686	650.691	92984.686	652.222		9420	1.062	94.200	100.000
39				Grade	92984.686	652.222	94324.535	679.844	2.062				1339.849
40	94434.535	682.112	-1.062	Hog Curve	94324.535	679.844	94544.535	683.212		-20724	-0.483	207.241	220.000
41				Grade	94544.535	683.212	94936.505	687.131	1.000				391.970
42	94986.505	687.631	1.500	Sag Curve	94936.505	687.131	95036.505	688.881		6667	1.500	66.667	100.000
43				Grade	95036.505	688.881	96713.601	730.809	2.500				1677.096
44	97013.601	738.309	-4.400	Hog Curve	96713.601	730.809	97313.601	732.609		-13636	-0.733	136.364	600.000
45				Grade	97313.601	732.609	98477.733	710.490	-1.900				1164.132
46	98552.734	709.065	1.400	Sag Curve	98477.733	710.490	98627.733	708.690		10714	0.933	107.143	150.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
47				Grade	98627.733	708.690	99131.442	706.172	-0.500				503.709
48	99271.442	705.472	-2.000	Hog Curve	99131.442	706.172	99411.442	701.972		-14000	-0.714	139.999	280.000
49				Grade	99411.442	701.972	99775.153	692.879	-2.500				363.711
50	99925.153	689.129	5.000	Sag Curve	99775.153	692.879	100075.153	692.879		6000	1.667	60.000	300.000
51				Grade	100075.153	692.879	100152.671	694.817	2.500				77.518
52	100492.671	703.317	-5.000	Hog Curve	100152.671	694.817	100832.671	694.817		-13600	-0.735	136.001	680.000
53				Grade	100832.671	694.817	101059.316	689.151	-2.500				226.645
54	101089.316	688.401	0.500	Sag Curve	101059.316	689.151	101119.316	687.801		12000	0.833	120.000	60.000
55				Grade	101119.316	687.801	101594.560	678.296	-2.000				475.244
56	101744.560	675.296	4.000	Sag Curve	101594.560	678.296	101894.560	678.296		7500	1.333	75.000	300.000
57				Grade	101894.560	678.296	102471.799	689.841	2.000				577.239
58	102521.799	690.841	-0.900	Hog Curve	102471.799	689.841	102571.799	691.391		-11111	-0.900	111.111	100.000
59				Grade	102571.799	691.391	104041.335	707.556	1.100				1469.536
60	104316.335	710.581	-2.600	Hog Curve	104041.335	707.556	104591.335	706.456		-21154	-0.473	211.537	550.000
61				Grade	104591.335	706.456	105455.101	693.499	-1.500				863.766
62	105555.101	691.999	2.500	Sag Curve	105455.101	693.499	105655.101	692.999		8000	1.250	80.000	200.000
63				Grade	105655.101	692.999	106478.335	701.231	1.000				823.234
64	106603.335	702.481	-1.850	Hog Curve	106478.335	701.231	106728.335	701.419		-13514	-0.740	135.135	250.000
65				Grade	106728.335	701.419	108068.042	690.031	-0.850				1339.707
66	108168.042	689.181	2.450	Sag Curve	108068.042	690.031	108268.042	690.781		8163	1.225	81.633	200.000
67				Grade	108268.042	690.781	109458.517	709.829	1.600				1190.475
68	109548.517	711.269	-1.100	Hog Curve	109458.517	709.829	109638.517	711.719		-16364	-0.611	163.637	180.000
69				Grade	109638.517	711.719	110862.740	717.840	0.500				1224.223

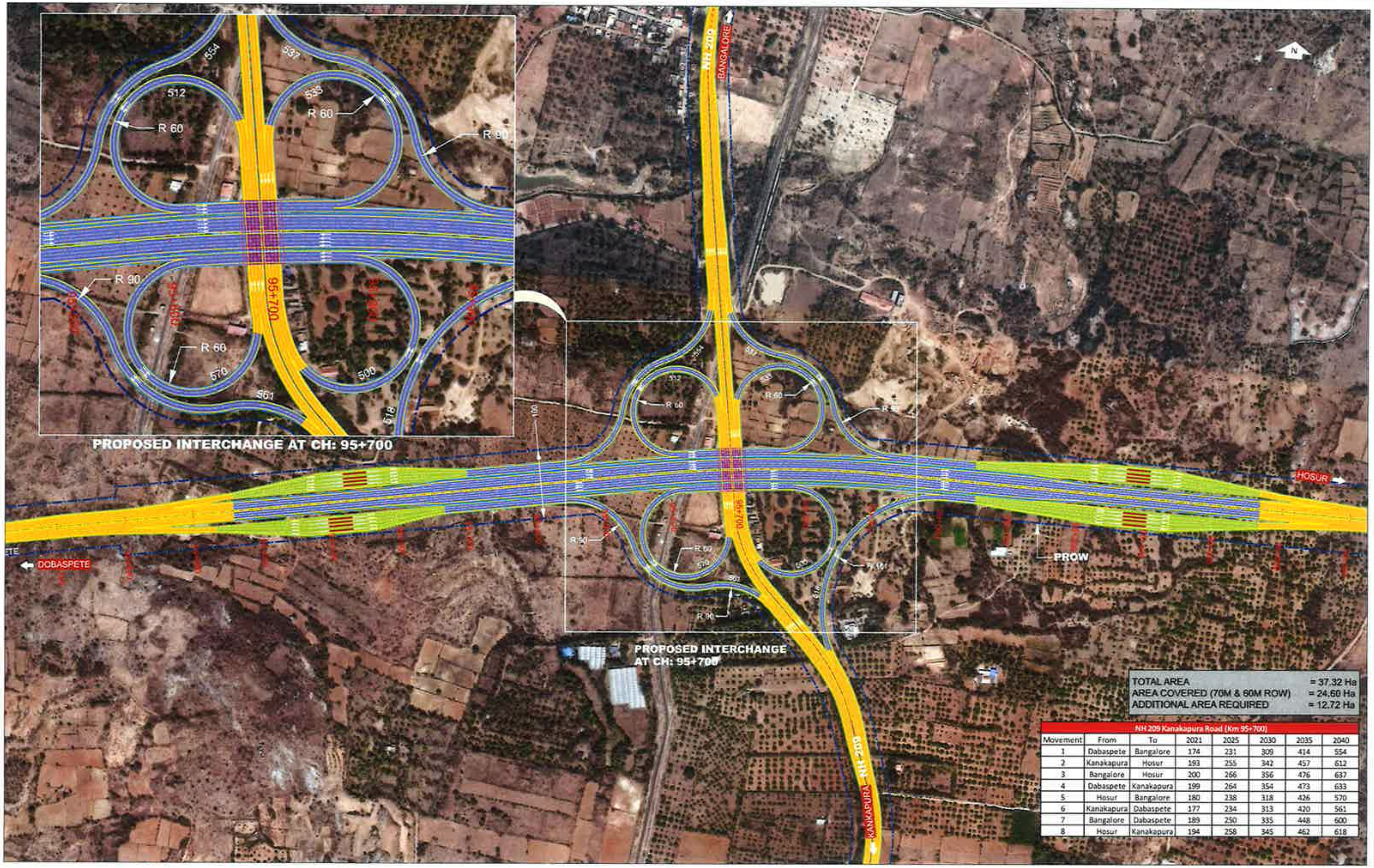
S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
70	110937.740	718.215	2.000	Sag Curve	110862.740	717.840	111012.740	720.090		7500	1.333	75.000	150.000
71				Grade	111012.740	720.090	111360.668	728.788	2.500				347.928
72	111670.668	736.538	-4.500	Hog Curve	111360.668	728.788	111980.668	730.338		-13778	-0.726	137.777	620.000
73				Grade	111980.668	730.338	112051.863	728.914	-2.000				71.195
74	112201.863	725.914	5.000	Sag Curve	112051.863	728.914	112351.863	730.414		6000	1.667	60.000	300.000
75				Grade	112351.863	730.414	114871.741	806.011	3.000				2519.878
76	115171.741	815.011	-3.608	Hog Curve	114871.741	806.011	115471.741	813.188		-16632	-0.601	166.320	600.000
77				Grade	115471.741	813.188	118092.286	797.268	-0.608				2620.545
78	118342.286	795.749	3.908	Sag Curve	118092.286	797.268	118592.286	803.999		12796	0.782	127.959	500.000
79				Grade	118592.286	803.999	120632.094	871.313	3.300				2039.808
80	120882.094	879.563	-2.100	Hog Curve	120632.094	871.313	121132.094	882.563		-23810	-0.420	238.095	500.000
81				Grade	121132.094	882.563	121555.606	887.645	1.200				423.512
82	121805.606	890.645	-3.700	Hog Curve	121555.606	887.645	122055.606	884.395		-13514	-0.740	135.135	500.000
83				Grade	122055.606	884.395	122212.218	880.480	-2.500				156.612
84	122337.218	877.355	3.500	Sag Curve	122212.218	880.480	122462.218	878.605		7143	1.400	71.429	250.000
85				Grade	122462.218	878.605	123084.548	884.828	1.000				622.330
86	123134.548	885.328	1.500	Sag Curve	123084.548	884.828	123184.548	886.578		6667	1.500	66.667	100.000
87				Grade	123184.548	886.578	123559.847	895.960	2.500				375.299
88	123699.848	899.460	-2.000	Hog Curve	123559.847	895.960	123839.847	900.160		-14000	-0.714	139.999	280.000
89				Grade	123839.847	900.160	124173.500	901.829	0.500				333.653
90	124233.500	902.129	1.729	Sag Curve	124173.500	901.829	124293.500	903.466		6940	1.441	69.402	120.000
91				Grade	124293.500	903.466	125524.601	930.908	2.229				1231.101
92	125649.601	933.694	-1.729	Hog Curve	125524.601	930.908	125774.601	934.319		-14459	-0.692	144.586	250.000

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
93				Grade	125774.601	934.319	126286.578	936.879	0.500				511.977
94	126396.578	937.429	-1.500	Hog Curve	126286.578	936.879	126506.578	936.329		-14667	-0.682	146.666	220.000
95				Grade	126506.578	936.329	126989.121	931.504	-1.000				482.543
96	127089.121	930.504	-1.000	Hog Curve	126989.121	931.504	127189.121	928.504		-20000	-0.500	200.000	200.000
97				Grade	127189.121	928.504	128582.122	900.644	-2.000				1393.001
98	128707.122	898.144	2.500	Sag Curve	128582.122	900.644	128832.122	898.769		10000	1.000	100.000	250.000
99				Grade	128832.122	898.769	129914.115	904.179	0.500				1081.993
100	129989.115	904.554	2.000	Sag Curve	129914.115	904.179	130064.115	906.429		7500	1.333	75.000	150.000
101				Grade	130064.115	906.429	131012.136	930.129	2.500				948.021
102	131162.136	933.879	-1.800	Hog Curve	131012.136	930.129	131312.136	934.929		-16667	-0.600	166.669	300.000
103				Grade	131312.136	934.929	132698.588	944.635	0.700				1386.452
104	132788.588	945.265	-1.200	Hog Curve	132698.588	944.635	132878.588	944.815		-15000	-0.667	149.997	180.000
105				Grade	132878.588	944.815	133470.718	941.854	-0.500				592.130
106	133570.718	941.354	1.734	Sag Curve	133470.718	941.854	133670.718	942.588		11536	0.867	115.363	200.000
107				Grade	133670.718	942.588	133925.205	945.727	1.234				254.487
108	134125.205	948.195	-2.839	Hog Curve	133925.205	945.727	134325.205	944.984		-14089	-0.710	140.887	400.000
109				Grade	134325.205	944.984	134563.048	941.165	-1.605				237.843
110	134663.048	939.560	4.105	Sag Curve	134563.048	941.165	134763.048	942.060		4872	2.053	48.715	200.000
111				Grade	134763.048	942.060	134995.103	947.861	2.500				232.055
112	135355.103	956.861	-5.300	Hog Curve	134995.103	947.861	135715.103	946.781		-13585	-0.736	135.849	720.000
113				Grade	135715.103	946.781	136940.946	912.457	-2.800				1225.843
114	137040.946	909.657	3.800	Sag Curve	136940.946	912.457	137140.946	910.657		5263	1.900	52.632	200.000
115				Grade	137140.946	910.657	138550.462	924.753	1.000				1409.516

S.No.	Vertical Intersection Points			Element	Vertical Tangent Points					Radius	M Value	K Value	Length of Element
	Chainage	Level	%Grade Diff.		Start Chainage	Level	End Chainage	Level	Grade (%)				
116	138600.462	925.253	0.200	Sag Curve	138550.462	924.753	138650.462	925.853		50000	0.200	500.000	100.000
117				Grade	138650.462	925.853	139577.329	936.975	1.200				926.867
118	139837.329	940.095	-3.700	Hog Curve	139577.329	936.975	140097.329	933.595		-14054	-0.712	140.540	520.000
119				Grade	140097.329	933.595	140622.945	920.455	-2.500				525.616
120	140732.945	917.705	2.000	Sag Curve	140622.945	920.455	140842.945	917.155		11000	0.909	110.000	220.000
121				Grade	140842.945	917.155	141074.584	915.996	-0.500				231.639
122	141199.584	915.371	2.500	Sag Curve	141074.584	915.996	141324.584	917.871		10000	1.000	100.000	250.000
123				Grade	141324.584	917.871	141895.881	929.297	2.000				571.297
124	142200.881	935.397	-4.460	Hog Curve	141895.881	929.297	142505.881	927.895		-13678	-0.731	136.776	610.000
125				Grade	142505.881	927.895	142946.981	917.045	-2.460				441.100
126	143021.981	915.200	-0.840	Hog Curve	142946.981	917.045	143096.981	912.725		-17853	-0.560	178.533	150.000
127				Grade	143096.981	912.725	144140.848	878.277	-3.300				1043.867
128	144340.848	871.677	4.100	Sag Curve	144140.848	878.277	144540.848	873.277		9756	1.025	97.561	400.000
129				Grade	144540.848	873.277	144637.130	874.047	0.800				96.282

Annexure 3.3: Interchange Option Drawings

- Figure 05A_Proposed IC OPTION-2 AT IC NH209_CH 95+360
- Figure 05_Proposed IC OPTION-2 AT IC SH35_CH 131+990
- Figure 01C_Proposed IC OPTION-1 AT IC SH17B _CH 139+260



TOTAL AREA	= 37.32 Ha
AREA COVERED (70M & 60M ROW)	= 24.60 Ha
ADDITIONAL AREA REQUIRED	= 12.72 Ha

NH 209 Kanakapura Road (Km 95+700)

Movement	From	To	2021	2025	2030	2035	2040
1	Dabaspete	Bangalore	174	231	309	414	554
2	Kanakapura	Hosur	193	255	342	457	612
3	Bangalore	Hosur	200	266	356	476	637
4	Dabaspete	Kanakapura	199	264	354	473	633
5	Hosur	Bangalore	180	238	318	426	570
6	Kanakapura	Dabaspete	177	234	313	420	561
7	Bangalore	Dabaspete	189	250	335	448	600
8	Hosur	Kanakapura	194	258	345	462	618

REV. NO.	DESCRIPTION	APVD
R1	COMMENTS AS PER RSC NHAI INCORPORATED	KM
R0	INITIAL SUBMISSION	KM

National Highways Authority of India (NHAI)

Louis Berger

CONSULTANCY SERVICES FOR PREPARATION OF DPR FOR DEVELOPMENT OF ECONOMIC CORRIDORS, INTER CORRIDORS, FEEDER ROUTES TO IMPROVE THE EFFICIENCY OF FREIGHT MOVEMENT IN INDIA UNDER BHARATMALA PARIYOJANA
LOT 3/ ANDHRA PRADESH, KARNATAKA, GOA & KERALA /PACKAGE 1

PROPOSED INTERCHANGE-OPTION-2
AT IC NH209 CH : 95+700

DRAWN:	DKR	DATE:	NOVEMBER 2016
DESIGNED:	IM	SCALE:	1 : 2500
CHECKED:	VA		
APPROVED:	KM		SCALE @ A1 SIZE SHEET

DRAWING NO:	SHEET NO.	REV.
FIGURE-05A		R1

TOTAL AREA = 20.31 Ha
AREA COVERED (70M ROW) = 13.83 Ha
ADDITIONAL AREA REQUIRED = 6.48 Ha

SH-35 Anekal-Denkanikottai (Km 132+300)

Movement	From	To	2021	2025	2030	2035	2040
1	Dabaspete	Anekal	188	249	333	446	596
2	Denkanikottai	Hosur	179	237	317	425	568
3	Anekal	Hosur	186	247	330	442	591
4	Dabaspete	Denkanikottai	191	253	338	453	606
5	Hosur	Anekal	179	237	317	424	567
6	Denkanikottai	Dabaspete	169	224	300	402	538
7	Anekal	Dabaspete	203	270	361	483	646
8	Hosur	Denkanikottai	193	256	343	459	615

REV. NO.	DESCRIPTION	APVD
R1	COMMENTS AS PER RSC NHAI INCORPORATED	KM
R0	INITIAL SUBMISSION	KM

National Highways Authority of India (NHAI)

Louis Berger

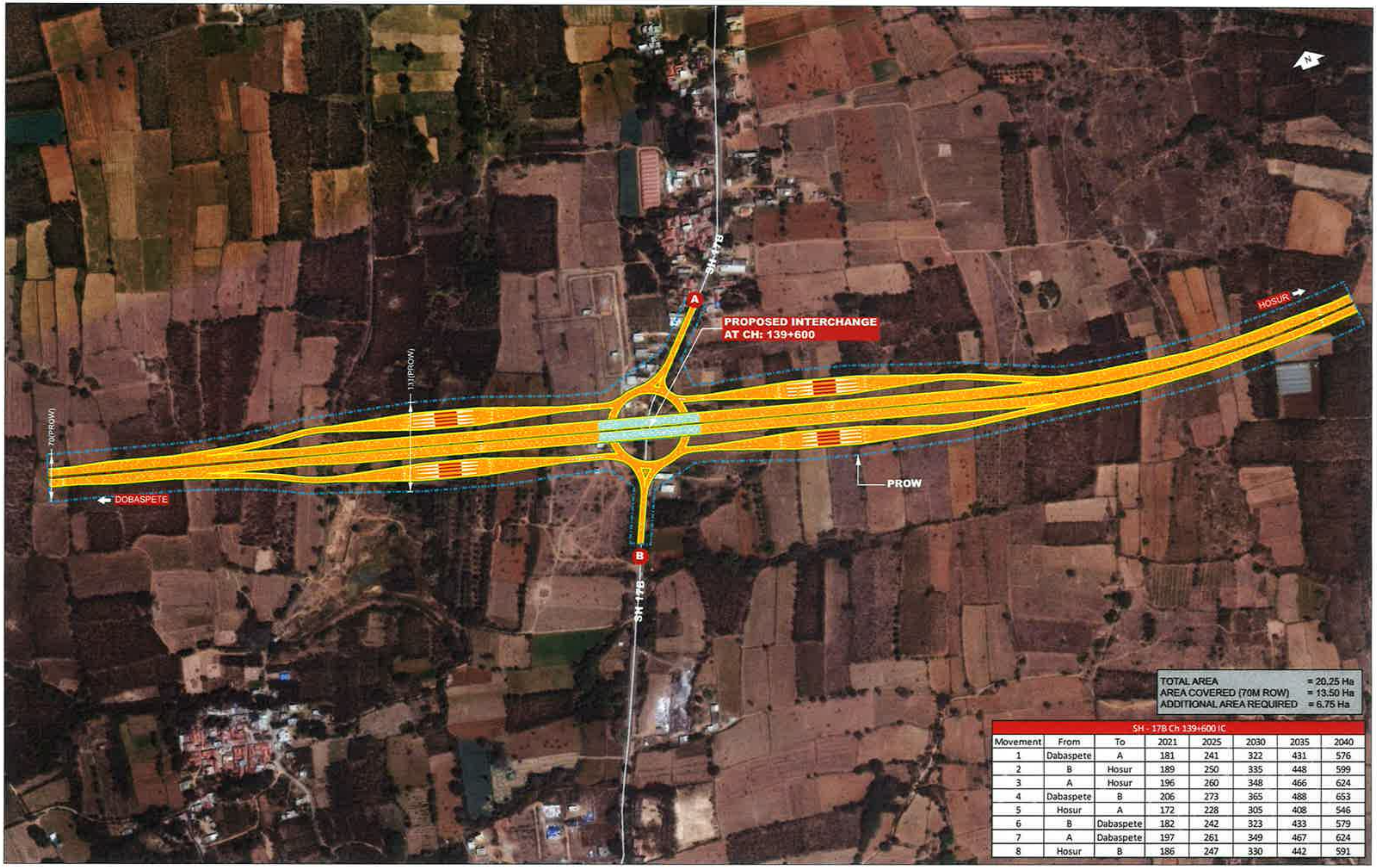
CONSULTANCY SERVICES FOR PREPARATION OF DPR FOR DEVELOPMENT OF ECONOMIC CORRIDORS, INTER CORRIDORS, FEEDER ROUTES TO IMPROVE THE EFFICIENCY OF FREIGHT MOVEMENT IN INDIA UNDER BHARATMALA PARIYOJANA
LOT 3/ ANDHRA PRADESH, KARNATAKA, GOA & KERALA /PACKAGE 1

PROPOSED INTERCHANGE-OPTION-3
AT IC SH35 CH : 132+300

DRAWN: DKR
DESIGNED: IM
CHECKED: VA
APPROVED: KM

DATE: NOVEMBER 2018
SCALE: 1 : 2500
SCALE @ A1 SIZE SHEET

DRAWING NO: FIGURE-05
SHEET NO.:
REV.: R1



TOTAL AREA	= 20.25 Ha
AREA COVERED (70M ROW)	= 13.50 Ha
ADDITIONAL AREA REQUIRED	= 6.75 Ha

SH - 17B Ch 139+600 IC							
Movement	From	To	2021	2025	2030	2035	2040
1	Dabaspete	A	181	241	322	431	576
2	B	Hosur	189	250	335	448	599
3	A	Hosur	196	260	348	466	624
4	Dabaspete	B	206	273	365	488	653
5	Hosur	A	172	228	305	408	546
6	B	Dabaspete	182	242	323	433	579
7	A	Dabaspete	197	261	349	467	624
8	Hosur	B	186	247	330	442	591

REV. NO. | DESCRIPTION | KM | APVD

National Highways Authority of India (NHAI)

Louis Berger

CONSULTANCY SERVICES FOR PREPARATION OF DPR FOR DEVELOPMENT OF ECONOMIC CORRIDORS, INTER CORRIDORS, FEEDER ROUTES TO IMPROVE THE EFFICIENCY OF FREIGHT MOVEMENT IN INDIA UNDER BHARATMALA PARIYOJANA
LOT 3/ ANDHRA PRADESH, KARNATAKA, GOA & KERALA /PACKAGE 1

PROPOSED INTERCHANGE-OPTION-1
AT IC SH17B CH : 139+600

DRAWN:	DKR	DATE:	OCTOBER 2018
DESIGNED:	IM	SCALE:	1 : 2500
CHECKED:	VA		
APPROVED:	KM	SCALE @ A1 SIZE SHEET	

DRAWING NO: FIGURE-01C | SHEET NO. | REV.

Chapter-4:
Methodology Adopted

TABLE OF CONTENTS

LIST OF TABLES

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CHAPTER-4: METHODOLOGY ADOPTED

4.1 GENERAL

The Feasibility Study aimed at evaluating the existing deficiencies of the project road in respect to functional, structural, efficiency and safety requirements for meeting the needs of projected traffic for the design period as per TOR. This carried out based on the findings from various surveys and investigations carried out, observations made and experiences gained from similar projects.

The feasibility study, in general, consists of:

- Traffic surveys
- Engineering Surveys and Investigations
- Environmental and Social Screening
- Outline of Design proposal
- Preliminary cost estimates
- Economic viability
- Financial viability

The methodology adopted in to carryout various tasks for the feasibility study discussed briefly in the following paragraphs. Outline of various proposals based on the results obtained from analysis surveys & investigations data, planning; designs for improvement of project road are separately dealt-with in relevant chapters. The broad methodology, prepared based on the Terms of Reference (TOR), has generally developed keeping IRC guidelines/standard practices.

Collection of available data

Secondary data especially with regard to socio-economic profile, past traffic trends, other relevant data have collected from various Government Departments and other bodies, reviewed, and used to the extent relevant and necessary. The historical data on traffic AND hydrology, to some extent, have collected from local PWD offices. The hydrology data has analysed for determining the flood discharges of various rivers / streams.

Data on accidents along the project road has collected from the respective police stations. This data has analysed to identify the black spots and stretches prone to accidents so to suggest mitigation measures.

Socio-economic profile

A thorough study of the socio-economic profile of the state and the project influence area (PIA) has carried out. The aspects include gender, local population, industry, agriculture employment, health, education, child labour etc.

Reconnaissance and Alignment

The consultants have made a study of the available land width (ROW), topographic survey maps of the project area and other relevant information collected.

A detailed reconnaissance survey has conducted on the total section of the project road and an assessment of possible alignment change at places, if required, has made. Detailed features such as land-use, habitation, water routes, canals, intersecting roads, railway lines, utilities such as OFC Cables, electrical lines (HT / LT), etc. have noted down. This has enabled the Consultants to visualize the possible problems likely to be encounter in surveys and investigations, design, and execution of the project. The detailed ground reconnaissance of project influence area has utilized for planning and programming the detailed surveys and investigations. Identification of homogenous sections has carried based on traffic data, pavement condition, and height of embankment. For each homogenous section, the related studies / surveys have carried out.

4.2 INVENTORY AND CONDITION SURVEY OF ROAD AND PAVEMENT

4.2.1 Road Inventory

Road inventory survey has carried out at 200m intervals along the project road to collect details of all the features of the existing road and pavement. The following aspects essentially been covered:

- Terrain
- Land use (built-up / agricultural / forest / industrial / barren)
- Village / Town
- Formation width
- Carriageway width - (type / width / condition)
- Shoulder (type / width / condition)
- Embankment height
- Submergence history, if any
- Details and configuration of major junctions.
- Details of cross roads
- Location of sharp curves
- List of important structures like temples, petrol pumps, weigh bridges, schools / colleges, passenger shelters, major buildings, industrial areas etc.
- Location of water bodies
- Right of way
- Culverts, bridges and other structures (type, size & span arrangement)
- Road side arboriculture
- Existing tree plantations
- Existing utility services on either side within ROW
- General drainage condition

As the proposed STRR is fully on Greenfield, the requirement of inventory and condition survey of road not envisaged.

4.2.2 Built-Up Area

The towns / villages falling on the project road mentioned in **Table 4.1**

Table 4-1: Built-up Stretches

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
1	1.500	Manne
2	4.100	Tattekere
3	6.700	Nijagal Kempohalli
4	7.100	Maddenahalli
5	8.200	Lakkuru
6	9.800	Agalakuppa
7	15.600	Hosapalya
8	23.300	Banawadi
9	28.200	Goruru
10	30.100	Gudemaranahalli Handpost
11	32.000	Gudemaranahalli
12	40.700	Byalakere
13	43.500	Magadi
14	52.400	Hanchikuppe
15	54.200	Atimgere
16	60.200	Gungarahalli
17	61.000	Melahalli
18	73.000	Basavanapura
19	74.300	Rampura Doddi
20	75.500	Ramanagara
21	81.000	Kunagal
22	85.700	Chikkenahalli
22	87.300	Anajawadi
23	89.300	Chikka Madhawadi
24	90.700	Alisab Doddi
25	93.000	Aralalusandra
26	96.300	Varager Halli
27	97.600	Chathra
28	104.000	Dodda Maralawadi
29	108.000	Banavasi
30	110.000	T. Maniyambal
31	125.000	Indalavadi
32	127.000	Thimmasandra
33	132.000	Vanakanahalli
34	135.000	Menasiganahalli
35	136.100	Muttur
36	142.600	Kappakollu

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
37	143.500	Payarakanahalli
38	145.500	S. Mudugandanahally
39	148.500	Golisandram
40	158.500	Thorapalli Agraharam
41	161.200	Kothur
42	161.800	Perandapalli
43	163.000	Kadirapalli
44	164.200	Alur
45	164.800	Dasapalle
46	167.200	Payarkuttalai
47	171.000	Nandimangalam
48	172.600	Attur
49	176.800	B. Mudaganahalli
50	179.600	Kadiriganadinna
51	180.500	Sampangere

4.2.3 Pavement Condition Survey

The proposed alignment is completely Greenfield and so payment Inventory and condition survey is not applicable.

4.2.4 Road Junction

There are number of major and minor road junctions exist in this section. All these junctions will be review and properly designed to cater for the future traffic as well in accordance with the Ministry's Type Designs for Intersections on national Highways. The details of major at grade road junctions along the proposed STRR given as below:

Table 4-2: Major cross roads

S No.	Chainage (km)	Description of Road	Type of Road	Cross Road (km)
1	0.000	Hoskote-Dabaspet	NH 207	131.250
2	1.500	Thyamagondlu-Sirganahalli	MDR	0.350
3	4.365	Yelekyathanahalli Road	MDR	4.500
4	7.110	Kanakapura-Koratagere	SH 3	129.990
5	8.900	Bangalore-Pune	NH 4/48	50.415
6	12.120	Honnenahalli-Sripathihalli	MDR	0.510
7	30.370	Bangalore-Mangaluru	NH 75/48	42.230
8	32.240	Gudemaranahalli-Pemmanahalli	MDR	2.400
9	33.640	Kanakapura-Koratagere	SH 3	104.100
10	44.475	Bangalore-Nagamangala	SH 85	47.120
11	45.370	Kanakapura-Koratagere	SH 3	93.100

S No.	Chainage (km)	Description of Road	Type of Road	Cross Road (km)
12	63.240	Kanakapura-Koratagere	SH 3	72.100
13	65.495	Jeeganahalli-Chikkanahalli	MDR	4.200
14	70.258	Bangalore-Mysuru	NH 275	318.120
15	78.110	Ramanagara-Mudhuwadi	MDR	4.910
16	97.690	Bangalore-Kollegal	NH 209	431.300
17	104.510	Harohalli-Dhodda Maralawadi	MDR	7.810
18	113.600	Harohalli-Indalavadi	MDR	11.200
19	132.300	Anekal-Thally Road	SH 35	51.500
20	138.590	Hosur-Thally Road	SH 17B	14.790
21	145.110	Hosur-Denkanikottai Road	SH 17A	12.210
22	152.360	Attibele-Rayakottai Road	SH 85	25.930
23	156.140	Rayakottai Road	SH 17	14.990
24	161.450	Bengaluru-Chennai	NH 44	48.020
25	174.450	Bagalur-Berikai Road	SH 17C	3.450

4.2.5 Railway Crossings & ROB

There are three railway level crossings/ROB exist in this stretch of the project road.

1. Km. 8.940

The proposed road alignment crosses the railway line at the km 51.000 of rail line of Tumkur - Yashwanthpur Section. Adjacent to railway line, NH4 also passes parallel to railways. The National Highway and railway line are at 20m distance apart. The existing railway track consists 2 lines (up line & down line) with no electrification. The nearest railway station is the Dobbaspet station.

2. Km 29.265

The proposed alignment crosses at km 28.200 of the railway line between Solur & Nelamangala Station of **Hassan-Yashwanthpur Section**. There existing rail track is of single line without electrification. There is an existing Underpass 50m away to proposed STRR alignment. The existing railway ROW is 45m.

3. Km 70.695

The proposed STRR alignment crosses the railway line at the km 38.900 of railway line between Ramanagara & Mayaganahalli Station of **Mysore to Yeshwanthpur Section).** The existing railway tracks both up and down lines are with electrification. The nearest town is Ramanagara. The national highway No, NH 267 passing parallel 500m away to the railway line. The railway ROW is 45m.

4. Km 154.503

The proposed Bangalore STRR crosses at CH: 153.200 of railway line Between Hosur & Keelamangalam Station of **Hosur-Dharmapuri section**. The existing railway track consisting of single line without electrification. The railway ROW is about 60m.

4.3 TOPOGRAPHICAL SURVEY

4.3.1 Objective

The basic objective of the topographic survey is to capture the essential ground features along the project alignment in X, Y, Z coordinate system to have Digital Terrain Model and to consider working out improvements, rehabilitation and upgrading of the project road. The survey will carried out by the help of Laser scanning or Light Detection and Ranging (LiDAR) systems mounted on vehicle

4.3.2 Scope of Work

i. Topographic Surveys along the Existing Right of Way (ROW): Carrying out topographic survey using LiDAR or equivalent technology along the existing road and realignments, wherever required and properly referencing the same with reference pillars fixed on either side of the centre-line at safe places within the ROW

ii. The detailed field surveys would essentially include the topographic surveys along the proposed location of bridge and alignment of approach road.

iii. The detailed topographic surveys should be carried out along the approach roads alignment and location of bridge approved by NHAI

vi.. Collection/ Extraction of details for all features such as structures (bridges, culverts etc.) utilities, existing roads, electric and telephone installations (both O/H as well as underground), huts, buildings, fencing and trees (with girth greater than 0.3metre) oil and gas lines etc. falling within the extent of survey.

4.3.3 Methodology

The complete methodology adopted for conducting topographical survey for the project road comprised of the following activities

i. Establishment of Main Control by DGPS

Fixing of Monuments

Keeping in view the importance and stability of control points, RCC pillars of specified dimensions 15cm x 15cm at the top, 20 cm x 20 cm at the bottom and 45 cm in height with an iron pin fixed at the top centre of each pillar were got pre-casted. After proper curing, these pre cast RCC pillars embedded in ground projecting about 15 cm above ground level. The balance

30cm embedded in ground with concrete cement layer all around to ascertain stability of the pillars. The top projected part of the pillar painted yellow. All pillars uniquely numbered with red paint. The locations of pillars were arranged in such a way that twin inter-visible points about 200-250m apart are available at an interval of every 5km along the entire road stretch. Pair of twin GPS pillars has the advantage that every 5km stretch independently use for starting and closing the traverse by Total Station. This 5km traverse be adjusted and independent detailed survey can be carried out.

The location of the pillars suitably selected away from the road but within the ROW so that it is not disturb by traffic. Also, the site selected in an open area so that the signals from the satellite received from all around above 15-degree altitude from the horizon. Proper description and sketch of the location of each pillar with respect to the surrounding details was prepared to ensure easy identification and traceability.

GPS Observations

The purpose of fixing starting control point to the best possible absolute accuracy, continuous GPS observations taken at GPS-00 near the beginning of the project for a period of about 6 hours. Based on this long observation, the coordinates of GPS-00 computed in "single point positioning" mode. Accepting GPS-00 as the fixed point, the other points observed in continuity and computed in "base line" mode.

GPS observations carried out in continuation of the observations carried out at GPS-00 for a period of about 45 minutes to one hour for a base line of 5kilometers depending upon the availability of satellites. Two GPS sets used for recording simultaneous satellite signals at both ends of the base line. Observations recorded in common time by both the receivers used for measurement of the base line. Observations taken using Leica GS08 Plus and Leica 1200 Series for the DGPS Survey.

GPS Data Processing

Data post processed with Leica Geo Office software and network adjustment done. Satellites available more than 16 nos. all along the survey corridor, result ambiguity was fine. Coordinates calculated in WGS 84- LAT-LONG, UTM zone requirement and scale factor statement for the same.

ii. Establishment of Secondary Control Points by DGPS

Secondary Control Points / Bench Marks fixed at an interval of about 250m by embedding pre-cast RCC pillars of the same specification as GPS pillars. These pillars embedded in concrete up to a depth of 30 cm with 5 cm wide layer all around and the balance 15 cm above ground painted yellow. All the pillars have numbered by red paint.

On establishment of secondary control points, traverse observations carried out with DGPS starting from one pair of GPS control points, closing at the next pair of GPS control points, and connecting all secondary control points in between. These traverse observations were processed using Leica Geo Office software to compute the coordinates of all subsidiary control points. The closing error of the traverse line checked.

iii. Establishment of Bench Marks by Digital Level

The elevations (Z value) of all the GPS control pillars as well as the secondary control points established by carrying out levelling from a known Bench Mark whose detail given in the chapter.

Double tertiary levelling was carried out by two levelling teams in fore and back directions using Leica Digital Level from reference benchmark to another reference benchmark connecting all intermediate GPS, Bench Marks and other temporary marks such as kilometre stones / culverts parapet etc. to establish accurate MSL heights of all the control points. Levelling discrepancy between two reference benchmarks was restricted to 12 √kmm in fore and back levelling, where 'k' is the distance in kilometre.

Heights (Z values) of all the GPS control points obtained from GPS observations replaced by their levelling heights before using these control points for detailed topographical survey.

4.3.4 Aerial LIDAR Survey

The main objective of the study is to prepare a technical methodology document for topographical survey of a road corridor utilizing LiDAR Technology. We propose Aerial LiDAR method to undertake this task. Aerial LiDAR will be carryout for the proposed area of interest. The aerial platform will consist of a Drone of suitable specifications like range, endurance etc. For the areas where data cannot be captured using Aerial LiDAR like under the bridges, culverts etc we will be using Hand-Held Scanning Equipment. As per requirement of the terms of references, LiDAR survey carried out in all stretches of project road.

The LiDAR surveys shall be carried out by M/s Goodland Surveys Pvt Ltd. having registered office in New No.3/12, Dharmaraja Nagar 4th Street, Karambakkam, Porur, Chennai - 600 116. Tamil Nadu N, India. Phone: .91 44 23860030 / Fax: .91 44 23860040

The carrying out of topographic survey will be one of the most important and crucial field tasks for this type of project. Aerial LiDAR Technology can meet the following accuracy levels:

- Fundamental horizontal accuracy of 10-15 cm.
- Fundamental vertical accuracy of 30 cm.
- Measurement points will be 300000 points per sec.

To establish accuracy, a checkpoint survey using DGPS (for horizontal accuracy) and Auto Level (for vertical accuracy) shall carried out to establish the fundamental horizontal and vertical accuracy. Sufficient ground control points (GCPs) as required for achieving the point cloud geo rectification will be observed using DGPS in WGS 84, and (Z) in Indian geodetic datum. All the required Control Points will signalized to enhance their visibility for the airborne images. Checkpoints once every 4km will established, and these will be different from any geo-referencing or control network points.

Aerial LiDAR: Airborne light detection and ranging (LIDAR) technology allows rapid and measurements of topography over large areas. The combination of LiDAR scanning technology with an aerial platform allows for extraordinary efficiency and speed for gathering accurate spatial data to support asset management needs for numerous industries, such as power generation and transmission, oil and gas, pipeline, rail and road transportation, architecture and engineering, and others.

Drone Specifications: Commercial application Drone with payload capability of over 2 kg in program mode flight will used. The Drone will also be able to record high-resolution imagery. Additionally, it will have safety features like return home mode in case of radio link failure and sense and avoid collision mechanisms. Hand-held method carried out to cover bridges, crossings, and gaps. Additionally, a 360° 4K resolution video camera will mounted on stencil that continuously records videos while scanning. This video reference will used for identification of features during post processing of data.

Flight Planning: We shall carry out detailed flight planning for each site considering the target accuracies and safety of the people on ground. Flights will only carried out during daytime and under normal weather conditions. The flight path would cover the study area completely by going through required number of cross flight lines to eliminate shadowing and allow for proper quality control. Flight line overlap would be 10% or greater, as required, to ensure there are no data gaps. The date, time, flight altitude, airspeed, scan angle, scan rate, and laser pulse rates will documented. Prior to initiating the aerial LiDAR mission, we shall prepare and finalize a flight plan. The specifications include the following criteria:

We shall prepare a digital flight line layout to ensure full coverage. Flight lines will extend continuously across the project area without interruption unless required for changes in terrain elevation. The flight plan will also contain the following information:

Projected flight lines, Flight line numbers, Intended coverage

Loading digital copy of the flight plan on to Drone, the airborne Tracker system utilizes GPS technology to ensure that all aerial survey carried as planned by providing a navigation display to assist the Drone pilot in maintaining the aircraft position both horizontally and vertically along the path, firing the scanner automatically at the correct position. Flight planning shall done using highest level of safety protocols. Only lightweight UAVs will used while flying over populated areas. Pilot along with observer will carry out all the flights within visual line of sight (VLoS) and will carried out only on clear visibility days. Ground control stations will used to monitor real time flight performance on the ground using a high range telemetry link.

It will used to capture the LiDAR data for the entire study area. In addition to the Point cloud, Photos also will captured.

Stencil Specifications

S No	Specifications
1	For detailed real-time detailed digital 3D model scanning and generation/ Baseline and Detail Modelling modes
2	File format: .ply
3	Multiple Platform Mounting Conversion use Aerial Drone
4	Real-time registered point cloud generation
5	Real-time localization, Multi sensor input (IMU, Feature Camera, Lidar), Continuously self-correcting process scheme for minimal drift, Intel NUC i7 dual

	core processor board, HDMI video output, Four USB3 ports, Mini-Display Port output, RJ-45 Ethernet port for network connectivity, 250 GB Solid State Drive, Ubuntu Linux OS, Velodyne VLP-16 3D scanning Lidar, 100m range, 360° Horizontal field of view, 30° Vertical field of view, Feature tracking camera,640x360 Resolution, 50Hz frame rate, Black & White images, Internal MEMS based IMU.

The following are the stages of data processing, eventually leading to the generation of 3D

- Pre-Processing
- Point Cloud Calibration
- Point Cloud Geo Referencing
- Quality Control & Validation, Pre-Processing of the raw LiDAR Data involves two stages as listed below:
- Point Cloud Calibration
- Point Cloud Geo-Referencing

4.3.5 Point Cloud Calibration

The Geocoded point cloud in XYZ format, obtained after initial pre-process, is subjected to Geometric corrections to compute the errors which are influenced by the movement of the aerial LiDAR, using software packages such as – **Terra Solid and Micro station**. The calibrated point cloud data could exhibit accuracy in sub-decimetre values.

Site Photographs:

	
DGPS observation at Bangalore STRR	DGPS observation at Bangalore STRR
	
Traverse survey at Bangalore STRR	Traverse survey at Bangalore STRR

	
Levelling survey at Bangalore STRR	TBM Pillaring work at Bangalore STRR

4.4 TRAFFIC SURVEYS

The following traffic surveys carried out to obtain all necessary data for satisfactory design and reliable economic and financial analysis;

- Classified Traffic Volume Counts
- Origin-Destination and Commodity Movement Surveys
- Axle loading characteristics or Axle load surveys
- Speed delay surveys

The details of traffic survey and analysis given in ***Chapter 7: Traffic Survey and Analysis***.

4.5 INVENTORY AND CONDITION SURVEY OF CULVERTS AND BRIDGES

4.5.1 Structures

There is no existing structure in this road as it is fully Greenfield. After many trails and in discussions proposed structures finalized. The details given in Chapter 3. The summary details are as below.

Table 4-3: No of Cross Drainage Structures Envisaged

Description	No. of Structures		
	Box Culverts	Minor Bridges/ Canal crossing	Major Bridges
Phase II – Package 1	54	6	1
Phase II – Package 2	Nil	Nil	Nil
Phase II – Package 3	19	2	Nil

4.6 SOIL AND MATERIAL INVESTIGATION

4.6.1 Landscape Characteristic and Physiography

The STRR alignment starts from starts from NH 207 near Dabaspet (Latitude: 13°15'07.09" & Longitude: 77°18'42.11") and ends in NH 44 (Latitude: 12°51'16.02" & Longitude: 77°48'31.88"). The entire corridor length of road is passing through rolling and hilly terrain. The land use by the side of the corridor includes agriculture activities, residential use, and commercial purpose. The altitude varies between 640 m and 950 m above mean sea level. The physiography of the project road is as follows:

- ***Karnataka State (Bangalore Rural District, Ramanagara District, Bangalore Urban District)***

  Physiographical, the project area divided in to rocky upland, plateau and flat-topped hills at an elevation of about 900 m average mean sea level

  The major part of project area sloping towards south and southeast forming Pedi plain interspersed with hills. The Pedi plains form the major part underlain by granites and gneisses with the highest elevation of 850 to 950m average mean sea level.

- ***Tamil Nadu State (Krishnagiri District)***

  The district forms part of the upland plateau region with many hill ranges and undulating plains. The western part of the district has hill ranges of Mysore plateau with a chain of undulating hills and deep valleys extending in NNE-SSW direction. The plains of the district have an average elevation of 488m average mean sea level. The plateau region along the western boundary and the northwest part of the district has an average elevation of 914m average mean sea level. The Guthrayan Durg with an elevation of 139 m average mean sea level is the highest peak in the district.

4.6.2 Climatology of the Project Area

4.6.2.1. Climate

The State enjoys three main types of climates. For meteorological purposes, the State has divided into three sub-divisions namely (a) Coastal Karnataka (b) North Interior Karnataka and (c) South Interior Karnataka.

The Tropical Monsoon climate covers the entire coastal belt and adjoining areas. The climate in this region is hot with excessive rainfall during the monsoon season i.e., June to September. The Southern half of the State experiences hot, seasonally dry tropical savanna climate while most of the northern half experiences hot, semi-arid, tropical steppe type of climate.

The climate of the State varies with the seasons. The winter season from January to February followed by summer season from March to May. The period from October to December forms the post-monsoon season.

The period from October to March, covering the post-monsoon and winter seasons, is generally pleasant over the entire State except during a few spells of rain associated with northeast monsoon, which affects the southeastern parts of the State during October to December. The months April and May are hot, very dry and generally uncomfortable. Weather tends to be oppressive during June due to high humidity and temperature. The next three months (July, August and September) are somewhat comfortable due to reduced day temperature although the humidity continue to be very high. The climate of project districts is generally dry throughout the year, except during the southwest monsoon.

4.6.2.2. Rainfall

The annual rainfall in the State varies roughly from 50 to 350cm. The rainfall increases significantly in the western part of the State and reaches its maximum over the coastal belt. The south-west monsoon is the principal rainy season during which the State receives 80% of its rainfall. The monthly rainfall data of project districts in last 5 years provided in following **Table 4-4 to 4-7**.

Table 4-4: Rainfall in Bangalore Rural District (Karnataka) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0	0	0	19	8.9
February	0	6.9	0.1	0	0
March	4.3	2.3	19.6	28.4	17.6
April	57.7	38.9	11	112	2.3
May	108.2	119.6	92.5	162.1	146.8
June	20.4	81.5	61.4	107.5	141.3
July	73.2	83.7	90.1	55.8	226.6
August	138.3	75.8	162.6	99.9	32.3
September	47.6	268.5	202.3	238.2	48.8
October	79.6	130.7	267.2	78.8	51.6
November	106.8	59.8	35.4	189.4	9.1
December	14.4	5.1	3.9	11.2	68.7
Average	**650.5**	**872.8**	**946.1**	**1102.3**	**754**

Source: India Meteorological Department (IMD)

Table 4-5: Rainfall in Ramanagara District (Karnataka) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0	0	0	1.5	2.2
February	0	1	0.3	0	0
March	0	6.6	46.4	17.2	0.2
April	65.8	61.7	32.4	139.5	3.8
May	60	87.5	88.8	161.3	113.4
June	10	90.7	91	80.2	72.9
July	76.1	48.6	32.5	28.8	184.6
August	85.3	112.8	111.4	136	70.7
September	42.9	263.7	186.3	226.8	29.2
October	89	88	189.2	81.1	49.9
November	96.7	32.9	26.9	196.5	7.6
December	14.3	5.5	5.1	2.9	57.5
Average	**540.1**	**799**	**810.3**	**1071.8**	**592**

Source: India Meteorological Department (IMD)

Table 4-6: Rainfall in Bangalore Urban District (Karnataka) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0.1	0	0	7.7	4.9
February	0	4	0.1	0	0
March	0.6	2.6	12.9	21.8	18.2
April	21.1	28.9	7.2	131.4	6.2
May	108.1	110.1	83.2	124.4	132.3
June	9.2	93.1	93.7	80.4	164
July	63.7	76.2	80.6	71.7	187.9
August	130.5	72.6	118.1	102	45.1
September	41.3	249.3	181.8	190.7	48.1
October	60	95.5	247.3	109.4	31.7
November	100.6	63.3	27.8	231.2	2.9
December	17.2	1.4	2	4	73.3
Average	**552.4**	**797**	**854.7**	**1074.7**	**714.6**

Source: India Meteorological Department (IMD)

Table 4-7: Rainfall in Krishnagiri District (Tamil Nadu) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0	0	0	-	0.2
February	0	7.2	1.7	-	0
March	4.9	1.2	7.7	-	1.9
April	40.5	39.1	6.5	-	3.8
May	107.2	105.1	189.6	-	144.4
June	13	47.2	77.1	-	87
July	85.3	22.4	39.6	-	185.5
August	98.9	95.7	71.1	-	49.1
September	45.3	212.9	84.8	-	5.2
October	196.5	143.6	213.1	-	34.7
November	78.7	83.7	33.5	-	8.5
December	24.8	7.9	32.9	-	76.9
Average	**695.1**	**766**	**757.6**	**-**	**597.2**

Source: India Meteorological Department (IMD)

4.6.3 Geology of the Region

The prevailing rock of these districts is a light to dark-grey or whitish biotic granite gneiss, which varies considerably from place to place, in texture, structure and appearance, according to the fitness or coarseness of its constituent grains and the relative abundance or scarcity, and mode of deposition of the darker Ferro-minerals. These complex Gneissic masses have been styled as "Peninsular Gneiss".

The soil in the valleys is good and loamy and is form of finer particles of the decomposed rocks.

The soil on the higher grounds is gravelly and reddish in colour.

4.6.4 Tests and Specifications

Based on field reconnaissance and requirement, various in-situ tests conducted and laboratory tests included in the testing program on soil samples along the alignment summarized in in **Table 4-8**.

Table 4-8: Site Sampling and Testing Criteria

S. No.	Type of Soil Sample	Sampling Criteria	Testing Criteria: Description of Test	Testing Criteria: Standard Code Applicable
i)	Subgrade soil samples from existing pavement along the Project Road	5 soil samples collected.	In-situ Moisture Content	IS 2720(Part 2)
			In-situ Dry Density	
			Soil Classification	IS 1498
			Sieve Analysis	IS 2720 (Part – 4)
			Atterberg Limits	IS 2720 (Part – 5)
			Laboratory Compaction Test (Modified Proctor Test)	IS 2720 (Part – 8)
			4-day soaked CBR	IS 2720 (Part – 16)
			Free Swell Index	IS 2720 (Part – 40)
ii)	Soil samples from borrow areas and OGL	19 borrow areas within reasonable lead distances and 35 samples of OGL samples collected.	Soil Classification	IS 1498
			Sieve Analysis	IS 2720 (Part – 4)
			Atterberg Limits	IS 2720 (Part – 5)
			Laboratory Compaction Test (Modified Proctor Test)	IS 2720 (Part – 8)
			4-day soaked CBR	IS 2720 (Part – 16)
			Shear Parameters (Direct Shear Test)	IS 2720 (Part – 13)
			Free Swell Index	IS 2720 (Part – 40)
iii)	Stone metal samples from crushers/quarries	Representative samples of various sizes of stone were collected from 4 crushers	Water Absorption	IS 2386 (Part – 3)
			Specific Gravity	IS 2386 (Part – 3)
			Aggregate Impact Value (AIV)	IS 2386 (Part – 4)
iv)	Water sample	Water Samples collected at 5 locations.	pH Value, Chlorides, Sulphates (SO_3), Acidity, Alkalinity, Organic, Inorganic impurities and suspended matter	IS 3025 series
v)	Flyash	Collected from 2 thermal power plants.	Sieve Analysis	IS 2720 (Part – 4)
			Atterberg Limits	IS 2720 (Part – 5)
			Laboratory Compaction Test (Modified Proctor Test)	IS 2720 (Part – 8)
			4-day soaked CBR	IS 2720 (Part – 16)
			Shear Parameters (Direct Shear Test)	IS 2720 (Part – 13)

S. No.	Type of Soil Sample	Sampling Criteria	Testing Criteria	
			Description of Test	Standard Code Applicable
			cohesion and Angle of internal friction	
			Free Swell Index	IS 2720 (Part – 40)
vi)	Pavement composition (pavement course, material type and thickness)	5 test pits evaluated.	-	

4.6.5 Investigation of Existing Subgrade

With the aforementioned objectives in view and in conformity with the provision of Clause 4.11.3.3 of the TOR, the following investigations to determine subgrade characteristic and strength have carried out.

- Visual observation of soil types along the alignment,
- Excavation of test pit (0.6 m x 0.6 mx 1.5m deep) and collection of representative samples for laboratory classification tests.

At each test pit, the materials encountered recorded and representative soil samples collected. The testing for subgrade soil included:

i. in-situ density and moisture content,

ii. Field CBR using DCP,

iii. Subgrade characterization (grain size and Atterberg limits),

iv. Laboratory moisture-density characteristics (modified compaction); and

v. Laboratory CBR and free swell Index.

Due to new Greenfield alignment, only a few locations it crosses the existing road .Hence 5 soil samples has collected from the existing project road (SH3). The typical test pit and soil collection depicted in **Figure 4-1** and **Table 4-9.** In addition, DCP test results showing penetration of cone in mm and number of blows at each pit presented in **Annexure 4.1.**


Figure 4-1: FDD and soil sample collection and DC testing at site

4.6.6 Test Results – Existing Subgrade

- **In-situ Tests**

In-situ density and moisture content determination done at subgrade level in each of the pit, using core cutter method. Field CBR of subgrade also measured using Dynamic Cone Penetration (DCP) test results obtained from field given below in **Table 4-9.**

Table 4-9: FDD and FMC of Existing Sub-grade Soil Samples

S. No	Details	Side	FDD	FMC	DCP-CBR (%)
1	Pit no:1	LHS	1.86	9.0	9
2	Pit no:2	RHS	1.82	9.0	6
3	Pit no:3	LHS	1.79	6.0	6
4	Pit no:4	RHS	1.75	5.0	6
5	Pit no:5	LHS	1.80	6.0	6

It note from the above table that, the field dry density (FDD) varies from 1.75 gm/cc to 1.86 gm/cc. In addition, field moisture content (FMC) varies from 5% to 9% along the existing alignment. Similarly, the DCP CBR varies from 6 to 9%.

- **Laboratory Tests**

The laboratory testing for subgrade includes:

- Characterization (Grain size and Atterberg limits at each test pits)
- Laboratory moisture-density characteristics
- Laboratory CBR (4-day soaked)
- Free Swell Index
- Swelling pressure

About 40 kg of soil sample collected in two bags from each test pit from the existing road section for testing purposes. The identification mark and location of the sample recorded and sent to the laboratory for conducting the tests indicated above.

Classification and Distribution

Details of soil sampling test result given in **Table 4-10.**

Table 4-10: Test Results of Existing Sub-grade Soil Samples

Ref. No	Location (km)	Side	Soil Classification	Grain Size Distribution IS:2720-IV					Clay & silt content %	Atterberg Limits [IS :2720-Pt-V]			Modified Proctor Test (IS:2720-Pt-VIII)		CBR (IS-2720-Pt-16)	Free Swell Index (%) (IS-2720-Pt-40)
				19.0 mm	4.75 mm	2.0 mm	425 micron	75 micron		Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI)	Max. dry density gm/cc.	OMC (%)		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SG-1	Pit no:1	LHS	SC	0.00	3.91	9.62	29.59	14.95	41.93	31.0	20.0	11.0	1.952	9.20	10.24	15.0
SG-2	Pit no:2	RHS	SC	0.00	3.21	19.24	15.45	36.25	25.85	31.0	19.0	12.0	1.966	10.30	11.29	30.0
SG-3	Pit no:3	LHS	SC	0.00	5.35	11.02	30.13	21.35	32.15	30.0	19.0	11.0	2.004	8.66	13.65	20.0
SG-4	Pit no:4	RHS	SC	0.00	4.45	11.68	35.57	16.86	31.44	29.0	18.0	11.0	1.960	9.31	10.50	15.0
SG-5	Pit no:5	LHS	SC	0.00	9.37	14.74	29.16	18.42	28.31	32.0	20.0	12.0	2.01	8.51	13.65	20.0

From the table, it is evident that subsoil is generally consistent throughout the project road and is predominantly clayey silt (SC) soil.

Laboratory California Bearing Ratio (CBR)

Laboratory CBR tests were carried out on the collected samples as per IS: 2720 (Part-16). Soaked CBR at 97% of MDD given in table above. The result varies from 10.24% to 13.65% with average value of 11.8%.

Graphical representation of CBR at 97% of MDD given in **Figure 4-2.**

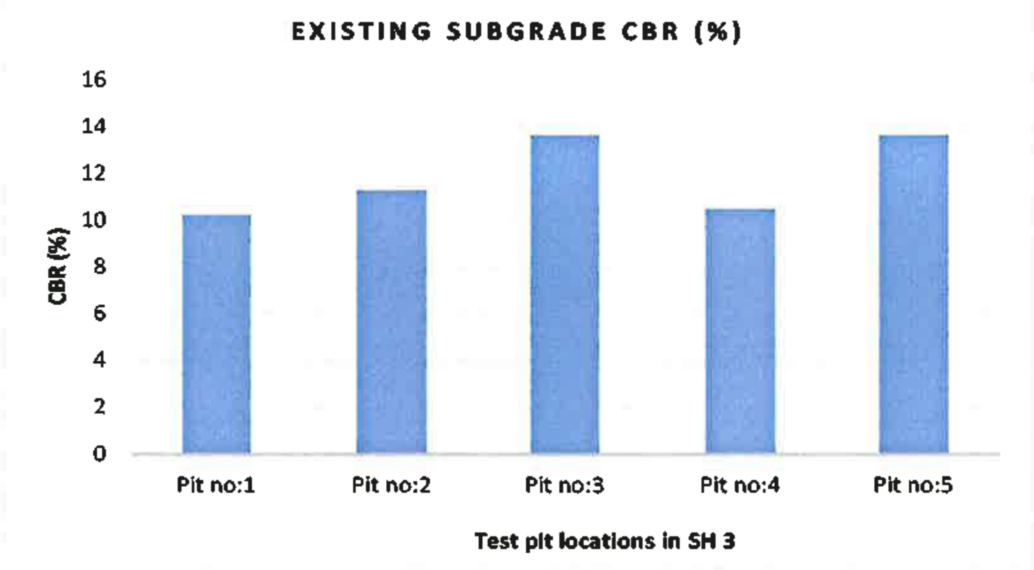


Figure 4-2: Existing Subgrade CBR (%)

Comparison of In-situ and Laboratory Tests

A graph between FDD v/s MDD and FMC v/s OMC has plotted and given as **Figure 4-3 and Figure 4-4** respectively.

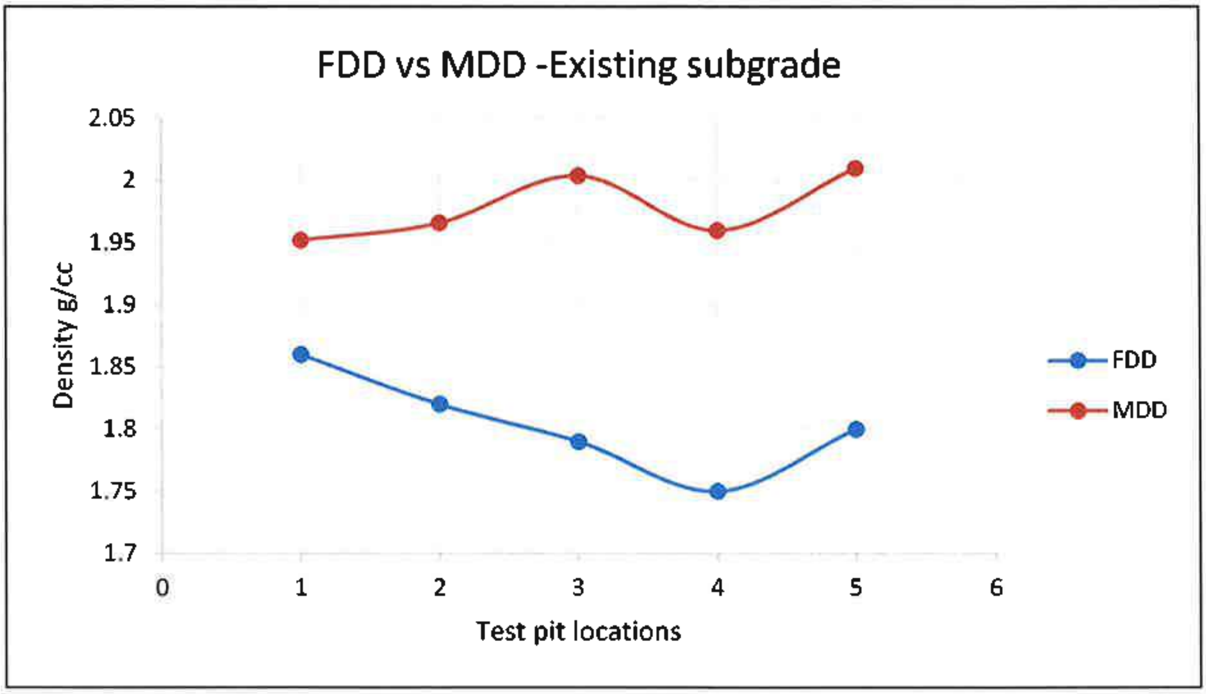


Figure 4-3: FDD vs MDD (gm/cc)

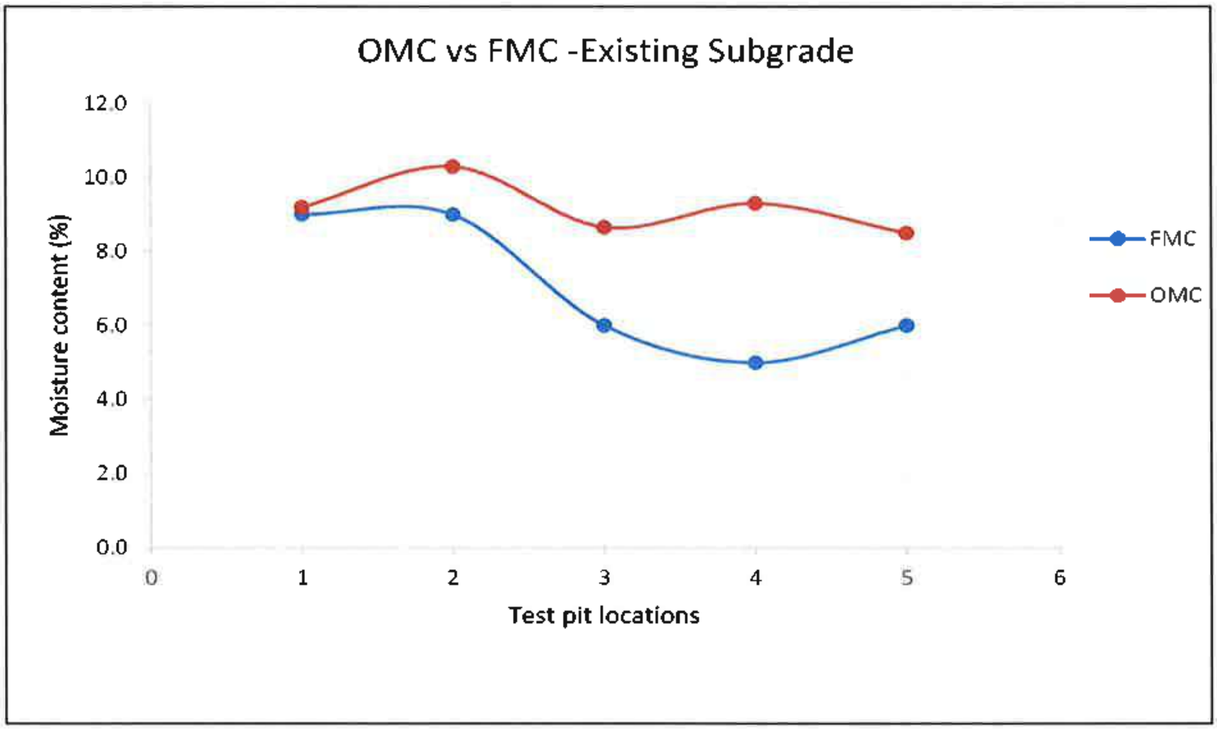


Figure 4-4: FMC vs OMC (%)

It note from the graph that FDD is slightly lower than MDD, which indicates that subgrade soil was not compacted to its optimum level at many locations. The relative compaction varies from 89.3% to 95.3 % with average degree of compaction as 91.2%. The natural moisture content is generally lower than optimum moisture content.

4.6.7 Investigation of Existing Pavement

In conformity with the provision of Clause 4.11.3.2 of the TOR, The Consultant carried out detailed field studies to the Pavement Investigations. The proposed road alignment passes through Greenfield area and the pavement shall constructed as new. However, at few locations the proposed alignment crosses the existing SH 3road. Hence, limited number of test pits investigated along SH 3.

Five pits have excavated and thickness of each identified layer measured on three vertical sides within the test pit. The average of the thicknesses so measured for a pavement layer taken as the thickness of that layer for a particular test pit location.

The existing pavement thicknesses as measured along the project road given in **Figure 4-5** and details placed in **Table 4-11.** Typical photographs showing excavated test pits shown in **Figure 4-6,** entitled "Test pit photographs".

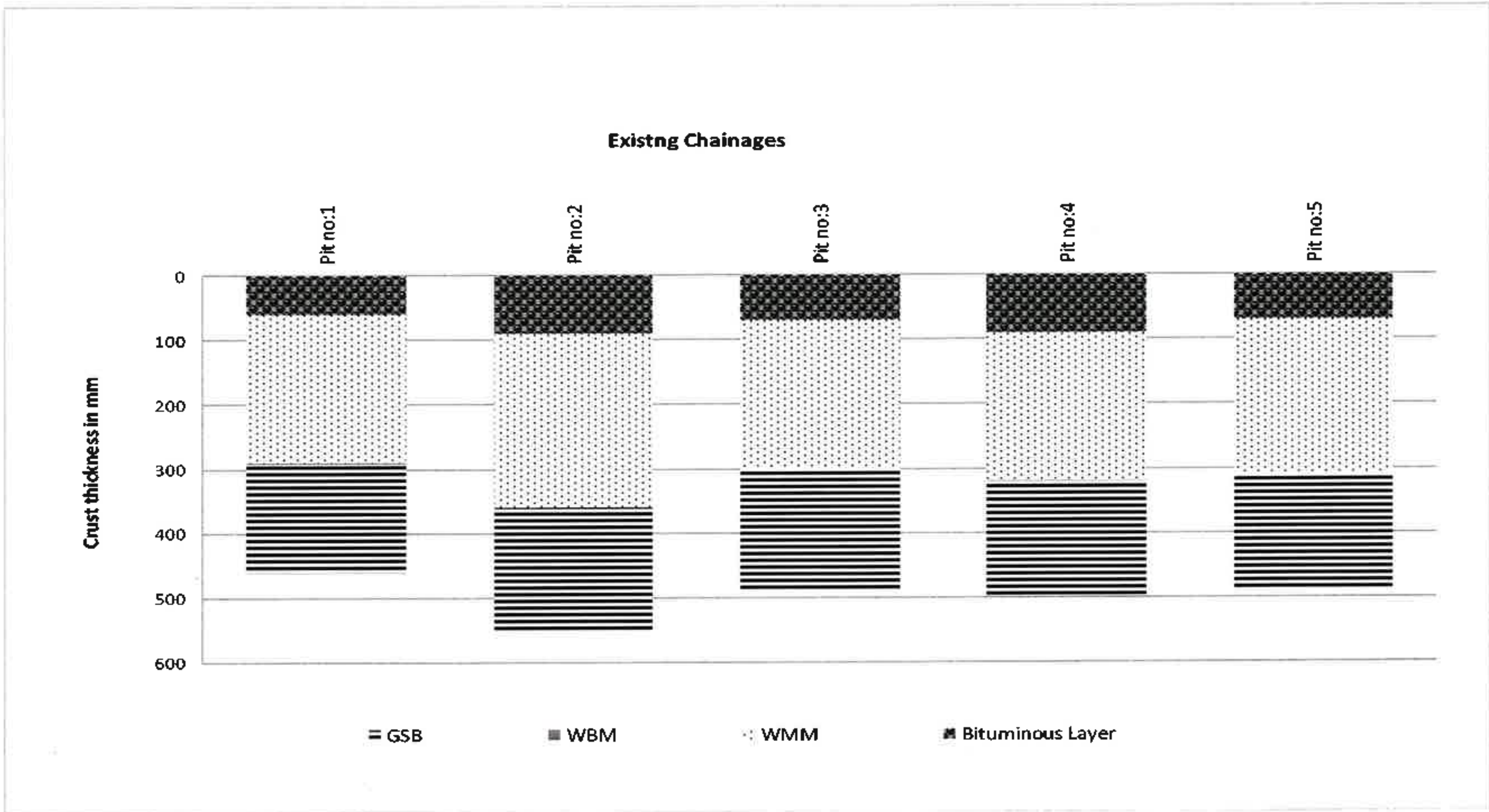


Figure 4-5: Existing Pavement Composition along SH 3

Test pit 2 at SH3-RHS

Test pit 3 at SH3-LHS

Test pit 4 at SH3-RHS

Test pit 5 at SH3-LHS

Figure 4-6: Test Pit Photographs

Table 4-11: Existing Pavement Composition

S No	Details	Side	Crust Composition in (mm)				FDD	FMC
			BT	WBM	GSB	TOTAL		
1	Pit no:1	LHS	60	170	230	460	1.86	9.0
2	Pit no:2	RHS	90	190	270	550	1.82	9.0
3	Pit no:3	LHS	70	190	230	490	1.79	6.0
4	Pit no:4	RHS	90	180	230	500	1.75	5.0
5	Pit no:5	LHS	70	180	240	490	1.80	6.0

Visual inspection and thickness measurements indicated that the existing pavement structure consisted of bituminous surfacing mostly in the thickness range of 60-90 mm with an average of 75 mm. Granular layers (generally consists of GSB and WBM layers) have been identified along the project stretch. WBM layer thickness varies in the range of 170mm to 190mm having average value of 182mm.

The total pavement thickness above subgrade is mostly in the range of 460-550mm thickness with an average thickness of around 498mm.

4.6.8 Investigation of Original Ground and Borrow Area

19 samples from borrow area and 35 samples from OGL were collected along the total project road. The present report exhibit details for Phase II, wherein seven sample from borrow area and 13 sample from OGL collected for the study.

4.6.9 Location of Borrow Areas

The objective of borrow area investigation was to identify suitable borrow sources (in terms of quantity and quality) in the near vicinity of the project road for embankment fill & sub-grade. A total of nine (09) borrow soils sources have been located, inspected and sampled.

A summary description of the borrow areas are given below. The details such as location with respect to project road Chainage, approximate distance from the source to the nearest point on the project road, estimated available quantity of soil and ownership details are also given at **Table 4-12**.The existing site conditions at borrow sources are presented in **Figure 4-7** and Lead chart has been shown in **Figure 4-8.**

Table 4-12: Location of Borrow Areas

Sample No.	Design Chainage	Side (LHS/ RHS/ Both)	Lead from existing Chainage (km)	Approx. Quantity (Cum)	Co-ordinate
BA-1	19.800	LHS	0.300	52500	13°8'56.4" N, 77°14'44.31" E
BA-2	23.500	RHS	3.200	43600	13°7'14.45" N, 77°14'35.61" E
BA-3	24.800	LHS	1.500	38900	13°6'25.78" N, 77°16'5.00" E
BA-4	30.400	RHS	1.500	45500	13°3'58.04" N, 77°13'40.96" E
BA-5	35.400	RHS	0.500	35900	13°1'29.66" N, 77°14'55.66" E
BA-6	37.500	LHS	0.700	64800	13°00'25.09" N, 77°14'25.46" E
BA-7	61.200	RHS	2.000	72500	12°49'12.25" N, 77°17'51.75" E
BA-8	61.100	LHS	0.400	39800	12°48'51.99" N, 77°16'56.52" E
BA-9	90.100	LHS	4.000	65000	12°35'50.6" N, 77°23'36.55" E
BA-10	113.000	RHS	0.500	45000	12°40'19.17" N, 77°33'49.53" E
BA-11	114.200	LHS	0.100	38000	12°40'44.27" N, 77°34'34.93" E
BA-12	122.900	LHS	0.750	74500	12°43'41.49" N, 77°37'34.29" E
BA-13	127.900	LHS	2.800	65000	12°43'1.06" N, 77°40'54.48" E
BA-14	148.800	LHS	6.280	62000	12°40'1.1" N, 77°48'13.53" E
BA-15	160.400	LHS	0.000	48000	12°42'19.15" N, 77°53'38.33" E

Sample No.	Design Chainage	Side (LHS/ RHS/ Both)	Lead from existing Chainage (km)	Approx. Quantity (Cum)	Co-ordinate
BA-16	146.600	LHS	5.000	40050	13°14'0.45" N, 77°15'46.56" E
BA-17	132.000	RHS	3.200	42500	12°39'38.38" N, 77°42'5.93" E
BA-18	139.300	RHS	3.500	38000	12°38'1.8" N, 77°44'58.55" E
BA-19	144.800	RHS	0.170	70000	12°38'8.4" N, 77°47'3.17" E

Figure 4-7: Typical Photographs of Borrow Areas

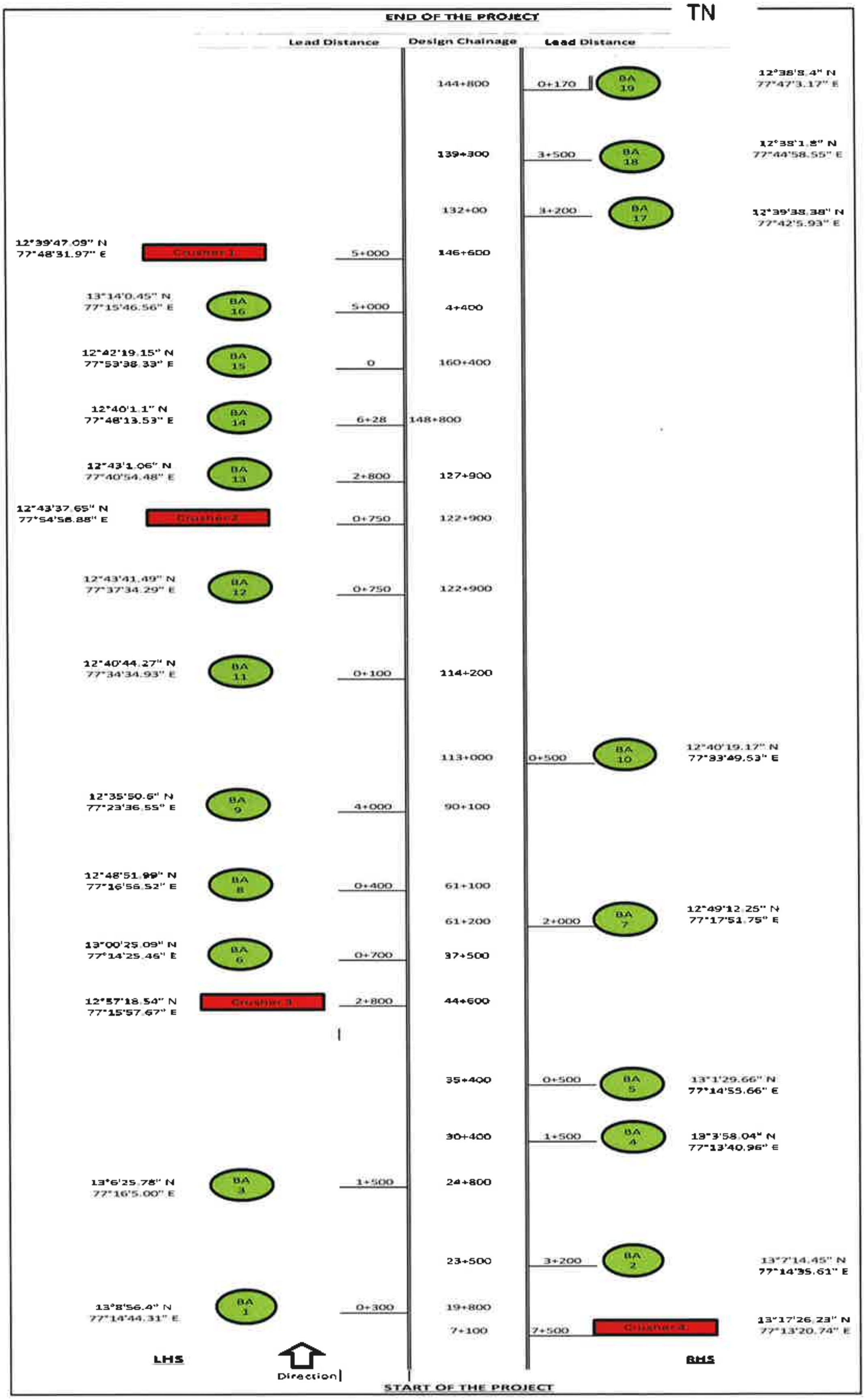


Figure 4-8: Lead chart of Borrow areas (as per design chainage)

4.6.10 Location of OGL

In situ soil Investigation carried out along the centreline of proposed new alignment stretches to assess the characteristic of in situ soil over which new pavement is constructed.

The OGL details given at **Table 4-13** and the existing site conditions at OGL presented in **Figure 4-9.**

Table 4-13: Location of OGL Areas

S. No.	Design Chainage (km)	Co-ordinate	S. No.	Design Chainage (km)	Co-ordinate
1	0.000	13°14'58.74" N , 77°18'32.26" E	19	90.000	12°37'20.42" N , 77°25'39.31" E
2	5.000	13°15'16.9" N , 77°15'50.11" E	20	95.000	12°37'32.65" N , 77°28'25.87" E
3	10.000	13°13'30.45" N , 77°13'54.51" E	21	100.000	12°37'17.18" N , 77°31'12.44" E
4	15.000	13°11'09.51" N , 77°13'53.83" E	22	105.000	12°38'55.4" N , 77°33'1.63" E
5	20.000	13°8'40.3" N , 77°14'42.27" E	23	110.000	12°41'2.68" N , 77°34'47.31" E
6	25.000	13°6'9.77" N , 77°15'32.1" E	24	115.000	12°43'6.76" N , 77°36'16.24" E
7	30.000	13°3'49.28" N , 77°16'39.68" E	25	120.000	12°43'23.75" N , 77°38'52.49" E
8	35.000	13°1'37.47" N , 77°15'7.33" E	26	125.000	12°40'21.41" N , 77°40'46.06" E
9	40.000	12°59'3.43" N , 77°14'32.29" E	27	130.000	12°39'25.7" N , 77°42'27.62" E
10	45.000	12°56'32.88" N , 77°14'26.03" E	28	135.000	12°38'9.17" N , 77°44'40.24" E
11	50.000	12°51'51.29" N , 77°16'44.77 E	29	140.000	12°38'14.13" N , 77°47'17.47" E
12	55.000	12°49'9.16" N , 77°17'2.34" E	30	145.000	12°38'43.73" N , 77°49'41.47" E
13	60.000	12°46'44.47" N , 77°16'58.94" E	31	150.000	12°40'4.96" N , 77°52'10.8" E
14	65.000	12°45'24.93" N , 77°19'09.57" E	32	155.000	12°45'2.18" N , 77°55'48.24" E
15	70.000	12°43'12.38" N , 77°18'17.18" E	33	160.000	12°47'24.85" N , 77°54'10.69" E
16	75.000	12°40'46.99" N , 77°18'59.24" E	34	165.000	12°49'39.06" N , 77°53'43.4" E
17	80.000	12°38'48.3" N , 77°20'0.47" E	35	170.000	12°52'11.29" N , 77°53'24.58" E
18	85.000	12°37'12.01" N , 77°22'59.88" E			

Figure 4-9: Typical Photographs of OGL

4.6.11 Test Results – Borrow Area and OGL

Types of laboratory test conducted on collected samples are as under:

- Grain size analysis
- Atterberg limits
- Optimum Moisture Content (OMC)
- Maximum Dry Density (MDD)
- California Bearing Ratio (CBR)
- Free Swell Index

The samples collected from field tested in the laboratory. Details of soil sampling test result given in **Table 4-14** and **Table 4-15** of Borrow soil and OGL sample respectively.

Table 4-14: Test Results of OGL Soil Samples

Ref. No	Location (km)	Soil Classification As per(IS 1498)	Grain Size Distribution (IS:2720-IV)					Clay & silt content (%)	Atterberg Limits (IS :2720-Pt-V)			Modified Proctor Test (IS:2720-Pt-VIII)		CBR %	Free Swell Index (%) - (IS-2720-Pt- 40)
			19.0 mm	4.75 mm	2.0 mm	425 micron	75 micron		Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI)	MDD (g/cc)	OMC (%)		
1	0.000	SC	0	9.11	12.53	21.03	26.42	30.91	30	18	12	2.005	10.420	13.84	20
2	5.000	SC	0	3.56	13.59	38.42	11.48	32.95	33	21	12	1.998	13.810	11.47	25
3	10.000	SC	0	7.98	14.65	22.87	20.96	33.54	38	25	13	1.948	10.870	10.50	30
4	15.000	SC	0	8.71	11.56	19.36	21.36	39.01	38	24	14	1.941	10.360	11.03	25
5	20.000	SC	0	10.32	8.23	22.36	28.56	30.53	31	20	11	1.968	10.120	13.12	25
6	25.000	SC	0	7.52	15.36	12.89	18.52	45.71	42	26	16	1.892	12.890	8.40	30
7	30.000	SC	0	2.66	23.85	15.36	21.95	36.18	40	25	15	1.931	11.520	8.92	25
8	35.000	SC	0	3.23	10.45	19.58	39.52	27.22	30	18	12	1.968	9.350	10.50	10
9	40.000	SC	0	9.23	12.36	21.75	16.23	40.43	36	21	15	1.948	13.560	9.83	25
10	45.000	SC	0	10.00	15.96	14.03	28.87	31.14	30	18	12	1.976	8.680	11.29	20
11	50.000	SC	0	6.32	10.80	25.32	23.12	34.44	35	21	14	1.979	11.530	13.12	30
12	55.000	SC	0	8.36	9.52	20.78	35.63	25.71	28	18	10	1.981	9.360	12.60	20
13	60.000	SC	0	3.25	13.60	24.52	23.56	35.07	34	21	13	1.991	8.670	10.20	25
14	65.000	SC	0	7.95	18.53	15.36	26.23	31.93	32	20	12	2.000	9.100	11.47	15
15	70.000	SC	0	8.23	14.03	18.57	26.32	32.85	33	21	12	1.956	9.210	10.76	15
16	75.000	SC	0	7.85	14.23	19.89	29.03	29.00	30	18	12	1.977	9.210	11.55	15
17	80.000	SC	0	9.98	13.23	17.52	27.03	32.24	32	20	12	1.975	8.890	11.29	15
18	85.000	SC	0	12.34	10.26	14.68	21.69	41.03	32	19	13	1.986	9.220	12.60	20

Ref. No	Location (km)	Soil Classification As per(IS 1498)	Grain Size Distribution (IS:2720-IV)					Clay & silt content (%)	Atterberg Limits (IS :2720-Pt-V)			Modified Proctor Test (IS:2720-Pt-VIII)		CBR %	Free Swell Index (%) - (IS-2720-Pt- 40)
			19.0 mm	4.75 mm	2.0 mm	425 micron	75 micron		Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI)	MDD (g/cc)	OMC (%)		
19	90.000	SC	0	8.59	15.98	14.85	28.36	32.22	31	19	12	1.971	8.230	11.03	20
20	95.000	SC	0	4.46	15.32	19.33	36.85	24.04	27	17	10	1.941	8.580	9.00	10
21	100.000	SC	0	19.56	16.58	25.32	13.52	25.02	32	18	14	1.980	13.060	12.38	20
22	105.000	SC	0	8.56	21.03	11.78	30.25	28.38	30	17	13	1.945	9.580	10.76	20
23	110.000	CI	0	1.63	15.78	11.46	20.58	50.55	33	19	14	1.865	13.850	6.30	45
24	115.000	CL	0	1.52	3.21	12.44	30.85	51.98	34	19	15	1.852	14.030	6.04	50
25	120.000	SC	0	2.33	23.15	15.78	21.96	36.78	32	19	13	1.931	11.230	8.92	35
26	125.000	SM	0	2.27	21.23	30.25	26.87	19.38	23	NP	NP	1.984	9.450	13.12	0
27	130.000	SC	0	7.66	18.23	15.33	27.52	31.26	32	20	12	2.000	9.560	12.90	15
28	135.000	SC	0	9.69	7.23	29.36	30.33	23.39	29	18	11	1.999	9.200	12.85	10
29	140.000	SM	0	5.42	13.26	40.25	23.80	17.27	21	NP	NP	1.970	9.450	13.12	0
30	145.000	SC	0	6.58	12.53	22.53	28.42	29.94	28	18	10	1.992	8.980	12.38	10
31	150.000	SM	0	5.85	10.93	36.96	23.24	23.02	18	NP	NP	1.990	9.020	13.91	0
32	155.000	SM	0	4.23	14.98	32.97	21.69	26.13	23	NP	NP	1.982	9.320	13.12	0
33	160.000	SM	0	4.24	6.59	27.20	31.98	29.99	16	NP	NP	1.979	9.100	12.87	0
34	165.000	SC	0	5.26	11.03	26.25	32.12	25.34	29	18	11	1.981	9.210	11.65	15
35	170.000	SC	0	3.43	12.08	22.99	33.61	27.89	29	19	10	1.965	8.990	11.29	10

Table 4-15: Test Results of Borrow Area Samples

Ref. No	Soil Classification As per(IS 1498)	Grain Size Distribution (IS:2720-IV)					Clay & silt content (%)	Atterberg Limits (IS :2720-Pt-V)			Modified Proctor Test (IS:2720-Pt-VIII)		CBR %	Free Swell Index (%) - (IS-2720-Pt- 40)
		19.0 mm	4.75 mm	2.0 mm	425 micron	75 micron		Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI)	MDD (g/cc)	OMC (%)		
BA-1	SC	0	10.25	8.25	18.58	25.48	37.44	34	21	13	1.982	10.050	13.39	20
BA-2	SC	0	10.58	28.24	19.42	16.36	25.40	27	17	10	2.012	8.450	14.17	15
BA-3	SC	0	14.59	24.32	9.52	19.80	31.77	34	21	13	2.009	8.900	13.91	25
BA-4	SC	0	1.35	18.18	37.07	15.71	27.69	30	18	12	1.935	11.200	9.19	15
BA-5	SC	0	3.95	9.36	21.84	24.73	40.12	34	19	15	1.965	10.310	11.29	30
BA-6	SC	0	7.58	21.35	28.41	9.15	33.51	34	20	14	1.984	10.420	13.39	20
BA-7	SC	0	12.22	14.19	34.53	15.94	23.12	32	19	13	2.018	12.250	12.01	25
BA-8	SC	0	15.68	13.45	22.54	10.08	38.25	35	21	14	1.902	13.980	7.91	30
BA-9	SC	0	10.25	20.36	16.58	28.42	24.39	30	18	12	1.988	10.860	11.20	20
BA-10	SM	0	5.01	13.09	33.63	25.16	23.11	21	NP	NP	1.980	9.120	13.12	0
BA-11	SM	0	10.78	14.35	36.25	11.25	27.37	21	NP	NP	2.066	8.900	15.48	0
BA-12	SC	0	20.50	16.97	25.94	11.25	25.34	29	18	11	1.982	11.300	10.39	20
BA-13	SC	0	9.11	12.59	21.36	16.42	40.52	35	21	14	1.948	12.200	9.83	30
BA-14	SM	0	1.42	5.00	30.55	46.77	16.26	19	NP	NP	1.976	8.980	11.03	0
BA-15	SC	0	3.42	13.59	43.25	1.98	37.76	32	21	11	1.998	13.800	11.47	30
BA-16	SC	0	7.89	19.58	14.58	22.25	35.70	34	20	14	1.941	10.600	10.24	25
BA-17	SC	0	13.26	16.25	12.25	27.45	30.79	33	22	11	2.025	9.100	13.39	20
BA-18	SC	0	12.55	10.36	9.58	20.61	46.90	34	20	14	1.948	13.300	9.29	30
BA-19	SC	0	5.23	13.26	23.52	24.15	33.84	30	18	12	2.005	8.600	13.09	25

4.6.12 Evaluation of Test Results

The physical requirement of borrow soil as per MORTH for various purposes (for use in Embankment and Subgrade) in road construction projects is given in **Table 4-16.**

Table 4-16: Physical requirement of Borrow Soil for various purposes

S. No	Type of Work	General Requirements	Density Requirements Maximum Laboratory Dry unit weight when tested as per IS:2720 (Part 8)
1	Embankments up to 3m height, not subjected to extensive flooding	The following types of material shall be considered unsuitable for embankment: a) Materials from swamps, marshes and bogs; b) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS:1498; c) Materials susceptible to spontaneous combustion; d) Material in a frozen condition; e) Clay having Liquid Limit exceeding 70% and Plasticity Index exceeding 45; f) Materials with Salts resulting in leaching in the embankment. g) Expansive Clay exhibiting marked swell and shrinkage properties ("free swelling index" exceeding 50% when tested as per IS:2720-Part40)	Not less than 15.2kN/cum or 1.52 gm/cc
2	Embankments exceeding 3m height, or embankments of any height subject to long periods of inundation	-Do-	Not less than 16.0kN/cum or 1.6 gm/cc
3	Subgrade and earthen shoulders / verges / backfill	-Do-	Not less than 17.5kN/cum or 1.75 gm/cc

Based on the test result of OGL, It found that the existing subgrade soil is strong enough to withstand the traffic load. All OGL samples have CBR value more than 8%. Hence, soil replacement are not required in most of the project vicinity. Similarly, borrow area soil sample have MDD more than 1.9 g/cc and CBR more than 8%. Hence all borrow area soil can be utilize for embankment as well as subgrade construction.

4.6.13 Quarry Materials for Construction – Stone Quarry

The locations of aggregate sources in the project vicinity have examined. Total four stone quarries/commercial crusher identified along the project road.

4.6.14 Location of Stone Quarries

The location of quarry/ commercial crusher and the approximate lead distance from each source to the nearest point on the project road given in **Table 4-17** for crushed aggregates sources. Location of stone quarries and the appropriate lead chart of quarries presented in **Figure 4-10**.

Table 4-17: Location of Stone Quarries

S. No.	Design Chainage	Side (LHS / RHS)	Type of Sample	Name of Quarry	Lead from existing Chainage (Km)	Co-ordinate
1	146.600	LHS	10mm & 20mm	VV Granite	5	12°39'47.09" N 77°48'31.97" E
2	122.900	LHS	10mm & 20mm	Shri Bharat Blue Metals & Enterprises	0.75	12°43'37.65" N 77°54'58.88" E
3	44.600	LHS		Trinate Exparts (Eco Sand)	2.8	12°57'18.54" N 77°15'57.67" E
4	7.100	RHS	10mm & 20mm	Sri Lakshmi Narayana Swamy	7.5	13°17'26.23" N 77°13'20.74" E

Aggregate source 1

Aggregate source 3

Figure 4-10: Location of Stone quarries

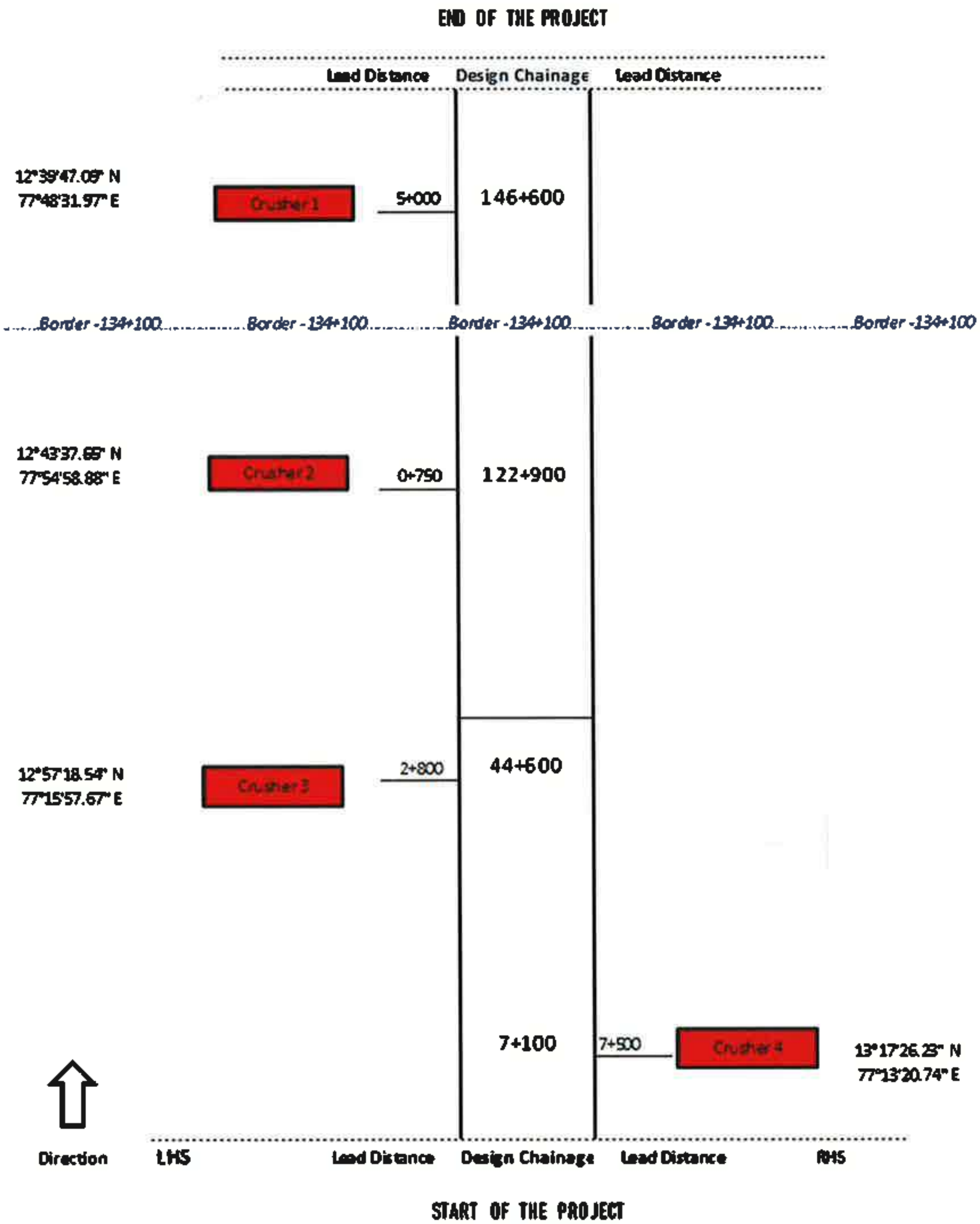


Figure 4-11: Lead chart of Stone Aggregate

4.6.15 Test Results – Stone Quarries

Types of laboratory test conducted on collected samples are as under:

- Water Absorption
- Impact Value
- Sp. Gravity
- Aggregate stripping value

The samples collected from stone quarries tested in the laboratory and test results presented in **Table 4-18.**

Table 4-18: Test Results of Aggregate Samples_20 mm Size

S. No.	Quarry Name	Co-ordinates	Aggregate Impact Value (%)	Specific Gravity	Water Absorption (%)	Stripping value in (%)
1	V.V.Granite	12°39'47.09" N 77°48'31.97" E	21.68	2.78	0.82	97
2	Shri Bharat Blue Metals & Enterprises	12°43'37.65" N 77°54'58.88" E	23.45	2.80	0.86	96
3	Trinate Exparts (Eco Sand)	12°57'18.54" N 77°15'57.67" E	23.97	2.80	0.88	96
4	Sri Lakshmi Narayana Swamy	13°17'26.23" N 77°13'20.74" E	22.98	2.80	0.87	98

4.6.16 Evaluation of Test Results

Above shown test results are analyzed as per the specifications for road and bridge works (Ministry of Shipping, Road Transport & Highways), Fifth Revision, 2013. The physical requirements shown below in **Table 4-19.**

Table 4-19: Physical requirement of Aggregates for various purposes

Property – Test	For WMM for Base / Sub-base Courses	For DBM	For BC	For CC Pavement	Structural Concrete
Cleanliness –Grain Size Analysis –Max % passing 75micron IS Sieve		Max 5%	Max 5%		
***Strength** -Los Angeles Abrasion Value IS:2386(Part-4)	40% Max	Max 35%	Max 30%	35	50
***Strength** -Aggregate Impact Value IS:2386(Part-4)	30% Max	Max 27%	Max 24%	Max 27%	45
Particle Shape -Combined Flakiness and Elongation Index (Total) IS: 2386 (Part-1)	35% Max	Max 35%	Max 35%	Max 35%	NA
Particle Shape -Flakiness Index					Max 35%
Water Absorption IS: 2386 (Part-3)	2%	Max 2%	Max 2%	Max 2%	
Stripping -Coating and stripping of Bitumen Aggregate mixtures –Minimum retained Coating	-	Min 95%	Min 95%	NA	NA

**Aggregate may satisfy requirement of either of the two tests -Los Angeles Abrasion Value or Aggregate Impact Value.*

Based on the above criteria **Table 4-20** presents a summary of the evaluation of stone metal for construction work.

Table 4-20: Evaluation of Stone Aggregates

S. No.	Quarry Location	Material Properties	WMM	BM	DBM	BC	Structural Concrete	Suitability
1	V.V.GRANITE	Water Absorption (%)	√	√	√	√	√	Suitable for all construction work
		AIV (%)	√	√	√	√	√	
		Sp. Gravity	√	√	√	√	√	
2	Shri Bharat Blue Metals & Enterprises	Water Absorption (%)	√	√	√	√	√	Suitable for all construction work
		AIV (%)	√	√	√	√	√	
		Sp. Gravity	√	√	√	√	√	
3	Trinate Exparts(Eco Sand)	Water Absorption (%)	√	√	√	√	√	Suitable for all construction work
		AIV (%)	√	√	√	√	√	
		Sp. Gravity	√	√	√	√	√	
4	Sri Lakshmi Narayana Swamy	Water Absorption (%)	√	√	√	√	√	Suitable for all construction work
		AIV (%)	√	√	√	√	√	
		Sp. Gravity	√	√	√	√	√	

It concluded that material from all the quarries fulfils the requirement of MORTH specifications. However, the quarries, which are falling with in the shortest lead, be selected for economical point of view. The value of combined flakiness and elongation index are crusher based and if required, be brought into limit by putting proper kind of crusher.

4.6.17 Quarry Materials for Construction – Sand Quarry

Sand quarries could not identified with near project corridor. However, crushed sand be used for the construction work by satisfying the requirements as per Table 1000-2 of MORTH specification. The fine aggregate shall be dense, durable clean and free from veins, adherent coating, and other deleterious substances. They shall not contain dust, lumps, soft or flaky materials. Mechanized sand washing or machines used to remove impurities from sand. The specification given in **Table 4-21.**

Table 4-21: Grading requirements of Fine aggregates

% passing	Zone I	Zone II	Zone III
% passing through 10mm	100	100	100
% passing through 4.75mm	90-100	90-100	90-100
% passing through 2.36mm	60-95	75-100	85-100
% passing through 1.18mm	30-70	55-90	75-100
% passing through 0.6mm	15-34	35-59	60-79

% passing	Zone I	Zone II	Zone III
% passing through 0.3mm	5-20	8-30	12-40
% passing through 0.15mm	0-10	0-10	0-10
Sp. Gravity	2 - 3.5		

4.6.18 Manufactured Materials

4.6.19 Cement

Ordinary Portland cement of Grade 43 and 53 manufactured by various manufacturers are locally available. Cement shall be conforming to IS: 8112 and / or IS: 12269. During the material survey, the following factories were identified which may be potential source of cement. List of factories shown in **Table 4-22.**

Table 4-22: List of cement factories near Project road

S.No	Name of cement company	Location	Approximate Lead
State :Karnataka			
1	Ultratech Cement Ltd	Bangalore	50 km from end of project road (180.000)
2	ACC The Associated Cement Companies Limited	Bangalore	52 km from end of project road (180.000)
3	Bharathi cement	Bangalore	52 km from start of project road (0.000)
4	Ambuja cement	Bangalore	60 km from Start of Project (0.000)

4.6.20 Steel

High strength deformed bars manufactured by various steel manufacturing companies conforming to IS 1786 are available with local stockiest. Nearest sources of steel plant is Steel Authority of India Limited (SAIL)-Bangalore. The plant located at the middle portion of proposed ring road project hence it is easily accessible. The approximate lead is 50km from the end of project road.

4.6.21 Bitumen

Since the project road will be subjected to moderate intensity of traffic during the design period and considering the prevailing climatic condition, it is recommended to use VG-40 Grade Bitumen conforming to IS: 73 – 2013 (Paving Bitumen) in the bituminous binder course and polymer modified bitumen of same grade in the wearing course.

Nearest source of bitumen in relation with all of the project roads is Indian Oil Corporation Limited-Chennai, which is 328 km from the end of project road.

4.6.22 Water

Water samples collected from available sources located within the project influence area and tests conducted to evaluate its suitability for use in construction work. The details of water sources identified near the project vicinity ae shown in **Table 4-23**. The site photographs shown in **Figure 4-12**.

Table 4-23: Location of water sample

SL. No.	Sample Nos.	Design Chainage (km)	Side	Northing	Easting
1	WA-01	82.600	LHS	12°39'51.9" N	77°20'08.22" E
2	WA-02	38.700	RHS	12°59'58.34" N	77°14'18.35" E
3	WA-03	14.300	LHS	13°11'37.81" N	77°14'15.16" E
4	WA-04	139.500	LHS	12°38'19.19" N	77°44'12.85" E
5	WA-05	157.600	LHS	12°41'21.72" N	77°52'54.08" E

Figure 4-12: Water sample location

The test results of identified water sources given in **Table 4-24**.

Table 4-24: Water sample test results

Ref. No.	SO3 (mg/lit)	Cl2 (mg/lit)	PH	TDS (mg/lit)	Organic content (mg/lit)
WA-01	13	45	8.64	392	10
WA-02	17	48	8.61	398	8
WA-03	14	52	8.67	387	11
WA-04	15	50	8.73	368	7
WA-05	18	47	8.52	359	14
Limit as per MORTH	Max 400 mg./l.	Max 2000 mg/l. for concrete not containing embedded steel and Max 500 mg/l for pre-stressed/ reinforced concrete work.	Not Less than 6	Max 2000 mg./l.	Max 200 mg/l.
Test Method	IS: 3025 (P-24)	IS: 3025 (P-32)	IS: 3025 (P-11)	IS: 3025 (P-17	IS: 3025 (P-18)

On perusal of the analysis data, it is observed that analyzed values of water samples are well below the prescribed limits as per IS: 3025 for all the parameters analyzed and hence safe for all construction purposes.

4.6.23 Fly Ash

Fly ash proposed to use as lightweight fill material for the embankments within stretches exhibiting weak embankment foundation. The use of fly ash will potentially reduce the settlement for locations where high embankments anticipated. As per GOI notification, the use of fly ash is mandatory in road construction work if available within 300 km of project influence area. Two locations of fly-ash source identified near the project road and listed below.

- **Bellary Thermal Power Plant, Kudatini, Bellary**

The thermal power plant is located in the state of Karnataka having the capacity of 1700MW. The source is approximately 280 km from the start of project road. The physical and chemical parameters of Bellary thermal power plant given in **Table 4-25 and 4-26** respectively.

Table 4-25: Physical Test Result of Fly Ash Sample - Bellary Thermal Power Plant

S. No.	Particulars	Observed Value	Requirement as per IS: 3812(P-1)-2003.
1	Fineness Specific Surface in m2/Kg by Blaine's Permeability Method	348	Minimum 320 m2/Kg
2	Particle retained on 45 micron IS Sieve	30.65	Maximum 34.0
3	Compressive strength at 28 Days in N/mm2	27.12	Not Less than 80% of corresponding Plain cement Mortar Cubes
4	Soundness By Autoclave test in %	0.18	Maximum 0.80

Table 4-26: Chemical Test Result of Fly Ash Sample - Bellary Thermal Power Plant

S. No.	Particulars	Observed Value	Requirement as per IS: 3812(P-1)-2003.
1	Silicon dioxide (Sio2) plus aluminum oxide (Al2O3) Plus iron oxide (Fe2O3), percent by mass.	76.32	Minimum 70.0
2	Silicon dioxide (Sio2), percent by mass	41.53	Minimum 35.0
3	Magnesium oxide(Mgo), percent by mass	3.62	Maximum 5.0
4	Total Sulphur as sulphur trioxide (SO3), percent by mass.	1.22	Maximum 3.0
5	Available alkalis as sodium oxide (Na2O), percent by mass.	0.56	Maximum 1.5
6	Total loss on ignition, percent by mass.	4	Maximum 5.0

- **Mettur Thermal Power Plant, Salem**

  The thermal power plant is located in the state of Tamil Nadu having capacity of 1440 MW. The source is approximately 200 km from the end of project road. The physical and chemical parameters of Mettur thermal power plant given in **Table 4-27 and 4-28** respectively.

Table 4-27: Physical Test Result of Fly Ash Sample - Mettur Thermal Power Plant

S. No.	Particulars	Observed Value	Requirement as per IS 3812(P-1)-2003.
1	Fineness Specific Surface in m2/Kg by Blaine's Permeability Method	341	Minimum 320 m2/kg
2	Particle retained on 45 micron IS Sieve	31.25	Maximum 34.0
3	Compressive strength at 28 Days in N/mm2	28.02	Not Less than 80% of corresponding Plain cement Mortar Cubes
4	Soundness By Autoclave test in %	0.2	Maximum 0.80

Table 4-28: Chemical Test Result of Fly Ash Sample- Mettur Thermal Power Plant

S. No.	Particulars	Observed Value	Requirement as per IS 3812(P-1)-2003.
1	Silicon dioxide (Sio2) plus aluminium oxide (Al2O3) Plus iron oxide (Fe2O3), percent by mass.	75.25	Minimum 70.0
2	Silicon dioxide (Sio2), percent by mass	40.55	Minimum 35.0
3	Magnesium oxide(Mgo), percent by mass	3.96	Maximum 5.0
4	Total Sulphur as sulphur trioxide (SO3), percent by mass.	1.62	Maximum 3.0
5	Available alkalis as sodium oxide (Na2O), percent by mass.	0.58	Maximum 1.5
6	Total loss on ignition, percent by mass.	3.92	Maximum 5.0

It is observed physical and chemical properties of fly ash are satisfying the requirements as per IS: 3812. Hence, fly ash from these sources used for the construction works.

4.7 PAVEMENT DESIGN

4.7.1 General

The project primarily envisages construction of 6-lane Greenfield road with paved shoulder of width 2.0 m and earthen shoulder of width 1.0m.

4.7.2 Homogeneous Section

Based on the reconnaissance survey and study of road network, the project road corridor divided into following homogeneous sections.

Table 4-29: Homogeneous Section

S. No.	From		To	
	Start Point	Chainage (km)	End Point	Chainage (km)
HS 1	Junction NH 4 - SH 3	0.000	Junction Hassan Road - SH 3	30.381
HS 2	Junction Hassan Road - SH 3	30.381	Junction SH 85 - SH 3	44.576
HS 3	Junction SH 85 - SH 3	44.576	Junction Mysore Road - SH 3	70.032
HS 4	Junction Mysore Road - SH 3	70.032	NH 209 (Chamarajanagar Road) - SH 3	95.365
HS 5	NH 209 (Chamarajanagar Road) - SH 3	95.365	Junction SH 85/SH35 (Anekal)	152.365
HS 6	Junction SH 85/SH35 (Anekal)	152.365	Junction NH 7 (Hosur Road) - SH 87	161.430
HS 7	Junction NH 7 (Hosur Road) - SH 87	161.430	Junction NH 7 (Hosur Road) - NH 648	179.969

4.7.3 Design Life

For Flexible Pavement:

As per IRC:37-2018, the Expressway pavement may be designed for a longer life of 20 years or higher, accordingly pavement design has been considered for 20 years design period.

The thickness of granular layer will provided for full design period.

For Rigid Pavement:

As per IRC: 58-2015, expressway should be designed for 30 years design period.

4.7.4 Vehicle Damage Factor (VDF)

The axle load survey provides data to enable the assessment of the damaging effect of heavily loaded vehicles. The Consultant conducted axle load survey for a 24-hour period using the Axle weighing pad at three locations (km 49.00 on NH-7, km 30.80 on NH-275 and km 51.00 on NH-4) in the project influence area.

The traffic census and the axle load surveys conducted side by side. In the traffic census surveys, all types of vehicles traveling in both directions counted throughout the Axle Load Survey period. The traffic census data provides the actual break down of the traffic composition at the particular location. Due to the requirement of stopping a vehicle for weighing, it is not possible to weigh all the commercial vehicles passing through the site. More than 10% of commercial vehicles weighed in the 24 hours duration on a random sampling basis.

The vehicle damage factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is define as equivalent number of standard axles per commercial vehicle. The VDF varies with the vehicle axle configuration, axle loading, terrain, type of road and from region to region. The VDF arrived at from axle load surveys on typical road sections to cover various influencing factors, such as traffic mix, mode of transportation, commodities carried, time of the year, terrain, road conditions and degree of enforcement.

In this study, 4th power law is used for converting axle loads into equivalent standard axle loads.

For design purposes, the variation in Axle loads is determined by reducing the actual axle loads to an "Equivalent Axle Load (EAL)", an equivalency is a convenient means of indexing the wide spectrum of actual loads to one selected value. The equivalent standard Axle load determined by the relationship:

For Single Axle having single wheel:

$$ESAL = \left(\frac{W}{6.6}\right)^4$$

For single Axle having dual wheels:

$$ESAL = \left(\frac{W}{8.16}\right)^4$$

For Tandem Axle (per tandem axle):

$$ESAL = \left(\frac{W}{15.09}\right)^4$$

For Tridem Axle (per tridem axle):

$$ESAL = \left(\frac{W}{22.83}\right)^4$$

Where: W = Axle Load in Tonnes

The relationship referred to as "Fourth power rule". The rule states that the damaging effect of an Axle load increases as a fourth power of the weight of an axle. In order to convert Axle loads from Axle load survey into ESAL, they grouped by intervals of one tonne and the frequency of each interval is determined. Equivalency factors obtained for each category from the "Fourth Power Rule". The product of frequency of each interval and the corresponding equivalency factor gives the ESAL for that weight class of the sample.

Thus:

Total ESAL = (No. of vehicles in each weight class) x (Load equivalency factor for that class)

The Vehicle Damage Factor (VDF) is an important indexing factor in characterizing the traffic loading for a road. It is a multiplier for converting the number of commercial vehicles of different axle loads, to the number of standard Axle load repetitions.

The VDF computed from the following relationship:

$$VDF = \frac{\text{Total ESAL}}{\text{No. of Vehicles Weighed}}$$

The VDF calculated for all commercial vehicles based on Axle load survey given in **Table 4-30**. The detailed analysis sheet given in **Appendix 4.1, *Volume II: Appendix to Main Report.***

Table 4-30: Adopted VDF

Vehicle Type	Banglore-Mysore Section		Banglore-Tumkur Section		Hosur-Krishnagiri Section		Adopted (max of all value)
	B-M	M-B	B-T	T-B	H-K	K-H	
LCV	0.061	0.548	0.71	1.021	0.482	0.406	1.021
Bus	0.909	1.024	0.935	0.945	1.085	0.914	1.085
2A Truck	1.878	1.43	1.53	2.546	2.819	3.924	3.924
3A Truck	4.412	3.087	3.306	5.794	6.225	6.827	6.827
4A Truck	7.307	4.882	5.204	5.502	4.82	4.017	
5A Truck	7.205	6.303	5.043	9.41	11.602	11.954	
6A Truck		11.258		9.756			
MAV*	7.299	5.316	5.184	5.917	6.001	5.357	7.299
* Weighted average of 4A, 5A and 6A Trucks							

4.7.5 Design Lane Traffic

As per IRC: 37-2018 for 6-lane divided carriageway, 60% of the commercial vehicles in one direction has considered.

4.7.6 Design Traffic

Traffic for pavement design purpose constitutes of commercial vehicles of >3.0 tonnes gross vehicle weight. The base year traffic in different categories for various links is estimate and projected by adopted growth rates for the entire design period.

Based on above the traffic loading in terms of cumulative number of equivalent standard axle loads are calculate for the period, 2022-2051 for the project road.

While working out the number of cumulative equivalent standard axles (ESA), the following assumptions have made:

Implementation of the project would take up in the year 2021 and that the project road would be open to traffic in the year 2022

The traffic loading in terms of the cumulative number of standard axles for the given period shall computed using the following relationship:

$$N_S = \sum_{i}^{DL} \sum_{i}^{n} \frac{365ADT_i\left[(1+GR_i)^{DL}-1\right]}{GR_i} VDF_i$$

Where,

N_S is cumulative number of standard axles for the period under consideration.

ADTi is average daily traffic for vehicle category "i" in the initial year.

GRi is growth rate for vehicle category, "i".

VDFi is vehicle damage factor in terms of equivalent number standard axles for vehicle category, "i".

DL is design life, year.

Based on the projection of traffic and the Vehicle Damage Factor of various types of commercial vehicles, Cumulative standard Axles (CSA) during the period of design life have been computed for all homogeneous section as given in **Appendix 4.2, *"Volume II: Appendix to Main Report"*** and summarized below in **Table 4-31**.

Table 4-31: Design Traffic Summary

Homogeneous Section	Chainage (km)		Cumulative Standard Axle (CSA) - in msa					Design Traffic (20 yr Design Period)	Design Traffic (30 yr Design Period)
	From	To	10th Year	15th Year	20th Year	25th Year	30th Year		
HS 1	0.000	30.381	20.56	37.67	61.43	94.02	138.13	65	140
HS 2	30.381	44.576	21.09	38.66	63.07	96.57	141.92	65	145
HS 3	44.576	70.032	21.76	39.92	65.16	99.80	146.72	70	150
HS 4	70.032	95.365	21.37	39.17	63.90	97.86	143.90	65	145
HS 5	95.365	152.365	21.21	38.88	63.42	97.11	142.78	65	145
HS 6	152.365	161.430	21.15	38.76	63.21	96.77	142.25	65	145
HS 7	161.430	179.969	26.00	47.64	77.70	118.93	174.79	80	175

4.7.7 Design CBR / Effective Subgrade modulus

The phase-wise 90th Percentile CBR are as follows:

	90th Percentile CBR (%)	
	OGL	Borrow area
Phase I	13.12	13.96
Phase II	13.1	
Phase III	13.52	
Adopted CBR	**13.25**	**13.96**

4.7.8 Estimation of Effective Subgrade Modulus (MR_effsubgrade)

90th Percentile CBR of OGL Soil = 13.25%

90th Percentile CBR of select Borrow Soil = 13.96%

Elastic Modulus of Embankment Soil = $17.6 \times (13.25)^{0.64} = 93.87$ MPa

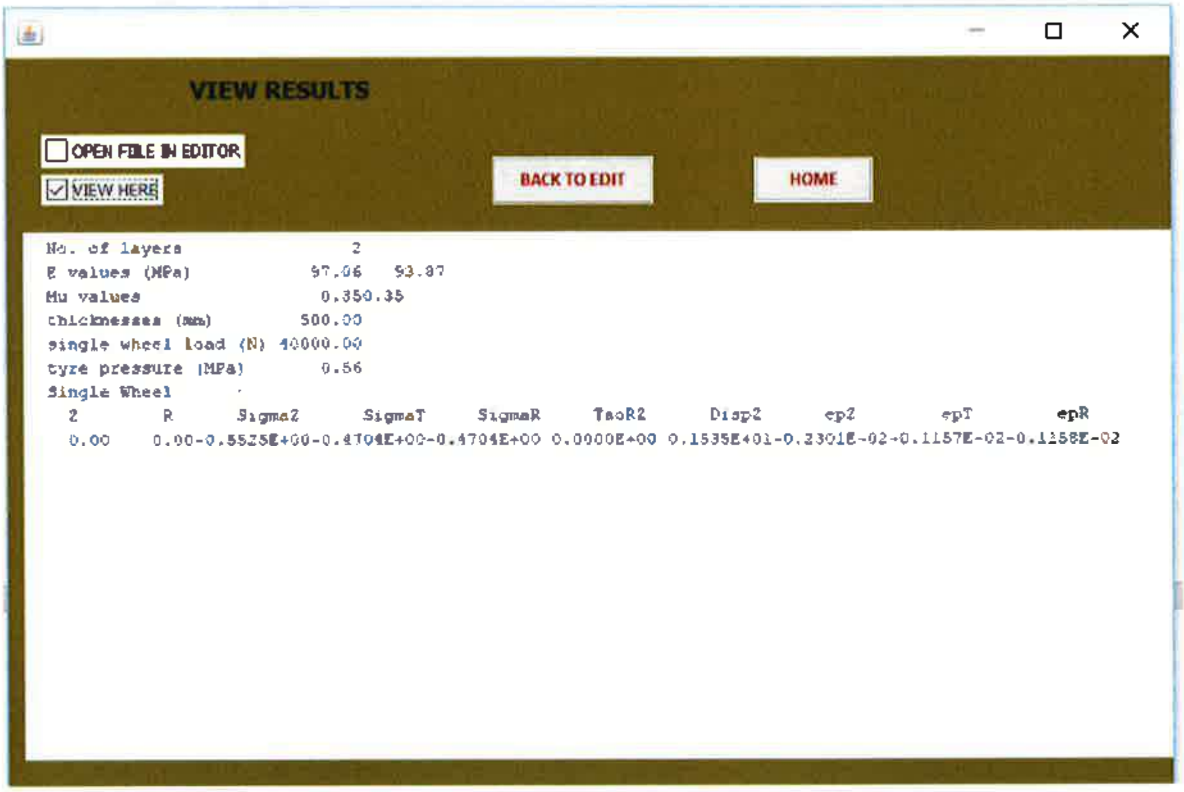
Elastic Modulus of select Borrow Soil = $17.6 \times (13.96)^{0.64} = 97.06$ MPa

Using the software IITPAVE, Surface deflection, δ = 1.535 mm

Effective Subgrade Modulus, $M_{R\_effsubgrade} = [2 \times (1 - \mu^2) \times p \times a] / \delta$

$= [2 \times (1 - 0.35^2) \times 0.56 \times 150.8] / 1.535$

= 96.55 MPa (Corresponds to 14.29% say 14%



CBR)

4.7.9 Structural Design of Pavement

The following options has considered:

Option 1: Flexible Pavement (Granular Base and Granular Sub-base)

Option 2: Flexible Pavement (Cement Treated Base and Granular Sub-base)

Option 3: Perpetual Pavement (Granular Base and Cement Treated Sub-base)

Option 4: Rigid Pavement

4.7.9.1 Option 1: Flexible Pavement (Granular Base and Granular Sub-base)

Design of new pavement based on the IRC-37: 2018 guidelines using the software IITPAVE. The input required to run the software given below.

The proposed road further divided into different packages from construction point of view, as given below in **Table 4-32**.

Table 4-32: Phase and Package Details (20 years Design Period)

Package Details		Chainage (km)		Length (km)	Design Traffic 20 years (msa)
		From	To		
Phase I	Package 1	0.000	46.300	46.300	65.000
	Package 2	46.300	79.000	32.700	70.000
Phase II	Package 1	79.000	112.600	33.600	65.000
	Package 2	112.600	120.700	8.100	65.000
	Package 3	120.700	144.480	23.780	65.000
Phase III	Package 1	144.480	179.969	35.489	80.000

Design Period = 20 yrs

Effective $E_{subgrade}$ = 96.55 MPa

Thickness of Granular Layer (GSB.WMM), h = 450 mm

$M_{R\_granular} = 0.2 \times E_{subgrade} \times h^{0.45}$

$= 0.2 \times 96.55 \times (450)^{0.45}$

= 301.81 MPa

$M_{R\_bituminous}$ = 1600 MPa for Modified Bitumen at 35 °C

$M_{R\_bituminous}$ = 3000 MPa for VG-40 Bitumen at 35 °C

Poisson Ratio - 0.35 for bituminous mix

- 0.35 for granular layer

- 0.35 for subgrade

Tyre Pressure – 0.56 MPa

Centre to centre distance between tyres – 310 mm

Wheel load – 20 kN

a. Performance Criteria

Fatigue Model

$N_f = 1.213 \times 10^{-4} \times [1/e]^{3.89} \times [1/M_R]^{0.854}$ (for 90% reliability and traffic > 30 msa)

Rutting Model

$N = 1.41 \times 10^{-8} \times [1/e]^{4.5337}$ (for 90% reliability and traffic > 30 msa)

b. Pavement Composition

Based on above parameters, the pavement composition are given below in **Table 4-33** and snapshot of IITPAVE software is given in **Appendix 4.3, *"Volume II: Appendix to Main Report"*** for reference.

Table 4-33: Pavement Composition – Granular Base and Granular Sub-base

Traffic	65 msa	70 msa	80 msa	Remarks
Allowable Horizontal Tensile Strain ($\times 10^{-6}$)	166.51	163.37	157.86	
Allowable Vertical Compressive Strain ($\times 10^{-6}$)	350.79	345.11	335.09	
Bituminous Concrete (BC)	50	50	50	PMB-40 (IRC:SP:53)
Dense Bituminous Macadam (DBM)	95	100	105	VG-40
Wet Mix Macadam (WMM)	250	250	250	
Granular Sub-base (GSB)	200	200	200	Gradation V or VI of MORTH
Effective Subgrade (CBR >= 14%)	500	500	500	
Actual Horizontal Tensile Strain ($\times 10^{-6}$)	163.2	158	153	
Actual Vertical Compressive Strain ($\times 10^{-6}$)	247.6	241.7	236.1	

Since the life of bituminous material is generally considered as 5 – 7 years after which it starts showing distresses, it is recommended to provide a functional layer (say 40 mm BC) to improve the riding quality and as well as life of bituminous layer after 5 years. Accordingly, the maintenance schedule given below in **Table 4-34.**

Table 4-34: Maintenance Schedule for Flexible Pavement (Granular Base and Granular Sub-base)

Year	Maintenance Schedule		
	BC (mm)	DBM (mm)	Remarks
5th year	40	-	Functional Overlay
10th Year	40	50	Structural Overlay
15th Year	40	-	Functional Overlay
20th Year	40	50	Structural Overlay
25th Year	40	-	Functional Overlay

4.7.9.2 Option 2 – Flexible Pavement (Cement Treated Base and Granular Sub-base)

Design of new pavement based on the IRC-37: 2018 guidelines using the software IITPAVE. Since cemented base may lead to early failure because of high flexural stresses in the cemented layer, therefore stage construction is not consider for this option. The input required to run the software given below.

Input Data

The proposed road further divided into different packages from construction point of view, as given below in **Table 4-35**.

Table 4-35: Phase and Package Details (30 yrs Design Period)

Package Details		Chainage (km)		Length (km)	Design Traffic 20 years (msa)
		From	To		
Phase I	Package 1	0.000	46.300	46.300	145
	Package 2	46.300	79.000	32.700	150
Phase II	Package 1	79.000	112.600	33.600	145
	Package 2	112.600	120.700	8.100	145
	Package 3	120.700	144.480	23.780	145
Phase III	Package 1	144.480	179.969	35.489	175

Design Life – 30 years

Effective $E_{subgrade}$ = 96.55 MPa

Thickness of Granular Layer (GSB), h = 300 mm

$M_{R\_granular} = 0.2 \times E_{subgrade} \times h^{0.45}$

$= 0.2 \times 96.55 \times (300)^{0.45}$

$= 251.47$ MPa

$M_{R\_CT\ base}$ = 5000 MPa

$M_{R\_aggregate\ Layer}$ = 450 MPa (100 mm crack relief layer between the cementitious and bituminous layers)

$M_{R\_bituminous}$ = 1600 MPa for Modified Bitumen at 35 ^{0}C

$M_{R\_bituminous}$ = 3000 MPa for VG-40 Bitumen at 35 ^{0}C

Poisson Ratio - 0.35 for bituminous mix

- 0.35 for aggregate layer
- 0.25 for CT base and sub-base layer
- 0.35 for subgrade

Tyre Pressure – 0.56 MPa

Centre to centre distance between tyres – 310 mm

Wheel load – 20 kN

a. Performance Criteria

Fatigue Model

$N_f = 1.213 \times 10^{-4} \times [1/e]^{3.89} \times [1/M_R]^{0.854}$ (for 90% reliability and traffic > 30 msa)

Rutting Model

$N = 1.41 \times 10^{-8} \times [1/e]^{4.5337}$ (for 90% reliability and traffic > 30 msa)

Fatigue Model for Cementitious Layer

$N = [(113000/E^{0.804} . 191)/e]^{12}$

b. Pavement Composition

Based on above parameters, the pavement composition are given below in **Table 4-36** and snapshot of IITPAVE software is given in **Appendix 4.3, *"Volume II: Appendix to Main Report"*** for reference.

Table 4-36: Pavement Composition for 30 years Design Life (CT Base and Granular Sub-base)

Traffic	145 msa	150 msa	175 msa	
Allowable Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	135.48	134.3	129.08	**Remarks**
Allowable Vertical Compressive Strain (x 10^{-6}) on Subgrade	293.9	291.71	281.96	
Allowable Tensile Strain (x 10^{-6}) in Cementitious Layer	64.96	64.77	63.95	
Bituminous Concrete (BC)	50	50	50	PMB-40 (IRC:SP:53)
Dense Bituminous Macadam (DBM)	50	50	55	VG-40

Traffic	145 msa	150 msa	175 msa	Remarks
Allowable Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	135.48	134.3	129.08	
Allowable Vertical Compressive Strain (x 10^{-6}) on Subgrade	293.9	291.71	281.96	
Allowable Tensile Strain (x 10^{-6}) in Cementitious Layer	64.96	64.77	63.95	
Crack Relief Layer /Wet Mix Macadam (WMM)	100	100	100	
Cement Treated Base (CTB)	140	140	140	
Granular Sub-base (GSB) - Drainage Layer	150	150	150	
Granular Sub-base (GSB) - Filter Layer	150	150	150	Gradation V or VI of MORTH
Effective Subgrade (CBR >= 14%)	500	500	500	
Actual Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	131.1	131.1	127.6	
Actual Vertical Compressive Strain (x 10^{-6}) on Subgrade	165.4	165.4	162.4	
Actual Tensile Strain (x 10^{-6}) in Cementitious Layer	64.28	64.28	62.61	

4.7.9.3 Option 3 – PERPETUAL Pavement (Granular Base and Cement Treated Sub-base)

Design of new pavement based on the IRC-37: 2018 guidelines using the software IITPAVE. Since cemented base may lead to early failure because of high flexural stresses in the cemented layer, therefore stage construction not considered for this option. The input required to run the software given below.

a. *Input Data*

Effective $E_{subgrade}$ = 96.55 MPa

$M_{R\_granular}$ = 350MPa

$M_{R\_CT\ Sub\text{-}base}$ = 600 MPa

$M_{R\_bituminous}$ = 1600 MPa for Modified Bitumen/SMA at 35 ^{0}C

$M_{R\_bituminous}$ = 3000 MPa for VG-40 Bitumen at 35 ^{0}C

Poisson Ratio - 0.35 for bituminous mix

- 0.35 for aggregate layer
- 0.25 for CT sub-base layer
- 0.35 for subgrade

Tyre Pressure – 0.56 MPa

Centre to centre distance between tyres – 310 mm

Wheel load – 20 kN

b. Performance Criteria

Fatigue Model

Allowable Tensile Strain below Bituminous Layer = 80 x 10^{-6}

Rutting Model

Allowable Vertical Strain above Subgrade = 200 x 10^{-6}

c. Pavement Composition

Based on above parameters, the pavement composition are given below in **Table 4-37** and snapshot of IITPAVE software is given in **Appendix 4.3, *"Volume II: Appendix to Main Report"*** for reference.

Table 4-37: Pavement Composition for Perpetual Pavement

Allowable Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	80	Remarks
Allowable Vertical Compressive Strain (x 10^{-6}) on Subgrade	200	
Stone Matrix Asphalt (SMA)	50 mm	PMB-40 (IRC:SP:53)
Dense Bituminous Macadam (DBM)	205 mm	VG-40
Crack Relief Layer /Wet Mix Macadam (WMM)	150 mm	
Cement Treated Sub-base (CTSB)	300 mm	
Effective Subgrade (CBR >= 14%)	500 mm	
Actual Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	78.81	
Actual Vertical Compressive Strain (x 10^{-6}) on Subgrade	135	

4.7.9.4 Option 4 –Rigid Pavement

IRC: 58- 2015 guidelines have primarily followed for the design of rigid pavement and Toll plaza.

A. Factors Governing Design of Rigid Pavement

➢ **Axle Load Characteristics**

Though the axle load limits are 10.2 tonnes (100 kN), 19.0 tonnes (186 kN) and 24.0 tonnes (235 kN) for single, tandem and tridem axles respectively, a large number of axles operating on our project road carry much heavier loads than the legal limits. Therefore, to estimate the repetition of single, tandem and tridem axles in each direction expected during the design period, axle load survey carried out along the project road.

It found that stresses in concrete pavements having thickness of 200 mm or higher not affected significantly by the variation of tyre pressure. A tyre pressure of 0.8 MPa is adopt for design.

- **Wheel Base Characteristics**

The spacing between successive axles of any vehicle needs to be consider to estimate the top-down fatigue cracking caused by axle loads during night period when the slab has the tendency of curling up due to negative temperature differential.

Usually the spacing of transverse joints is not more than 4.5m, the axles with spacing of more than 4.5m are not expect to contribute to top-down fatigue cracking.

- **Design Period**

The rigid pavement been designed for Thirty (30) years.

- **Traffic Consideration**

Design Lane

The lane carrying the maximum number of heavy commercial vehicles is termed as design lane.

Design Traffic

The traffic count (AADT) and the corresponding traffic estimates indicating day (usually 6.00 AM to 6.00 PM) and night traffic (6.00 PM to 6.00 AM) separately is required for design of pavement as day hour loading is responsible for bottom-up cracking whereas night hours loading may lead to top-down cracking.

As mentioned in the guidelines, for six-lane divided highways, 25 percent of the total traffic in the direction of predominant traffic is consider for design of pavement for bottom-up cracking.

However, only those commercial vehicles with the spacing between the front axle and the first rear axles less than the spacing of transverse joints should be consider for top-down cracking analysis.

- **Temperature Consideration**

Temperature differential between the top and bottom fibers of concrete pavements causes the concrete slab to curl, giving rise to stresses. The maximum temperature differential values for design purpose given in Table 1 of the IRC: 58-2015.

- **Embankment Soil and Characteristics of Subgrade and Sub-base**

CBR of embankment soil placed below the 500mm select subgrade should be determined for estimating the effective CBR of subgrade and its 'k' value for design. In the absence of any plate load test, the design 'k' value estimated from soaked CBR value as given in Table 2 of IRC: 58-2015.

The main purpose of the sub-base is to provide a uniform, stable and permanent support to the concrete slab laid over it. A sub-base of Dry Lean Concrete (DLC) having a 7-days average compressive strength of 10 MPa determined as per IRC-SP: 49 considered for design. The thickness of DLC kept 150mm as recommended in the guidelines.

As per Clause 5.7.3.9 of IRC: 58-2015, commercially available synthetic geo-composite layer can also use at the interface of subgrade and granular subbase layer (needed for levelling) for separation and drainage in place of granular layers. Accordingly, a drainage layer (GSB material) of 100 mm provided below the DLC layer and synthetic geo-composite layer below GSB layer. However, the contribution of this layer for estimating the effective modulus of subgrade reaction of the foundation generally ignored.

A de-bonding interlayer of polythene sheet having a minimum thickness of 125 micron between DLC and concrete slab considered in design.

➢ **Concrete Strength and Properties**

Flexural strength of concrete is required for the purpose of design of concrete slab. Usually, concrete design based on 28 days strength. In the case of concrete pavement, 90 days strength can considered in view of the fact that during initial period of 90 days, the number of repetitions of load is very small and has negligible effect on cumulative fatigue damage of concrete. Increasing the 28 days flexural strength by a factor of 1.10 recommended as per guidelines to get 90 days strength. However, in no case, 28 days flexural strength of pavement quality concrete (PQC) should be less than 4.5 MPa.

The Modulus of Elasticity (E) of concrete considered for design corresponding to 28 days flexural strength of 4.5 MPa is 30,000 MPa. Similarly, the Poisson's ratio and Coefficient of thermal expansion for design purpose considered is 0.15 and 10x10-6 per degree centigrade respectively.

B. Design of Slab Thickness and Joints

The design calculations are given in **Appendix 4.4, *"Volume II: Appendix to Main Report"*** and the pavement design details so obtained are summarized below:

- Thickness of Cement Concrete Pavement 300 mm
- Thickness of Dry Lean Cement Concrete Sub-base 150 mm
- GSB Layer 100 mm
- Synthetic geo-composite layer
- Subgrade (CBR >= 14%) 500 mm

Types of Joints

- Contraction Joints @ 4.5 m c/c
- Longitudinal Joints to be provided between adjoining slabs of 3.5 m width
- Construction Joints, wherever necessary, such as at the end of day job or preferably should meet at the contraction joints.

Load Transfer Devices

i. Dowels for Transverse contraction and construction Joints

  - Diameter 32 mm
  - Length 500 mm
  - Spacing 255 mm

ii. Tie Bars for Longitudinal Joints

- Diameter 12 mm
- Length (deformed bars) 640 mm
- Spacing 465 mm

4.7.10 Paved Shoulder

The composition of the paved shoulder will be same as that of main carriageway.

4.7.11 Truck Lay-Bye – Concrete Block

Interlocking concrete blocks proposed for truck lay-bye as per IRC: SP: 63-2004 (Guidelines for the Use of Interlocking Concrete Block Pavement) and conforming to IS 15658: 2006 (Precast Concrete Blocks for Paving – Specification).

Accordingly, the proposed composition of the concrete block pavement given below in **Table 4-38**.

Table 4-38: Composition of Concrete Block Pavement

Details	Thickness (mm)
Paver Block Thickness	100 (M 40 grade)
Sand Bed	40
WMM	150
GSB	250

4.8 PRELIMINARY COST ESTIMATES

The methodology adopted for preparation of rate analysis is as follows:

- The rates for cement, bitumen and steel are consider from market rate with GST.
- The Unit rates have been taken from Schedule of Rate , National Highway Circle Bangalore for the year 2018-19 approved with effect from 31-01-2019Lead calculated as per material survey has been take for rate analysis.

The lead of bitumen ascertained from nearest refinery, which is Chennai and for cement and steel, the location of main city to the appropriate location of plant site in the project corridor. The format for working out rates for different items of bill of quantities is finalised from the standard data book published by MORT&H. In order to work out preliminary cost estimate, work items broadly split into the following sub- heads.

1. Site Clearance and earthworks
2. Granular pavement courses
3. Bituminous Courses
4. Bridges, Culverts, Retaining walls and other structures
5. Kerbs, Drainage and other Protective works
6. Road Junctions
7. Toll Plaza
8. Road Furniture and Road Safety Works

4.9 ECONOMIC VIABILITY

Simultaneous to, and linked with the traffic survey, data collection has been undertaken in relation to the cargo related vehicle fleet. It has been possible to collect some of this information from the OD surveys. In addition, information has obtained from vehicle dealers and operators to determine the types of vehicles commonly used their utilization and the cost of parts, labour, maintenance, and repairs.

The Consultants recommend, given to the uncertainty inherent, in use of high, medium, and low growth scenarios; it has been carried advice to have two growth periods representing the short to medium term and the long term.

Consultant made use of the HDM-IV model to conduct the economic analysis of the route. The model requires classified traffic volumes, both existing and forecast vehicle fleet, and detailed engineering data relating to the existing road and the existing and future maintenance and repair regimes, including costs. Each traffic section as indicated by the traffic studies has modelled separately to produce an Economic Internal rate of Return (EIRR), Net Present Value (NPV), and Benefit/Cost Ratio (BCR) for the proposed and alternative rehabilitation schemes.

It is essential for the validity of the results to establish a reasonable "do minimum" situation against which each scheme compared. A "do nothing" scenario, wherein the road is not maintain, will produce unrealistically high benefits for all other schemes; hence, the base case should include a minimum reasonable level of intervention to prevent road closure.

Sensitivity tests have carried out including low and high traffic growth scenarios, increasing and reducing existing traffic volumes by 10% and increasing construction, maintenance, and rehabilitation costs by 10%. Together, these tests reveal the economic robustness of the proposed project.

4.10 FINANCIAL VIABILITY

The financing of a project inter-linked with the cost requirement - (capital and running costs) future traffic flows and revenue potential. A financial model would developed to project total revenues over a period of 30 years. The model would help determine the following under commercial format:

- Different user fee scenarios (toll)
- Funding options as packages for private participation
- With govt. participation in funding

Funding options as packages for private participation would cover:

- BOT
- Concession
- Leasing
- Management contract
- Performance agreement
- Servicing out or contracting out
- Corporatization

Govt. participation examined in the following manner:

- With Govt. subsidy
- Without Govt. subsidy

Partly financed through public funds supplementing the toll collection by other revenue sources or any other revenue augmentation method.

The Consultant would propose and finalize with R&B, parameters, formats, and scenarios in respect of commercial analysis for adopting a business-like approach. Pricing strategy well designed as to ensure cost recovery and tariff adjustment corresponding to cost increase. The Consultant would try to balance the conflicting goals in this context, namely (i) ensuring reasonable and just price from consumer angle and (ii) allowing for adequate profit margin through price cap approach.

Financial Analysis would carried out to determine

- Projected income statement
- Balance sheet
- Discounted cash flow including detailed cash outflow and inflow besides amortization statements
- Sensitivity analysis under a number of probable scenarios including traffic volume, traffic rate/price-cap etc.

Financial scheme would finalized after the financial analysis carried as stated above.

4.11 ENVIRONMENTAL SCREENING

Environmental Screening has conducted during feasibility stage as pre-requisite of the impact assessment study. The objectives are to establish the environmental settings of the project area, identification of sensitive environmental issues within the project area, categorization of the project based on activities proposed and sensitivity of the proposed project, to assess direct and induced impacts due to the project and scoping of detailed EIA study. The requirement of the statutory clearances pertaining to environment shall also identified based on the location of environmental features along the project.

The screening process mainly consisted of following activities:

a) Study of background information on project and related policy and legal issues
b) Collection of secondary data
c) Reconnaissance survey of the project impact zone
d) Analysis of data and Screening exercise
e) Project Categorization
f) Preliminary identification of environmental impacts and mitigation
g) Scope of detailed EIA study

a) Study of Background information

Study of Project Documents: First task was to study the project documents to have the understanding of the project objectives, its main components, its boundary etc. Unless the project well understood, its different impacts on environment and social issues cannot properly identified.

Study of Laws and Regulations: Laws and regulations enacted by Government of India and Government of Karnataka and Tamil Nadu State, relevant to road construction and environment have studied. The applicability of various acts and laws specified.

Study of Guidelines, Standards: Ministry of Environment, Forest and Climate Change (MOEF&CC), Indian Road Congress (IRC), Bureau of Indian Standards (BIS), etc. have published different useful documents, which studied for screening exercise.

Some of these documents are:

- EIA notification 2006 and further amendments
- Environment Impact Assessment – A Manual, 2001 – Ministry of Environment, Forest and Climate Change (MOEF&CC), Government of India (GoI)
- Environmental Impact Assessment – Guidance Manual for Highways 2010, MOEF&CC, GoI
- Environmental Guidelines for Rail/Road/Highway Project – 1989, MOEF&CC, GoI
- Karnataka and Tamil Nadu Environmental laws & regulations
- Guidelines for Environmental Impact Assessment, 1989, Indian Roads Congress (IRC 104-1988)
- Handbook on Environmental Procedures and Guidelines, 1994 MOEF&CC, GoI
- Guidelines on Landscaping and Tree Plantation, Indian Roads Congress (IRC:SP:21-2009)
- Guidelines on requirements for Environmental Clearance for Road Projects, Indian Roads Congress (IRC:SP:93-2011)
- Guidelines on Preparation and Implementation of Environment Management Plan, Indian Roads Congress (IRC:SP:108-2015)
- Green Highways (Plantation & Maintenance) Policy-2015

b) Collection of data from secondary sources

After having the background information about the project and its environmental aspects from legal and policy points and guidelines on such studies, the next step involved collection of data from secondary sources.

The data has collected on meteorology, demography, forests and related aspects, land use pattern, topography etc. from reliable sources. In addition, additional relevant environment data has collected from individual research works; either published or unpublished. The source of the data has documented in the report as reference. The data collected will broadly subjected to the ground truth verification during detailed field investigations and modifications that may be necessary to the database will carried out.

c) Reconnaissance survey of the project impact zone

A drive over inspection of the project corridor has carried out by the environmental expert in order to identify the sensitive environmental features along the project corridor and identification of category of the project with respect to the location of the project. Important environmental components within the project influence area have identified. Those were, road side trees, water bodies, public utilities, religious structures, educational institutes/schools, hospitals/health centres, community resources, congested areas etc.

Project Influence Area

Direct Influence Area

The areas of direct influence have confined in a linear fashion along the corridor where the construction activities take place. It is proposed to upgrade the project road from 2 lane to 4/6 lane. Keeping in view, the proposed widening, the direct impact zone has taken as 60 m, PROW of the project road and bypasses.

Indirect Influence Area

However, for various other environmental components, which are likely to have a broader area of influence, a distance of 10 km on either side of the road (as per the MoEF&CC EIA Notification 2006, GoI, and its amendment thereafter) has considered to define the indirect area of Influence.

d) Analysis of data and Screening exercise

The data collected through the above steps has compiled to develop the environmental scenario of the project area and the sensitive components within that. The full road length and CoI put under screening to identify the hot spot zones. The identification of hot spots in project area would help in further study and preparation of detailed Environmental Impact Assessment report and Environmental Management Plan for the project at later phase.

Environmental Evaluation

Project impacts on different environmental components identified through a scientific procedure.

Identified Valued Environment Components (VECs) in the Project

Following is a list of important environment components that identified as VECs in the projects route during the field survey.

Physical environment

- Land use
- Wetlands, Rivers, Rivulets and other Surface water bodies
- Soil erosion
- Natural hazards such as Cyclone
- Air/Water/Noise pollution
- Disposal of debris/materials resources

Bio-Environment

- Number of trees within the CoI and ROW
- Wildlife/nesting places/migratory routes and other habitats

- Ecologically sensitive areas
- Protected Forests and Reserved Forests
- Unprotected and Community Forests
- Biosphere Reserve, National Parks and Wildlife Sanctuaries

Socio-Economic Environment

- Drinking water sources
- Schools/hospitals/college (declared silence zones)
- Cultural and Religious properties
- Archaeological monuments and properties
- Common Property Resources
- Residential and Commercial properties
- Tourism locations

e) Project Categorization as per EIA Notification 2006 and further amendments

The GoI EIA Notification of 2006 (replacing the EIA Notification of 1994), sets out the requirement for Environmental Impact Assessment in India. This states that Environmental Clearance (EC) is required for specified activities/projects, and this must obtained before any construction work or land preparation (except land acquisition) may commence. Projects are categorized as A or B depending on the scale of the project and the nature of its impacts. The categorisation for highways and roads projects is as below:

Project or Activity		Category with threshold limit		Conditions if any
		A	B	
7(f)	Highways	i) New National Highways and ii) Expansion of National Highways greater than 100 km involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on re-alignments or by-passes.	i) All New State Highway projects ii) State Highway expansion projects in hilly terrain (above 1,000m AMSL) and or ecologically sensitive areas	General Condition shall apply **Note:** Highway include expressways

Source: MOEF&CC Notification 2006 and amendments thereafter

Category A projects requires EC from the national Ministry of Environment, Forest and Climate Change (MOEF&CC).

Category B projects require environmental clearance from the State Environment Impact Assessment Authority (SEIAA).

General Condition (GC): Any project or activity specified in Category 'B' will be treated as Category A, if located in whole or in part within 5 km from the boundary of:

(i) Protected Areas notified under the Wild Life (Protection) Act, 1972,
(ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time,
(iii) Notified Eco-sensitive areas,
(iv) inter-State boundaries and international boundaries.

The proposed project involves expansion of new national highway having length greater than 100 Km and involving additional right of way/ land acquisition greater than 40 m on existing alignments and 60 m on re-alignments and by-passes therefore fall under Category-A and attract conditions of obtaining prior Environmental Clearance from Ministry of Environment, Forests & Climate Change (MOEF&CC).

f) Preliminary identification of Environmental impacts and mitigation

Road construction related impacts occur at three stages of the project viz. Planning and Design, Construction and Operation stage. The broad impacts on physical, ecological and social environment identified based on the screening data and Impact identification matrix developed highlighting the general mitigation measures.

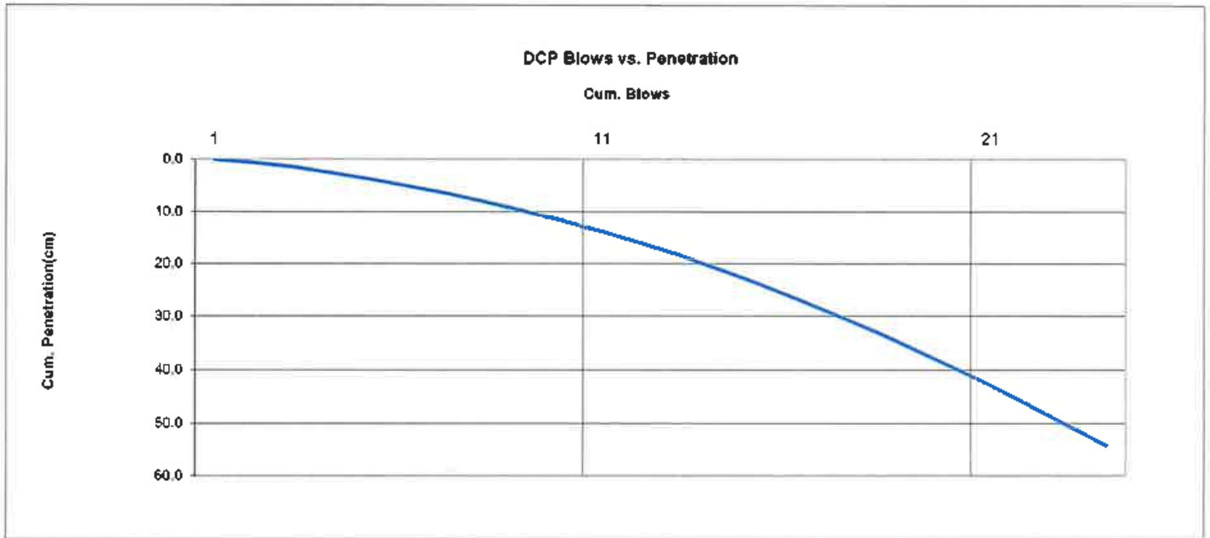
g) Scope of detailed EIA study

The scope of detailed EIA study will defined through the general TOR as suggested by MOEF&CC for Road and Highways and as defined in contract document under scope of work.

Analysis Sheet for DCP Tests

Cum. Blows	Reading (mm)	Cum. Penetration (cm)
1	4	0.0
2	10	0.6
3	18	1.4
4	29.3	2.5
5	41.3	3.7
6	55	5.1
7	69.4	6.5
8	85.3	8.1
9	102.7	9.9
10	122.1	11.8
11	143.1	13.9
12	165.5	16.2
13	188.9	18.5
14	213.9	21.0
15	241.3	23.7
16	270.3	26.6
17	300.1	29.6
18	331.1	32.7
19	363.8	36.0
20	397.7	39.4
21	432.4	42.8
22	469.4	46.5
23	507.8	50.4
24	546.2	54.2

Chainage	Pit No: 1
Location (km):	SH 03



As Per IRC:58

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR
Layer-I	51	6	27	9
Layer-II	159	8	10	
Layer-III	218	7	6	
Layer-IV				

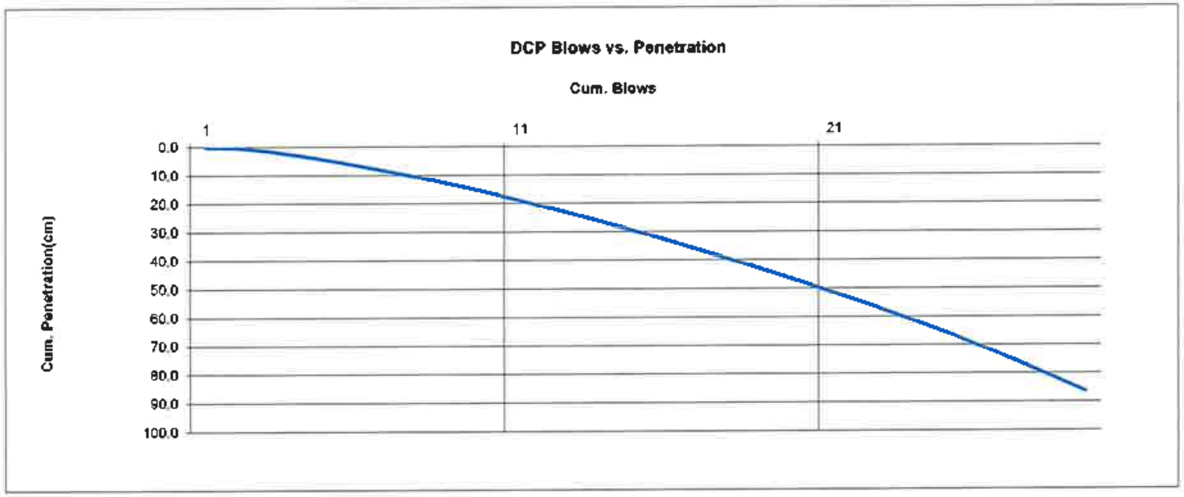
As Per TRL only for Refrence

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR

Analysis Sheet for DCP Tests

Cum. Blows	Reading (mm)	Cum. Penetration (cm)
1	4	0.0
2	7	0.3
3	18	1.4
4	34	3.0
5	53	4.9
6	72.7	6.9
7	93.7	9.0
8	116.4	11.2
9	140.4	13.6
10	166.8	16.3
11	193.8	19.0
12	222.5	21.9
13	251.7	24.8
14	281.7	27.8
15	312.9	30.9
16	345.6	34.2
17	378.8	37.5
18	412.8	40.9
19	447.7	44.4
20	483.4	47.9
21	519.4	51.5
22	557.4	55.3
23	597.1	59.3
24	638.5	63.5
25	680.5	67.7
26	724.9	72.1
27	770.9	76.7
28	818.7	81.5
29	867.7	86.4

chainage	Pit No:2
Location (km):	SH 03



As Per IRC:58

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR
Layer-I	49	5	23	6
Layer-II	170	7	8	
Layer-III	296	9	6	
Layer-IV	349	8	4	

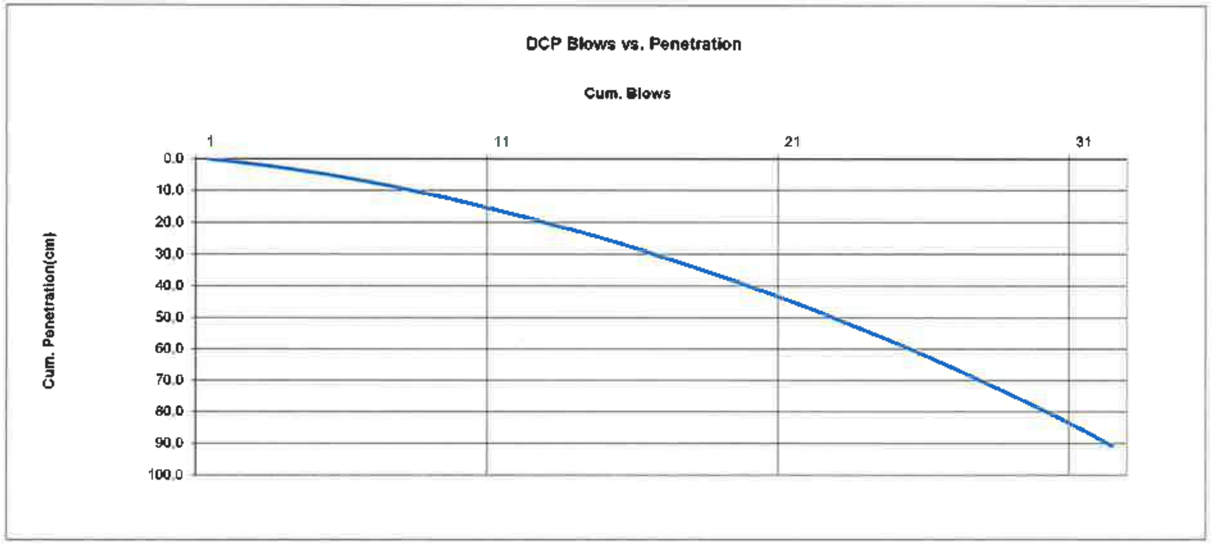
As Per TRL only for Refrence

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR

Analysis Sheet for DCP Tests

Cum. Blows	Reading (mm)	Cum. Penetration (cm)
1	8	0.0
2	18	1.0
3	29.4	2.1
4	42.4	3.4
5	56.6	4.9
6	72.3	6.4
7	89.7	8.2
8	109.1	10.1
9	129.1	12.1
10	150.3	14.2
11	172.6	16.5
12	196.5	18.9
13	221.2	21.3
14	246.6	23.9
15	272.9	26.5
16	301.1	29.3
17	330.1	32.2
18	360.2	35.2
19	391.4	38.3
20	423.8	41.6
21	457.7	45.0
22	492.7	48.5
23	529.1	52.1
24	566.4	55.8
25	605.6	59.8
26	646.6	63.9
27	688.5	68.1
28	731.5	72.4
29	775.2	76.7
30	820.1	81.2
31	865.6	85.8
32	915.3	90.7

chainage	Pit No:3
Location (km):	SH 03



As Per IRC:58

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR
Layer-I	82	7	19	6
Layer-II	270	11	8	
Layer-III	555	14	5	
Layer-IV				

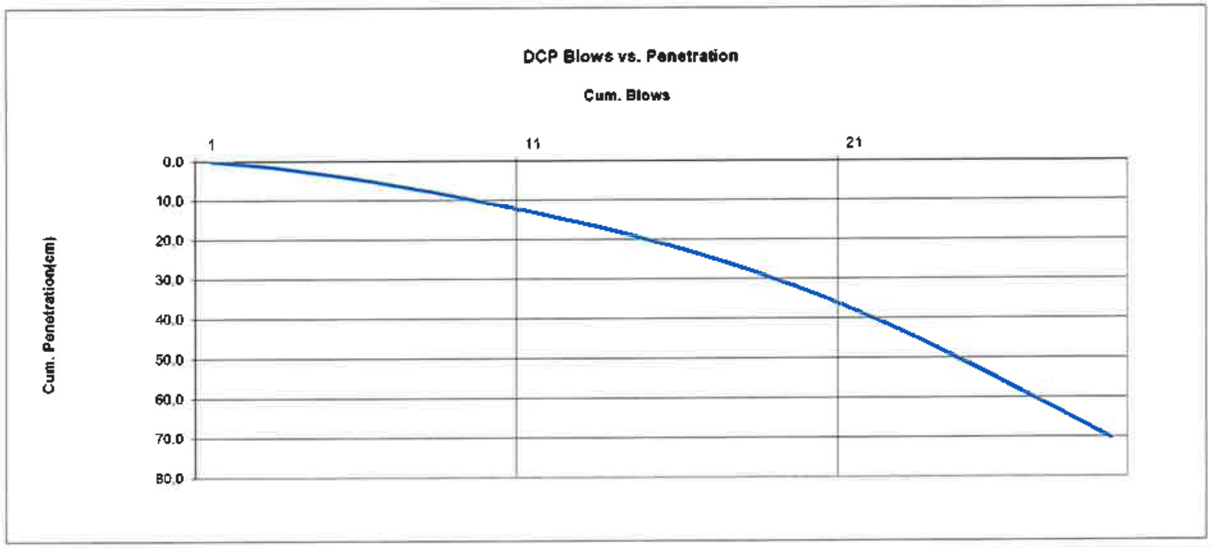
As Per TRL only for Refrence

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR

Analysis Sheet for DCP Tests

Cum. Blows	Reading (mm)	Cum. Penetration (cm)
1	5	0.0
2	12	0.7
3	21	1.6
4	32	2.7
5	43.7	3.9
6	56.6	5.2
7	70.7	6.6
8	85.6	8.1
9	101.6	9.7
10	118.5	11.4
11	135.7	13.1
12	153.6	14.9
13	172.5	16.8
14	192.7	18.8
15	214.7	21.0
16	237.7	23.3
17	263.4	25.8
18	290.7	28.6
19	319.7	31.5
20	351	34.6
21	384.7	38.0
22	419.9	41.5
23	456.9	45.2
24	496.7	49.2
25	537	53.2
26	579	57.4
27	621.8	61.7
28	664.6	66.0
29	707.4	70.2

chainage	Pit No:4
Location (km):	SH 03



As Per IRC:58

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR
Layer-I	97	9	20	8
Layer-II	136	7	11	
Layer-III	469	13	5	
Layer-IV				

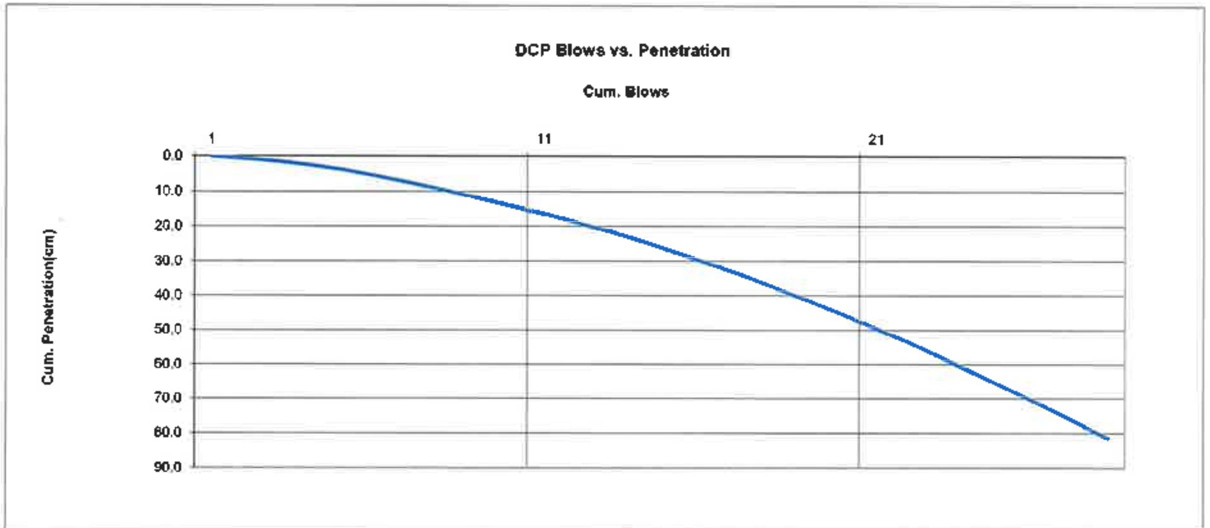
As Per TRL only for Refrence

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR

Analysis Sheet for DCP Tests

Cum. Blows	Reading (mm)	Cum. Penetration (cm)
1	4	0.0
2	10	0.6
3	18	1.4
4	29	2.5
5	43	3.9
6	60	5.6
7	79	7.5
8	100	9.6
9	122.4	11.8
10	145.4	14.1
11	169.4	16.5
12	194.1	19.0
13	220.1	21.6
14	248	24.4
15	279.4	27.5
16	312.4	30.8
17	346.6	34.3
18	382.6	37.9
19	420	41.6
20	458.7	45.5
21	498.5	49.5
22	539.9	53.6
23	584.7	58.1
24	630.4	62.6
25	676.1	67.2
26	722.1	71.8
27	770.1	76.6
28	818.1	81.4

chainage	Pit No:5
Location (km):	SH 03



As Per IRC:58

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR
Layer-I	118	9	16	6
Layer-II	190	7	7	
Layer-III	506	12	4	
Layer-IV				

As Per TRL only for Refrence

Stratum	Penetration (mm)	Blows	DCP-CBR	Equivalent CBR

Chapter-5:
Socio Economic Profile

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CHAPTER-5: SOCIO ECONOMIC PROFILE

5.1 INTRODUCTION

The proposed project road section of Satellite Towns Ring Road Bangalore west side (STRR) in Bangalore rural, Ramanagara, Bangalore and Krishnagiri district of the state of Karnataka and Tamil Nadu been specified in Chapter 1. The project influence area (PIA) of the project identified in Chapter 5 Socio-economic profile: (1) Direct PIA as the vicinity on both sides of the project road, (2) Indirect PIA of the districts of Bangalore rural, Ramanagara, Bangalore Urban and Krishnagiri. The socio-economic profile of the indirect project influence area has been prepared based on secondary official sources of information and discussed in this chapter. The present chapter provides with a screening report on possible social impacts of the vicinity of the project based on an initial assessment from the reconnaissance survey and Preliminary Land Acquisition/ Resettlement Plan. The project road details are as below.

Table 5:1: Details of Project Road Sections

Sl. No.	Section Name	Existing/ Proposed Chainage	Stretch of Land (km)	Total Length	State Name	District	Tehsil/ Taluka	NH/State Highway
1.	Satellite Ring Road Bangalore City (STRR)	Km 0.000 to 134.365 km	140	179.969 km	Karnataka	Bangalore Rural	Nelamangala	Newly declared NH 948A
		Km 134.365 to Km 179.969	45.604			Ramanagara	Magadi	
							Ramanagara	
							Kankapura	
						Bangalore Urban	Anekal	
					Tamil Nadu	Krishnagiri	Hosur	
							Denikinikottai	

The proposed project road of west side STRR, starts from NH 207 (at km 131.250) in Dobbasapete and terminates near Bagalur in Tamil Nadu/Karnataka border. The STRR alignment is totally a Greenfield alignment totalling the length of 180km. The alignment passes through Bangalore Rural, Bangalore Urban and Ramanagara districts of Karnataka state (m) and Krishnagiri district of Tamil Nadu state.

The road passes through several habitat areas viz. Dobbasapete. Banawadi, Gudemaranahalli, Rangenahalli, Magadi, Attimgere, Melehalli, Ramanagara, Kunagal, Kanakapura, Banavasi, Indalawadi, Anekal, Perandapalli, Devaripalli, Kalkunte Agrahara.

5.2 PROJECT INFLUENCE AREA

A detailed accounting of the socio-economic profile of the Project Influence Area (PIA) has been prepared which traces the PIA's economic performance of the past and establishes the likely growth prospects of the future. The output of this Chapter is the economic growth prospects of the PIA with respect to certain selected economic variables and serves as the basis for arriving at a realistic traffic growth rate, for different vehicle categories.

The direct project influence area identified as the vicinity on both sides of the project road. The indirect influence areas will consist of Bangalore rural, Ramanagara, Bangalore and Krishnagiri district of the state of Karnataka and Tamil Nadu. The socio-economic profile of the project influence areas are prepared based on secondary official sources of information.

5.3 STATE: KARNATAKA

Karnataka is a state in the southwest region of India. The capital and largest city is Bangalore (Bengaluru). Karnataka is border by the Arabian Sea to the west, Goa to the northwest, Maharashtra to the north, Telangana to the northeast, Andhra Pradesh to the east, Tamil Nadu to the southeast, and Kerala to the south. The state covers an area of 191,976sqkm or 5.83 percent of the total geographical area of India. It is the seventh largest Indian state by area. According to the 2011 census of India, the total population of Karnataka was 61,095,297 of which 30,966,657 (50.7%) were male and 30,128,640 (49.3%) were female, or 1000 males for every 973 females. The literacy rate was 75.36% with 82.47% of males and 68.08% of females being literate. 84.00% of the population were Hindu, 12.92% were Muslim, 1.87% were Christian, 0.72% were Jains, 0.16% were Buddhist, 0.05% were Sikh, 0.02% were belonging to other religions, and 0.27% of the population did not state their religion.

Karnataka had an estimated GSDP (Gross State Domestic Product) of about US$115.86 billion in the 2014–15 fiscal year. The state registered a GSDP growth rate of 7% for the year 2014–2015. Karnataka's contribution to India's GDP in the year 2014–15 was 7.54%. With GDP growth of 17.59% and per capita GDP growth of 16.04%, Karnataka is on the sixth position among all states and union territories. In an employment, survey conducted for the year 2013–2014, the unemployment rate in Karnataka was 1.8% compared to the national rate of 4.9%. In 2011–2012, Karnataka had an estimated poverty ratio of 20.91% compared to the national ratio of 21.92%.

5.4 DISTRICT PROFILE: BANGALORE RURAL

Bangalore district is located in the southeast part of Karnataka state. Bangalore is the district headquarters and capital of the state. Bangalore Rural district is located in the southeast part of Karnataka state between the north latitude 12° 15' and 13° 31' and East longitude 77° 04' and 77° 59', covering parts of the topo-survey sheets 57 G and H. The district bound by Kolar and Tumkur district in the north, Mandiya district on the west, Chamarajanagar district on the south and towards southeast by Tamil Nadu state. Bangalore district is well serve by road railway and airways. The National Highways passing through the district is connecting the state capital with other major cities like Hyderabad, Pune and Chennai. The interior villages are well connect by metalled roads. Bangalore district is also well serve by Railways. The railway line connects Bangalore to New Delhi, Hyderabad Bombay and Chennai.

5.4.1 Geography

Bangalore Rural District is located in the Southeast corner of Karnataka State. Spanning a Geographical area of 2,259 sq km, the district lies stretched between the latitudinal parallels of 12 15' N and 13 35' N on the one hand and the longitudinal meridians of 77 05' E and 78 E on the other. The new district physically almost surrounds the northern side of the Bangalore (Urban) District opening Hoskote Taluk in the East, ends Nelamangala Taluk in the west. The headquarters of the new district is at Bangalore itself. The district on the plateau with an average elevation of 629 to 950 metres from mean Sea level has ranges of Hills which are actually spurs of the Eastern Ghats, Stretching northwards with peaks like the Banantimari etta, Mudawadi Betta, Bilikal Betta, Siddadevara Betta, etc. in the South-West side. The Savandurga and Shivaganga peaks are another row of Hill ranges, spreading up to the Nandi Hills running across the Bangalore urban district.

Bangalore Rural District had many prehistoric sites at places like Jadigenahalli (Hosakote Taluk). The District abounds in wonderful Tourist spots. Places of scenic beauty, tall Hills, forts and beautiful monuments beckon the Tourists to visit them. The new district forms a part of Deccan Plateau and the rock formation belong to the category of peninsular Gneiss. The Granite Gneisses that abound in Neelmangala, Devanahalli and Taluks have created captivating Landscapes all along and they have provided jobs to hundreds engaged in quarrying.

The Arkavati, the Kanva and the Dakshina Pinakini are the tributary Rivers, which flow through the District in the General Direction from North to South. Cultivable lands are mainly rain-fed and dry farming is a characteristic feature of the district. Largely this rural district is Agricultural and Ragi is the main crop through mulberry raised over considerable tracts. The climate of the district is salubrious and very agreeable. It is devoid of extremes. However, rainfall is meagre, and as no major river flows in the district, Irrigation facilities are limited. This district too had often suffered from deficit and capricious rainfall conditions and the resultant phenomenon of crop failure.

An open country, which is lacking in natural barriers. Tumkur and Kolar Districts bound Bangalore Rural District on the North: on the South Bangalore Urban District, east by Kolar District and Tamil Nadu State and on the West by Tumkur and Ramanagara Districts. The outline map of the district roughly resemble a human ear, the hollow in the centre and the portion connecting the ear to the head representing the Bangalore (Urban) district.

5.4.2 Rivers

The major portion of Bangalore rural district lies in the Arkavati valley. The Arkavati, the Kanva and the Dakshina pinakini (southern Pennar) are the rivers, which flow through the district in the general direction from north to south.

5.4.3 Climate

The climate in Bangalore rural district is quite solubnous, with three different seasons. The pre monsoon starts from January to May. This period can divided into winter January to February and summer (march-may) winter is characterised by generally clear skies and very little rainfall. From April onward thunderstorms occur increasing during the month of May. Temperature is lowest during December and January. The temperature ranges from 34^0 C to 15^0 C. Average annual rainfall is around 986.19 mm. The Relative humidity ranges from 79 %to 45 %.

5.4.4 Religion

The villages in the state are comprised of Hindus as the majority community. The presence of Muslims and Christians as the two non-Hindu and minority communities is limited. This is due to their economic position in the social structure of the village community, where they are generally non-land-owning households and lead their lives by performing certain other occupations, but also needed for the village's Jajmani system in the traditional society. These included collection and sale of leather from dead domesticated farm animals, sale of copper, aluminium and steel vessels and their repair, tailoring, preparation of cotton beds, smithy and a few others. The Christians are limited to a few pockets of the state where the Church began its activities in the 19th century and led to the conversion of people particularly from the Dalit and tribal communities. Thus, both the non-Hindus found more in the urban than rural areas.

This situation is echo in our sample villages also. Of the total 115 households contacted for collecting information on the survey's subject matter, a majority (96.5 per cent) hailed from the Hindu religion. Barring these 111 households, the remaining all four belonged to Muslim community (3.5 per cent).

5.4.5 Language

Kannada is the official language of Karnataka and spoken as a native language by about 64.75% of the people. Other linguistic minorities in the state as of 2011 are Urdu (9.72%), Telugu (8.34%), Tamil (5.46%), Marathi (3.95%), Tulu (3.38%), Hindi (1.87%), Konkani (1.78%) and Malayalam (1.69%)

5.4.6 Demography

Bangalore Rural District is located in the southeast corner of Karnataka spanning a geographical area of 2,298 sq.km and it forms about 3.02 percent of the total area of the state. The total population of the district is 9,90,923, Literates 77.9%, Population density 431 per/sq km. and Sex ratio is 946 as per the 2011 census. The district lies between the latitude parallel to 12 15' North and the longitude and meridians 77 05' East and 78 West.

Table 5.2: Salient Features of the district

S. No.	Particular	Units	Figure
1	**Area**	In '000 Sqkm	5814
2	**Administrative Units**		
3	Revenue Villages	Number	1051
4	Revenue Talukas	Number	4
5	Gram Panchayats	Number	228
6	Municipalities (including corporations & NPs)	Number	5
7	**Population**		
8	Total	In Persons	990923
9	Male	In Persons	509172
10	Female	In Persons	481751
11	Male to Total Population	%	51.38
12	Female to Total Population	%	48.62
13	Sex	Ratio	946
14	Rural	In Persons	722179
15	Urban	In Persons	268744
16	Rural Population (%)	%	72.88
17	Urbanization	%	27.12
18	Density of Population (per Sq. Km.)	In Persons	431
19	**Child Population (0 - 6 Years)**		
20	Total	In Persons	107062
21	Males	In Persons	54908
22	Females	In Persons	52154
23	Rural	%	72.29
24	Urban	%	27.71
25	Sex Ratio (Females per 1000 Males)	Ratio	950
26	**Literates**		
27	Total	In Persons	688749
28	Males	In Persons	385311
29	Females	In Persons	303438
30	**Literacy Rate**		
31	Total	%	77.9
32	Males	%	84.8
33	Females	%	70.6
34	**Scheduled Castes Population**		
35	Total	In Persons	213700
36	Males	In Persons	107424

S. No.	Particular	Units	Figure
37	Females	In Persons	106276
38	Sex Ratio (Females per 1000 Males)	In Persons	989
39	**Scheduled Tribes Population**		
40	Total	Number	52903
41	Males	Number	27147
42	Females	Number	25756
43	Sex Ratio (Females per 1000 Males)	Number	949
44	**Working Population**		
45	Total	Number	459891
46	Males	Number	315499
47	Females	Number	144392

5.4.7 Working Profile

Coming to the understanding of findings about the economic conditions of the respondent households, we deal with the source of income as the predominant indictor of such a situation. What are the sources of the respondents' household income? While agriculture is understandably the main occupation of a majority of them, it is not the only source for many of them. In other words, 61.7 per cent depend upon the farm for their livelihood and supplement it with wage work. This is true of the land-owning households, which are increasingly finding it hard to sustain themselves only from the income derived out of agriculture. Lands are rain fed and not all of them are equipped with pump-set irrigation facility to cultivate all through the year and also to grow commercial crops that sell well in the market fetching them competitive rates of income for agricultural produce.

Alternative employment is also true of the totally landless and those having only marginal extent of lands. All the three categories - landed with small land size holdings, landed with marginal land size holdings and the landless - all depend on wage employment as a source of income to their households. Respondents from 17.3 households (20 households out of 115 households) work as daily wage earners. They are exclusively dependent upon wage labour for livelihood. It does not rule out possibility of wage employment among the 61.7 per cent of the agriculture-dependent households.

5.4.8 Connectivity

This district is well connect with National Highways and Indian Railways.

- There are 5 railway stations with a total railway route length of 204.39 km
- Bengaluru – Guntakal Railway line connecting to Mumbai, Ahmedabad, Jaipur, Delhi, Hyderabad passes through Doddaballapur
- Bengaluru – Chennai railway line passes through Hoskote Taluk
- Bengaluru – Hubli – Pune railway Line passes through Nelamangala Taluk
- Yelahanka – Bengerpet – KGF railway line passes through Devanahalli
- NH – 7 UP to TN via Karnataka passes through Dobbaspet
- NH – 48 Bengaluru, Hassan, Mangalore passes through Devanahalli
- NH – 4 Thane to Chennai via Karnataka passes through Hoskote

- NH – 7 Bengaluru – Tumakuru passes through Dobbaspet
- Kempegowda International airport is situate in the district.

5.4.9 Economy

The main occupation of the people in the district is cultivation and most of them are agricultural labourers. The literacy rate is 61.9% in rural parts of which male literacy rate is 72.4% and 51.1% is female literacy rate. In addition, in urban parts of the district the literacy rate is 76.2 % of which male literacy rate is 81.9% and female literacy rate is 70.10%.

The contribution of Horticulture to the Economy of the district is quite substantial. The district has considerable tracts under Horticultural crops like mango and Grapes. Betel vine Gardens also seen in many places. Animal Husbandry is being practice since Generations as an adjunct to Agriculture. A high degree of Urbanisation of Bangalore city has enhanced the economic importance of dairy, poultry keeping And Horticulture, which provide livelihood to a very large section. Considerable numbers are also engaged in raising sheep for wool as well. Vijayapura have been the most notable centres of Sericulture and Doddaballapura and Devanahalli are remember for prosperous silk weaving Industry. The District lies in the southern maiden region of the State and is largely.

- Per capita GDP is INR 7557 crore for the district in the year 2012-13
- Per capita annual income in the district is INR 109380 for the year 2012-13

Table 5.3: Contribution to GSDP of Karnataka

Bangalore Rural District's Contribution to GSDP of Karnataka (2012-13)		
Description	INR Crores	Contribution (%)
Total district GDP	7557	2.5
Agricultural and Allied	846	2.0
Industry	3097	3.7
Services	3614	2.0

5.4.10 Industry

Plenty of quarries and crushing plants spread over the entire district. Granite quarrying and crushing are going on for the past three decades and density of crushing plants in the district is high. The district has 24 textiles 31 chemical 86 engineering factories are the important industries in the district and their total employees are 37190.

- 71 large and medium scale industries with aggregated investment INR 4335.21 crore
- 9307 small – scale industries with aggregated investment INR 1414.43 crore
- 12% of MSMEs in aerospace sector

Potential Sectors are garments, automobile parts, electronic goods, granites, Ophthalmic lenses, machine tools, Aerospace, logistic facilities for development of e-commerce.

5.4.11 Tourist Places

Tourist Places within the district are:

- Shivagange Betta near Dobbaspet
- Vijayavittal Temple at Arasinakunte
- Fort and International Airport in Devanahalli taluk,
- Ghati Subramanya Swamy Temple in Doddaballapura Taluk

Doddaballapura Taluk is famous for Handlooms and having Industrial area & Apparel Park.

5.5 DISTRICT PROFILE: RAMANAGARA

Ramanagara is a part of the Southern Karnataka Plateau and is located in the South – eastern corner of Karnataka State. Ramanagara City is the administrative headquarters of this district. The district is part of Bangalore Division. It has the greatest extent of 105.25 km. from north to south and 62.08 km. from east to west, covering a total geographical area of 3516 sq.km. The most conspicuous areas of very low and very high area of the district is located at 365 and 1225 metres of contour lines above the mean sea level respectively. The district lies between the north latitude of 12 degrees 14 minutes to 13 degrees and 11 minutes and east longitudes between 77 degrees 3 minutes to 77 degrees 8 minutes. The district bound on the north by Bangalore Rural and Tumkur districts, on the northeast by Bangalore Urban district and on the west by Mandya district. On the South and southeast, Chamarajanagar district and districts of Tamil Nadu State cover the district. Its average elevation is 800 meters above the mean sea level.

5.5.1 Geography

District has a geographical area 3576sqkm, which accounts 1.85% of the geographical area of the state, and has 27th place in the state. It has an average elevation of 747 metres (2450 feet). Ramanagara is famous for the huge rocky outcroppings. Topography, drainage, soil, climate, vegetation, demography etc. are the main factors to socioeconomic development.

The uplands are often bare or covered with low scrub jungles and the low lands are dotted with series of irrigation tanks. It represents an uplifted plain at an elevation of 900 meters. The surface has dissected on the western and southern parts of the study unit-giving rise to a broken and rugged topography. In the west, the terrain is rugged and broken and is composed of a succession of hills and valleys intersected by rocks and rapid streams with sandy beds. In the south, the hills get closer. The lands are cover with denser vegetation and the general level declines as one moves south towards the Cauvery. The Granite rocks are the most prevalent rocks of Bangalore Metropolitan Region. The Savanadurga Betta is an enormous mass of granite, which stands on a base of about 12 km in circumference and rises to a height of 1,207 meters above MSL. The hill consists of two peaks, one called Bilibetta another Karibetta. The Geomorphology of Bangalore is flat except for a ridge in the middle. The highest point in Ramanagara district is Shivaganga hill, which rises to a height of about 1,380 meters above the MSL.

The central part of Ramanagara district is cover by Clay skeletal soil rocky land in combination. Towards south, the soil is more coarse loamy and coarse loamy silt. Pokey land found in the south, southeast and east. Towards east, hilly ranges are present. More of clayey and clayey loamy soil found here. Clayey soil found in a scattered pattern in central and northern part of Ramanagara. Ramanagara soil is favourable for agriculture except the few rugged terrains.

The popular places for rock climbing are; Savanadurga that is 31km away from Ramanagara, Ramadevarabetta located within the city, SRS betta that is 15.1km away from Ramanagara, Thenginkalbetta near to SRS betta and Kabbaladurga, which is 35km away from Ramanagara.

5.5.2 Drainage

The main drainage of the district is from north to south. The Arkavati, the Kanva and Shimsha are the important rivers of the district. The basin of the Shimsha River accounts for smaller portion of land on the western sector of the district. Arkavathi is a tributary of the river Cauvery and its source is a well in the southwest portion of Nandi hills. Taking a south – westerly route, the river passes through Doddaballapura taluk and Nelamangala taluk of Bangalore Rural district, receives the rivulet, Kumudavati from the west at Thippagondanahalli and flows through Magadi taluk passing east of the Savanadurga penetrating the hills, Ramgiri and Shivanagiri, it runs through the Ramanagara taluk and then through Kanakapura taluk. Finally, the river flows into the Cauvery on the southern borders of the district.

The Kanva River emerges from the hills to the north of Malur in Chanapatna taluk and enters a broad and fertile valley that stretches out up to the borders of the taluk and finally joins the Shimsha River. A reservoir has formed by building a dam across the river near Abur and its water effectively utilized for irrigation. Number of coconut gardens found on the lower parts of the river where the soil is well suited for the purpose. The drainage pattern in the area can described as semi dendritic to dendritic.

However, tanks play a vital role in Ramanagara district economy. At present, some of the streams are highly polluted to an extent that they are no more streams but drains of household sewage and let outs of industrial waste. In some cases, the streams cut off or blocked by constructions, which often lead to urban floods during the heavy rains.

5.5.3 Climate

The climate of the study area is salubrious and very agreeable. It is free from extremes. The climate of the Ramanagara is class as the seasonally dry tropical savanna climate, with four main seasons.

- Cold weather season (December to February).
- The hot weather season (March to May).
- The southwest monsoon season (June to September).
- The northeast monsoon season (October to November).

The cold weather season is a period of generally fine cool weather with mainly clear blue skies. It is a period of little or no rainfall. The hot weather season is a dry month with low humidity. April and may are the months of considerable thunderstorm activity. The southwest monsoon season is a moist, cloudy and rainy period. It is also a period of fairly strong and steady winds, blowing from the south west to west. The northeast monsoon from October is also a moist rainy period but with slightly less clouds. Wind are weaker and blow from east-north east to northeast. The change in wind direction from west-south west to east-north east between September and early October is very characteristic.

The temperature ranges between 33^0 C and 16^0 C. with an average of 24^0 C. the summer heat is moderate by occasional thunderstorms and squalls. April is to be the warmest month, with mean temperature of about 27.1^0 C. And the mean daily maximum of 33.6^0 C and a mean monthly highest maximum temperature of 35.3^0 C. December is the coldest month with a mean temperature of about 20^0 C. January has the lowest daily minimum of 14^0 C, and the monthly lowest minimum of 11^0 C. However, the average range of monthly mean temperature is 7^0 C.

Ramanagara receives adequate rainfall of about 915 mm from the northeast monsoon as well as the southwest monsoon. The mean number of annual rainy days is about 60 days. The northeast rainfall brings about 241 mm in about 14 rainy days. Usually this follows the southwest monsoon with a break of few days. Which is the period of summer thunderstorms brings mean rainfall of about 156 mm in 10 rainy days. Thus, the wettest months are August, September and October.

5.5.4 Religion

The villages in the state are comprised of Hindus as the majority community. The presence of Muslims and Christians as the two non-Hindu and minority communities is limited. As per official census 2011 and population data 2018 of Ramanagara district, Hindu are majority in Ramanagara state. Total population of Ramanagara district is 1,082,636 as per census 2011. Hinduism constitutes 88.60% of Ramanagara population. Muslims are minority in Ramanagara state forming 10.56% of total population.

Table 5.4: Religious status of the District

District	Ramanagara
Population	1082636
Hindu	88.60%
Muslim	10.56%
Christian	0.59%
Sikh	0.04%
Buddhist	0.01%
Jain	0.08%
Other	0.01%

5.5.5 Language

Kannada is the official language of Karnataka and spoken as a native language by about 64.75% of the people. Other linguistic minorities in the state as of 2011 are Urdu (9.72%), Telugu (8.34%), Tamil (5.46%), Marathi (3.95%), Tulu (3.38%), Hindi (1.87%), Konkani (1.78%) and Malayalam (1.69%)

5.5.6 Demography

According to the 2011 census, Ramanagara district has a population of 1,082,636. The district has a population density of 303 inhabitants per square kilometre. Its population growth rate over the decade 2001-2011 was 50.6 %. Ramanagara has a sex ratio of 976 females for every 1000 males.

Table 5.5: Salient features of the district

S. No.	Particular	Units	Figure
1	**Area**	In '000 Sq. Km	3576
2	**Administrative Units**		
3	Revenue Villages	Number	823
4	Revenue Talukas	Number	4
5	Gram Panchayats	Number	130
6	Municipalities (incl. Corpns. & NPs)	Number	2
7	**Population**		
8	Total	In Persons	1082636
9	Male	In Persons	548060
10	Female	In Persons	534576
11	Male to Total Population	%	50.62

S. No.	Particular	Units	Figure
12	Female to Total Population	%	49.38
13	Sex	Ratio	976
14	Rural	In Persons	814877
15	Urban	In Persons	267759
16	Rural Population (%)	%	75.27
17	Urbanization	%	24.73
18	Density of Population (per Sq. Km.)	In Persons	303
19	**Child Population (0 - 6 Years)**		
20	Total	In Persons	107841
21	Males	In Persons	54963
22	Females	In Persons	52878
23	Rural	%	71.70
24	Urban	%	28.30
25	Sex Ratio (Females per 1000 Males)	Ratio	962
26	**Literates**		
27	Total	In Persons	674758
28	Males	In Persons	378461
29	Females	In Persons	296297
30	**Literacy Rate**		
31	Total	%	69.22
32	Males	%	76.76
33	Females	%	61.50
34	**Scheduled Castes Population**		
35	Total	In Persons	203819
36	Males	In Persons	102612
37	Females	In Persons	101207
38	Sex Ratio (Females per 1000 Males)	In Persons	986
39	**Scheduled Tribes Population**		
40	Total	Number	22946
41	Males	Number	11619
42	Females	Number	11327
43	Sex Ratio (Females per 1000 Males)	Number	975
44	**Working Population**		
45	Total	Number	531459
46	Males	Number	344349
47	Females	Number	187110

5.5.7 Working Profile

Agriculture is one of the most primary & oldest occupations of Ramanagara district. Agriculture is the main source of livelihood in Ramanagara district & it is a main source of income. Major crops produced in the district are Ragi, Paddy, Maize, Tur, Groundnut, Sunflower and Sugarcane. Horticulture is also famous in Ramanagara district. Mango, Banana, Pineapple, Papaya, Sapodilla (chiku), Jack fruit, Grapes, Tomato, Onion, Chilli, Roses, Gladiolus are the major horticulture crops in Ramanagara district.

5.5.8 Connectivity

This district is well connect with National Highways and Indian Railways.

- NH-48 (Bengaluru – Mangalore) and NH – 209 (connecting Bengaluru to Dindigal – Tamil Nadu) passes through the district
- District has railway connectivity to Bengaluru, Mysore and other location with 6 Railway Stations and 44km of railway line
- Double line conversion of Bengaluru – Mysore is under progress

The district has Nearest Airport in Bengaluru at a distance of 89 km

5.5.9 Economy

The main economy of the district is:

- Ramanagara is famous for its silk market, one of the biggest in Asia, giving it the other name of Silk City; it is also known as Cosmopolitan Cocoon Market because of the people from different states participates in cocoon transaction here. On an average, 35 Metric tons of cocoons transacted daily in this market.
- In Ramanagara, there are 600 cottage basins (improved), 85 multi end reeling units and 04 Automatic Reeling Unit of 400 Ends capacities. There are also about 95 Twisting units functioning at this place.
- Ramanagara district includes the Bidadi Industrial Area, the first Industrial Area in the state, which houses the manufacturing units of Toyota and Coca-Cola, and a 1400 MW combined cycle gas-based power plant.

The unique position attained by trade and commerce sector is another important feature of the economy of the district. In the early days, trade and commercial activities were dependent on powerful moneylenders, who exploited the helpless debtors. The intervention of the government by enacting acts to control and regularise these moneylender were implement. The number of licensed money lenders, pawn brokers and finance corporations in the district increased due to the expansion of trade and commercial activities in the district.

GDDP is INR 5639 crores for the district in the year 2012-13. Per Capita annual income in the district is INR 70095 for the year 2012-13.

Table 5.6: Contribution to GSDP of Karnataka of Ramanagara District

Ramanagara District's Contribution to GSDP of Karnataka (2012-13)		
Description	**INR Crores**	**Contribution (%)**
Total district GDP	5639	1.9
Agricultural and Allied	1096	2.6
Industry	1369	1.6
Services	3173	1.8

5.5.10 Industry

Ramanagara has a very famous silk market, which is also one of the biggest in India, for this reason, the district known as 70 Silk town. The Bidadi industrial area has established in Ramanagara district and has the manufacturing units of Toyota and Coca-Cola, and a 1400 MW combined cycle gas-based power plant.

- 64 Large and Medium Scale Industries

- 1633 small scale industries with aggregated investment INR 169.4 crores
- 2 industrial areas (total 5 phases) and 4 Industrial estates

Potential sectors:

- Sericulture
- Agriculture and Allied Sectors
- Textiles and Apparels
- Mechanical and Automobile
- Chemicals
- Export Oriented Zones
- Aerospace Related Industries
- Development of Amusement Parks, Film City
- Construction Materials

5.5.11 Tourist Places

Sangama

The main tourist attraction of Kanakapura taluk is the confluence of the rivers Arkavathy, and Kaveri, (the sangama), nearly 33 km from Kanakapura. It is tourist attraction of Kanakapura.

Rocks of Ramanagara

Ramanagara also known as the land of seven hills. Shivaramagiri, Yatirajagiri, Somagiri, Krishnagiri, Revannasiddeshwara Betta, Jalasiddeshwara Betta and Sidilakallu Betta are the seven hills that dot the landscape of Ramanagara.

Ramadevarabetta

Another well-known hill is Ramadevara betta in Ramanagara district. Small door like grottoes made in the rock to resemble caves. It was also in this region that the famous Hindi movie, Sholay, shot.

JanapadaLoka

JanapadaLoka is situate in Ramanagara district on the Bangalore - Mysore highway at a distance of 55 km from Bangalore. JanapadaLoka is an organization that is committed to preserving and propagating the rural folk culture of Karnataka. Art gallery, open-air theatre and museum are also located here.

Kanva Reservoir

Kanva Reservoir is about 70km from Bangalore and 13km from Channapattana between Ramanagara and Channapattana. Kanva Reservoir built in 1946 across the River Kanva (a tributary of the River Cauvery). The river here named after the sage Kanva, who was supposed to have lived in this region during the time of Ramayana. Kanva Reservoir has five automatic Siphons, each with a displacement of 14000 cusecs of water. It is also an excellent picnic spot, with facilities for fishing and an ideal spot for camping and bird watching.

Magadi

Magadi is located at a distance of 50 km from Bangalore. Magadi is the birthplace of Kempegowda who built Bangalore. Magadi has remnants of an old fort, which is said to have been built by Kempegowda in which is situated the temple of Rameshwara, his family God. The ruins of his palace are point out to the south-west of this temple, where only broken brick and ruined walls noticed.

Savandurga

Savandurga is a hill located at a distance of 60 km west of Bangalore. It also known as Magadi Hills. The hill is famous for a temple also believed to be among the largest monolith hills in the world. Pilgrims who come to visit the Basaveshwara Savandi veerabhareeshwra swamy temple situated at the foothills frequently visit the Savandurga hills. At the foothill, there is a village by the same name and the forest around has stated as reserved forest and there is protected garden of the herbs of medicinal interest.

Shivaganga

Shivaganga is located at a distance of 60 km from Bangalore. Shivaganga also known as DakshinaKasi or the Varanasi of the South. Temples dedicated to Gangadhareswara, Hanna Devi and a cave spring called 'Pattala' found at the top of the hill.

Channapattana

Channapattana is located 60 km south-west of Bangalore on Mysore-Bangalore highway. The City ruled by the King Timmapparaja urs and later Jagadevaraya choose it as his Capital city. Channapattana is popular for its wooden toys and lacquer ware. Lacquer ware products include brightly colored wooden toys in various shapes and sizes, door curtains and powder boxes, besides a range of distinctive jewellery.

Kengal Hanumanthaswamy Temple

The temple is located in Vandaraguppe village, Ramanagara district, Karnataka. Thousand years ago, Vyasa (sage) was passing by a bright red boulder. Upon discovering this, he was all excited and visualized a Hanuman etched from those rocks. The Omni present lord Hanuman, fulfilled Vyasa's wish by slowly emerging from the rocks, with crisp details as Vyasa imagined. "Hoysala kings" built the temple. After Hoysalas, no one cared to maintain the temple and as a result, the temple almost reduced to rumble.

Mekedaatu (Goat's leap)

Mekedaatu or Goat's Leap, a famous picnic spot is about 95 km from Bangalore via Kanakapura. Mekedaatu is situate within the limits of the Muggur forest. Mekedatu is a beautiful picnic spot where the river Kaveri and river Arkavathi merges at the Sangam. From this point, about 3.5 kilometre downstream, the river Kaveri flows through a deep gorge so narrow that one would think that a goat could leap and cross it.

5.6 DISTRICT PROFILE – BANGALORE

Bangalore is a district of the Indian state of Karnataka. It is located in southern India on the Deccan Plateau. Its elevation is over 900m (3,000ft) above sea level, the highest of India's major cities. The district is located in the southeast part of Karnataka. It is having an area extent of 2190 sq.km and is located between the North latitude 12°39' 32": 13°14' 13"and East longitude 77°19'44": 77°50'13". The district bound by Bangalore rural district in the East, West and North except in southeast, where the district bounded by Dharmapuri district of Tamil Nadu state. The Bangalore urban district comprises of four taluks and within it lies the Bangalore city -the capital of

Karnataka. It is the central point for running the state administration and now known as Bruhat Bangalore Mahanagare Palike (BBMP). Bangalore is the sixth largest city of India and one of the fastest growing cities of Asia. It has acquired the name of 'Silicon City", due to its progressive trend in Information technology Now, after the IT boom, Bangalore city has suddenly overgrown its size and the district administration is facing a challenging task for providing necessary infrastructures to the related economic activities, trade, commerce and housing facilities. Especially, the enormous pressure on water particularly ground water in the district needs scientific planning and effective management of water resources

5.6.1 Geography

The district can divided into rocky upland, plateau & flat-topped hills at a general elevation of about 950amsl.The major part is sloping towards south and southeast forming pediplains interspersed with hills all along the western part. The pediplains form the majority of the district underlain by granites and gneisses with the highest elevation of 850 to 950m msl. The pediplain constitute low relief area having matured dissected rolling topography with erosional land slope covered by a layer of red loamy soil of varied thickness. The pediplains is dissect by streamlets flowing in southern direction.

Anekal taluk represents an uneven landscape with intermingling of hills and valleys. The western portion of the taluk is rocky and bare. Rocky outcrops raising 60 to 90 metres above the ground level are common. The ground much dissected and is a region of rapid erosion. The eastern portion of the taluk on the other hand forms a plain country. The western portion is jungle and marked by a continuous chain of hills, through which several rivulets combine and drain into the Arkavati. The water falling on the eastern portions of the taluk drains into the South Pinakini near Hosur (Dharmapuri district) beyond the State boundary. The Bangalore North taluk is more or less a level plateau lying between 839 to 962 metres above mean sea level. In the middle of the taluk, there is a prominent ridge running north & northeast to south & southwest. The highest point (Doddabettahalli 962 metres) is on this ridge. The gentle slopes and valleys on either side of this ridge hold better prospects of ground water utilization. The low-lying areas marked by a series of tanks varying in size from a small pond to those of considerable extent, but all very shallow.

Bangalore South and Bangalore East taluks represents an uneven landscape with intermingling of hills and valleys. The highest and lowest area of Bangalore South taluk lies between 717 m and 973 m, whereas the same for Bangalore East taluk lies between 860 to 928 metres above mean sea level. Bare rocky outcrops of granites and gneisses raising 30 to 70 metres above the ground level are common in the southern portion. The area is much dissect with rapid erosion particularly in the southern parts. Southern and western portions present a rugged topography composed of granitic and gneissic masses. The eastern portions form an almost featureless plain with minor undulations. Small shrubs and bushes cover the hilly terrain in the southern part.

5.6.2 Drainage

The major rivers of the district are Shimsa, Kanva, Arkavathi, South Pennar and Vrishabharathi. There are two major river basins in the district namely Cauvery and South Pennar. Shimsha and Kanva River of the Cauvery basin is draining majority of the district and Anekal taluk is drain by South Pennar river of Ponnaiyar basin, which takes its birth from Nandi hills and flows towards south.

The Arkavati River flows in the district for a small distance in Bangalore north taluk. The South Pinakini touches the borders of the district to the northeast of the Anekal taluk. The granitic ridge running north and northeast to south and southwest almost in the middle of the taluk governs the drainage pattern of the Bangalore North taluk. The drainage towards east made up of a network of nalas generally flowing from west to east with storage tanks along with nalas, ultimately feeding the South Pinakini River. In the western half, the drainage pattern made up of a network of nalas generally flowing from east to west with storage tanks along the nalas, ultimately feeding the Arkavathi River. The Bangalore East taluk drains to the east into the south Pinakini basin and Bangalore South taluk drains to the west into the Arkavati basin. The Vrishabhavati, a tributary of the Arkavati, flows in the district before joining the Arkavati near Muduvadidurga. The tributary takes its birth in the Bangalore city at Basavanagudi and the Suvarnamukhi from Anekal taluk joins the tributary before joining the Arkavati. The Basavanahole originating beyond and Muthyalamadu falls passes through Anekal taluk and join the Arkavati near Kanakapura.

5.6.3 Climate

Bangalore is consider to be climatically a well-favoured district situated in the heart of South Deccan of Peninsular India. Physically its situation is of considerable significance as it is on a ridge-top running through the middle of the Mysore plateau from west to east, at an average elevation of 900 metres. The district enjoys a very agreeable climate and it is free from extremes. The climate of the district is classify as the seasonal dry tropical Savana climate with four seasons. The dry season with clear bright weather is from December to February. The summer season from March to May is follow by the south-west monsoon from June to September. October and November constitute the post-monsoon or retreating monsoon season. The main features of the climate of Bangalore are the agreeable range of temperature, from the highest maximum 330 C in April to the lowest maximum of 140 C in January and the two rainy seasons, June to September and October to November, coming one after the other but with opposite wind regimes, corresponding to the southwest and northeast monsoons.

The average rainfall in the district ranges from 864mm in Bangalore South and Bangalore East taluks to 943mm in Bangalore North taluk. Among the taluks in the district, the pre-monsoon rainfall contributes 19 to 20 per cent of the annual rainfall, southwest monsoon contributes 52 to 56 per cent and northeast monsoon contributes 25 to 28 per cent of the annual rainfall.

5.6.4 Religion

The villages in the state are comprised of Hindus as the majority community. The presence of Muslims and Christians as the two non-Hindu and minority communities is limited. As per official census 2011 and population data 2018 of Bangalore district, Hindu are majority in Bangalore state. Total population of Bangalore district is 9,621,551 as per census 2011. Hinduism constitutes 80.29% of Bangalore population. Muslims are minority in Bangalore state forming 12.97% of total population.

Table 5.7: Religious status of the Bangalore District

District	Bangalore
Population	1082636
Hindu	80.29%
Muslim	12.97%
Christian	5.25%
Sikh	0.14%
Buddhist	0.06%
Jain	0.01%
Other	0.43%

5.6.5 Language

Kannada is the official language of Karnataka and spoken as a native language by about 64.75% of the people. Other linguistic minorities in the state as of 2011 are Urdu (9.72%), Telugu (8.34%), Tamil (5.46%), Marathi (3.95%), Tulu (3.38%), Hindi (1.87%), Konkani (1.78%) and Malayalam (1.69%)

5.6.6 Demography

According to the 2011 census, Bangalore district has a population of 9,621,551. The district has a population density of 4381 inhabitants per square kilometre. The growth of population in rural areas of the district is 12.16 per cent while in urban areas it is 51.91 per cent. Bangalore has a sex ratio of 916 females for every 1000 males.

Table 5.8: Sallent features of the district

S. No.	Particular	Units	Figure
1	**Area**	In '000 Sq. Km	2196
2	**Administrative Units**		
3	Revenue Villages	Number	668
4	Revenue Talukas	Number	4
5	Gram Panchayats	Number	130
6	Municipalities (incl. Corpns. & NPs)	Number	9
7	**Population**		
8	Total	In Persons	9621551
9	Male	In Persons	5022661
10	Female	In Persons	4598890
11	Male to Total Population	%	52.20
12	Female to Total Population	%	47.80
13	Sex	Ratio	91600
14	Rural	In Persons	881607
15	Urban	In Persons	8749944
16	Rural Population (%)	%	9.06
17	Urbanization	%	90.94
18	Density of Population (per Sq. Km.)	In Persons	4381
19	**Child Population (0 - 6 Years)**		
20	Total	In Persons	1052837
21	Males	In Persons	541656
22	Females	In Persons	511181
23	Rural	%	9.58
24	Urban	%	90.42
25	Sex Ratio (Females per 1000 Males)	Ratio	944
26	**Literates**		
27	Total	In Persons	7512276
28	Males	In Persons	4078041
290	Females	In Persons	3434235
30	**Literacy Rate**		
31	Total	%	87.67

S. No.	Particular	Units	Figure
32	Males	%	91.01
33	Females	%	84.01
34	**Scheduled Castes Population**		
35	Total	In Persons	1198385
36	Males	In Persons	607725
37	Females	In Persons	590660
38	Sex Ratio (Females per 1000 Males)	In Persons	972
39	**Scheduled Tribes Population**		
40	Total	Number	190239
41	Males	Number	99164
42	Females	Number	91075
43	Sex Ratio (Females per 1000 Males)	Number	918
44	**Working Population**		
45	Total	Number	4246927
46	Males	Number	3115361
47	Females	Number	1131566

5.6.7 Working Profile

A worker is define as a person who has participated in any economically productive activity with or without compensation or profit and a reference period to define a person as worker was one year preceding the date of enumeration. As per the definition, of the total population in the district, 44.14percent are workers. The male and female workers are 62.03 and 24.61percent respectively.

The workers further classified as main workers and marginal workers. The main workers are persons who worked for 6 months or more during the reference period and persons worked for less than 6 months are marginal workers. As classified above, of the total workers, 90.85 percent are main workers and 9.15 percent are marginal workers. The gender composition of workers as per Census classification further explains that male main workers are comparatively higher than female main workers and female marginal workers are good in number than male marginal workers.

5.6.8 Connectivity

Bangalore is a divisional headquarters in the South Western Railway zone of the Indian Railways. There are four major railway stations in the city: Krantiveer Sangolli Rayanna (KSR) Railway Station, Bangalore Cantonment railway station, Yeshwantapur junction and Krishnarajapuram railway station, with railway lines towards Jolarpettai in the east,Chikballapur in the north-east, Guntakal in the north, Tumkur in the northwest, Nelamangala in the west, Mysore in the southwest and Salem in the south.

The Rail Wheel Factory is Asia's second largest manufacturer of wheel and axle for railways and is headquarter in Yelahanka, Bangalore.

Bangalore is serve by Kempegowda International Airport, located at Devanahalli, about 40 kilometres (25 miles) from the city centre. It formerly known as Bengaluru International Airport.

5.6.9 Economy

The Economy of Bangalore is an important part of the economy of India as a whole.

The establishment and success of high technology firms in Bangalore has led to the growth of Information Technology (IT) in India. IT firms in Bangalore employ about 35% of India's pool of 2.5 million IT professionals and account for the highest IT-related exports in the country.

Estimates of the city's income Metro GDP have ranged from US$45 to US$83 billion (PPP GDP), and have ranked it either fourth- or fifth-most productive metro area of India.

One of the important factors spurring Bangalore's growth was heavy central government investment in Bangalore's public sector industries, partially because it is geographically out-of-reach from India's rivals Pakistan and China. This led to the concentration of technical and scientific navigator in Bangalore. This is a factor in leading the "IT revolution" in Bangalore.

Bangalore is the second fastest-growing major metropolis in India, and is the country's fourth largest fast-moving consumer goods (FMCG) market. Forbes considers Bangalore one of "The Next Decade's Fastest-Growing Cities". The city is the third largest hub for high-net-worth individuals and is home to over 10,000-dollar millionaires and about 60,000 super-rich people who have an investment surplus of ₹45 million (US$706,865) and ₹5 million (US$78,500) respectively.

5.6.10 Industry

Industry in Bangalore district spread across sectors, for example, we have engineering industries, aeronautical industries, textile industries, information technology industries, and biotechnology industries. District is the country's leading information technology services exporter, employing nearly 35 per cent of the Information Technology/ Information Technology enabled services workforce of the country.

The district also has the biggest biotechnology cluster in India, which as per estimates at around 137 units accounts for almost 40 per cent of the total units in the country. Leading biotechnology and pharmaceutical firms in Bengaluru Urban District include Biocon, Astra Zeneca, British Biologicals, Essilor India, Bio-Gen Extracts, Jubiliant Biosys, Millopore India Ltd, Novo Nordisk India, Siemens Hearing Instruments, Himalaya Drug Company, etc.

Bengaluru Urban district also has numerous manufacturing clusters which include Picture 2.1 A view of an Information Technology company in Bengaluru Urban district Picture 2.2 A view of a leading biotechnology company in Bengaluru Urban district 30 Peenya, Whitefield, Bommasandra, Jigani, Attibele, Kadugodi-Sadaramangala etc. Peenya is the largest industrial cluster in Asia with 5000 plus medium, large and small-scale industries giving employment to more than five lakh people. Some of the prominent manufacturing companies in Bengaluru Urban District are Bosch, L&T Komatsu, Kirloskar, Escorts, Bharat Heavy Electricals Limited, Bharat Earth Movers Limited, Bharat Electronics Limited, Hindustan Machine Tools, Huwaei Technologies, General Electric, Airbus Engineering Centre, Ace Micromatic Group, etc. Bengaluru Urban district also has many textile units, many of which are small-scale industries employing a sizeable number of workers.

The district is also emerging as the aerospace hub of India, India's only aircraft manufacturer Hindustan Aeronautics Limited is located here and four of its six R&D centres are in located in Bengaluru Urban District. An aerospace special economic zone spreading over 250 acres has established near Bengaluru International Airport. Other notable aerospace industries located in the district are Defence Research Development Organisation, Indian Space Research Organisation, National Aerospace Laboratory, Antrix Corporation, Aeronautical Development Agency, Airworks India Engineering, Quest Global, Mahindra Aerospace, Avembsys, International Aerospace Manufacturing Pvt. Ltd, Honeywell Technology solutions etc.

5.6.11 Tourist Places

The city known as the "Garden City of India". Bengaluru was one of the most important tourist centers of the Karnataka state. Central business district of Bangalore consists of places MG Road, Brigade Road, Commercial Street, Vidhana Soudha etc. Bangalore had many lakes and parks. Double-decker open roof bus are offered by BMTC as special buses for sightseeing in Bengaluru

- **Jayaprakash Narayan Biodiversity Park** (JP Park) is on an 85-acre (340,000 m2) site at Mathikere in the north-west area of Bangalore. The park has four lakes, lawns spread over 25 acres (100,000 m2), over 250 varieties of trees and shrubs can be found there all the time
- **Cubbon Park** is located in the heart of the city and spreads over 300 acres (1.2 km2). The park created in 1884, by Major General Richard Sankey. The park is home to numerous trees and plants that span over 68 general and 96 species. The park also known for its kids train.
- **Bangalore Fort** originally built by Kempegowda in 1537 A D. It is located next to the Victoria Hospital Gate in the K.R Market area.
- **Tipu Sultan's Summer Palace** built in 1791, is a two-storied ornate wooden structure with exquisitely carved pillars, arches and balconies. It houses a museum that contains artifacts relating to the Hyder-Tipu regime.
- **Bangalore Palace** (1862) is located near Mekhri Circle and Cantonment Railway station and built to look like a smaller replica of the Windsor in England.
- **Mayo Hall** designed in memory of the Lord Mayo and regarded as one of the finest designs of British architecture.

5.7 STATE: TAMIL NADU

Tamil Nadu literally 'The Land of Tamils' or 'Tamil Country') is one of the 29 states of India. Its capital and largest city is Chennai (formerly known as Madras). Tamil Nadu[9] lies in the southernmost part of the Indian Peninsula and is bordered by the union territory of Puducherry and the South Indian states of Kerala, Karnataka, and Andhra Pradesh. It is bounded by the Eastern Ghats on the north, by the Nilgiri, the Anamalai Hills, and Kerala on the west, by the Bay of Bengal in the east, by the Gulf of Mannar and the Palk Strait on the southeast, and by the Indian Ocean on the south. The state shares a maritime border with the nation of Sri Lanka. Tamil Nadu is the eleventh-largest state in India by area and the sixth most populous. The state was ranked sixth among states in India according to the Human Development Index in 2011, and is the third-largest state economy in India with ₹13,842 billion(US$220 billion) in gross domestic product. Tamil Nadu is home to many natural resources. In addition, its people have developed and continue to develop classical arts, classical music, and classical literature. The state is also home to a number of historic buildings and religious sites including Hindu temples of Tamil architecture, historic hill stations, multi-religious pilgrimage sites, and eight UNESCO World Heritage Sites.

5.8 DISTRICT PROFILE: KRISHNAGIRI

The holy land of wise scholars, men of valour and courage, blessed with the green valleys, hills and hillocks and inhabited by people known for innovative farming was divided, for the formation of Krishnagiri district, carved out of Dharmapuri district as 30^{th} district of Tamil Nadu.

'Krishna' refers to 'black' and 'giri' refers to 'hill'. This district is gift with black granite hillocks and named as "Krishnagiri".

Krishnagiri district bounded by Vellore and Thiruvannamalai districts in the East, Karnataka state in the west, State of Andhra Pradesh in the North Dharmapuri District in the south. Its area is 5143 sqkm. This district is elevated from 300m to 1400m above the mean sea level. It is located between 11° 12'N to 12° 49'N Latitude, 77° 27'E to 78° 38'E Longitude.

5.8.1 Geography

The prominent geomorphic units identified in the district through interpretation of satellite imagery are structural hills in the southwestern part of the district, denudational land forms like buried pediments in the plains and inselbergs and plateaus represented by conical hills aligned with major lineaments. Krishnagiri district forms part of the upland plateau region with many hill ranges and undulating plains. The western part of the district has hill ranges of Mysore plateau with a chain of undulating hills and deep valleys extending in NNE-SSW direction. The plains of the district have an average elevation of 488m msl. The plateau region along the western boundary and the northwest part of the district has an average elevation of 914m The Guthrayan Durg with an elevation of 1395m msl is the highest peak in the district.

5.8.2 Drainage

Krishnagiri district forms parts of Cauvery and East Coast Minor Rivers basins. Cauvery River forms the southwestern boundary of the district. Dodda Halla is the most important tributary of Cauvery draining the rugged terrain in the northwest part of the district. Ponnaiyar is the major river draining the district and is ephemeral in nature. It originates from Nandhi hills in Karnataka, enters Tamil Nadu west of Bagalur and flows almost in a southeast direction till it reaches Manjamedu from where it flows along the district boundary before entering the district, again near Hanuman Tirtham. After flowing for a short distance in an easterly direction, it again follows the district boundary before entering the neighbouring Dharmapuri district. Pambar and Burgur Ar., are among the important tributaries of Ponnaiyar draining part of the district.

5.8.3 Climate

The climate of Krishnagiri district is comparatively more pleasant than that of the surrounding districts due to general dryness of atmosphere and appreciable drop in temperature in the monsoon season. The year may be divide into four season namely dry season from January to March, summer season April and May, southwest monsoon season from June to Sept. and northeast monsoon season from October to December.

During summer season (April to May); the maximum temperature is about 37°C, and the mean daily minimum temperature of about 25°C in the plains. There is a gradual decrease of both day and night temperatures from June onwards till December, when the mean daily maximum temperature is about 30°C and the mean daily min. is about 19°C in plains.

The day temperature increases gradually from January onwards. The lowest temperature reached in January when the mean daily minimum is about 19°C. However, in higher areas i.e., Hosur, Thally and Krishnagiri taluks day and night temperature are lower by about 2 to 3°C. In these areas, weather is comparatively pleasant round the year.

The district receives the rain under the influence of both southwest and northeast monsoons. The normal annual rainfall over the district varies from about 750 to about 900 mm. It is the minimum around Hosur (767.7 mm) and Rayakottai (768.0 mm) in the northern and central parts of the district. It gradually increases towards west and east and is the maximum around Denkanikotai (910.7 mm) in the western part.

5.8.4 Religion

The villages in the state are comprised of Hindus as the majority community. The presence of Muslims and Christians as the two non-Hindu and minority communities is limited. As per official census 2011 and population data 2018 of Krishnagiri district, Hindu are majority in Krishnagiri state. Total population of Krishnagiri district is 1,879,809 as per census 2011. Hinduism constitutes 91.70% of Krishnagiri population.

Table 5.9: Religious status of the Krishnagiri District

District	Krishnagiri
Population	1879809
Hindu	91.70%
Muslim	6.13%
Christian	1.91%
Sikh	0.02%
Buddhist	0.01%
Jain	0.02%
Other	0.01%

5.8.5 Language

Three languages namely Tamil, Telugu and Kannada are predominantly speak in this district. Major religions are Hindu, Islam and Christianity. This district stands as an ideal exhibit of National integration and religious harmony. The society exhibit the confluence of different languages and religions.

5.8.6 Demography

According to the 2011 census, Krishnagiri district has a population of 1,879,809. The district has a population density of 370 inhabitants per square kilometre. The growth of population of the district is 20.41 per cent. Krishnagiri has a sex ratio of 958 females for every 1000 males.

Table 5.10: Salient features of the district

S. No.	Particular	Units	Figure
1	**Area**	In '000 Sq. Km	5129
2	**Administrative Units**		
3	Revenue Villages	Number	655
4	Revenue Talukas	Number	5
5	Gram Panchayats	Number	352
6	Municipalities (incl. Corpns. & NPs)	Number	2
7	**Population**		
8	Total	In Persons	1879809
9	Male	In Persons	960232
10	Female	In Persons	919577
11	Male to Total Population	%	51.08
12	Female to Total Population	%	48.92
13	Sex	Ratio	958
14	Rural	In Persons	1451446
15	Urban	In Persons	428363
16	Rural Population (%)	%	77.21

S. No.	Particular	Units	Figure
17	Urbanization	%	22.79
18	Density of Population (per Sq. Km.)	In Persons	367
19	**Child Population (0 - 6 Years)**		
20	Total	In Persons	217323
21	Males	In Persons	112832
22	Females	In Persons	104491
23	Rural	%	166231
24	Urban	%	51092
25	Sex Ratio (Females per 1000 Males)	Ratio	926
26	**Literates**		
27	Total	In Persons	1187958
28	Males	In Persons	667062
29	Females	In Persons	520896
30	**Literacy Rate**		
31	Total	%	71.46
32	Males	%	78.72
33	Females	%	63.91
34	**Scheduled Castes Population**		
35	Total	In Persons	267386
36	Males	In Persons	135474
37	Females	In Persons	131912
38	Sex Ratio (Females per 1000 Males)	In Persons	974
39	**Scheduled Tribes Population**		
40	Total	Number	22388
41	Males	Number	11419
42	Females	Number	10969
43	Sex Ratio (Females per 1000 Males)	Number	961
44	**Working Population**		
45	Total	Number	877779
46	Males	Number	561634
47	Females	Number	316145

5.8.7 Working Profile

The important crops of Krishnagiri District are Paddy, Maize, Ragi, Banana, Sugarcane, Cotton, Tamarind, Coconut, Mango, Groundnut, Vegetables and Flowers. The district has an excellent scope for agro business. Regional Agricultural Research Centre of Tamil Nadu Agricultural University is functioning efficiently at Paiyur in Kaveripattinam union since 1973. This centre is functioning in 18.5 hectare of land. It helps the peasants to develop and adopt the modern technique of cultivation. It has developed hybrid seeds by research, which yields more tonnage and good quality.

5.8.8 Connectivity

This district is connect by Prime Minister's Golden Quadrilateral (GQ) Project executed by National Highways Authority of India. This district has a network of National Highways converging.

- NH-7 (Kanyakumari-Kashmir)

- NH-46 (Chennai-Bangalore)
- NH-66 (Pondicherry-Bangalore)
- NH-207 (Sarjapur-Bagalur-Hosur)
- NH-219 (Krishnagiri-Kuppam)

Apart from this, state highways and district highways are linking almost all the towns and villages of the district. Four National highways converge at the Head Quarters of this district is unique.

People of Krishnagiri District belong to various racial groups. People from Kashmir, Maharashtra, Karnataka and Andhra have settled in this District. Hence, it can be rightly call a Cosmopolitan society. Ancient Art & Culture is preserve and maintained by inhabitants. The major entertainment for rural folk form the 'Street Play' (Therukoothu) and 'Sevaiattam'.

The following major Highways passes through Krishnagiri District:

Table 5.11: Connectivity of the major highways to the Krishnagiri district

S. No.	Start-End Point	NH No.	Length(Km)
1	Kanniyakumari–Varanasi	7	2460
2	Krishnagiri–Ranipet	46	144
3	Pondicherry–Krishnagiri	66	214
4	Krishnagiri–Madanapalli	219	175
5	Sarjapur–Bagalur–Hosur	207	40

Salem, Bangalore Broad gauge line run through Hosur. A railway line between Jolarpet and Hosur (Via) Krishnagiri will pave way for further improvement of industrial growth in Hosur. This will link Chennai city and its port facilities with the growing town of Hosur, which is also a hub for horticulture crops. However, this will take some time for realization. As per new budget report, the proposed new line would take off from Jolarpet Junction, Tirupattur and pass through Kandili, Bargur, Krishnagiri and Shoolagiri a length of 104 km to join at Rayakottai. Another survey was conduct for a new rail link between Krishnagiri and Dharmapuri in 2004-05.

5.8.9 Economy

- Krishnagiri district is famous for Mangoes. Krishnagiri district is also famous for the Granite Industry with quarries and processing units spread around the district. Hosur, one of the most industrialized places in the state is located in this district.
- With 40% share, the district is the top producer of Ragi in Tamil Nadu.
- The national fruit of India and of the state of Tamil Nadu is mango. The major crop of Krishnagiri district with 300.17 km² area of cultivation is mango. The district produces 300,000 tonnes annually and in Tamil Nadu Krishnagiri District is the First Place in The Production of Mango. Almost 20% of the mango varieties like 'Thothapuri' and 'Alphonso' that are produce in this district processed into pulp. In addition to mango pulp processing, tonnes of mangoes processed into juice every year in this district. A large-scale mango export zone has approved for the Krishnagiri district. This will allow growing as well as processing of mangoes thus yielding higher profits for the farmers.

5.8.10 Industry

Approximately 25 industries located in these district process mangoes. Much of the population in this district is employ through mango cultivation directly and other labour class benefit through employment in mango processing units. There are about 150 mango nurseries which produce mango saplings in and around 'Santhur Village'. The district exports mango based products worth over ₹8 billion. Under the horticulture development program, government owned horticulture farms are functioning here. Through these units, about 300,000 fruit saplings are produce and distributed under different schemes. Apart from production and export, Krishnagiri also hosts Mango exhibition every year that is the unique in its kind in line with the annual exhibition held at New Delhi.

5.8.11 Tourist Places

Thousands of visitors visit Krishnagiri each year. Majority come from Hosur, Bangalore, Dharmapuri, Vaniyambadi, Ambur and Chennai. The Krishnagiri Dam (Krishnagiri Reservoir Project Dam) is construct in 1958 during the rule of the then Chief Minister late Kamaraj located near the town. Nearby, Sayed Basha hills has a fort that was the fortress of the ruler, Tippu Sultan. Treks to the nearby hills/mountains as well as farmhouses are located in the outskirts. The boathouse is situate 8 km from the central bus stand, which also houses a children's park. There are variety of ancient temples near Krishnagiri. Nearby Ramapuram is the site of a 500-year-old Rama Temple that draws many visitors each year.

The presence of museum in this District known for traditional culture, Art and Architecture, Heritage and Historical Background is a blessing in disguise, to spread the traditional and heritage, culture and art of Tamil Nadu and Krishnagiri District in particular. This museum is functioning since 1993 AD, situated on Gandhi Salai in Krishnagiri. Historical monuments are preserved and exhibited here. It is not only a place of tourism but also a centre of education. This museum collects the monuments, Classifies and preserves them to conduct research on its historical worthiness. The syed Basha Mountain is very famous for two Sufi martyr saints who had been slain in a battle long ago, every year on 10th of Shawwal (Islamic month) a grand celebration is made . Almost thousands gather during this Urs festival with devotion and respect.

Chapter-6:
Indicative Design Standards, Methodologies and Specifications

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CHAPTER-6: INDICATIVE DESIGN STANDARDS, METHODOLOGIES AND SPECIFICATIONS

6.1 GENERAL

This Chapter intends to give brief description of Design Standards adopted in the Design. The Consultants have evolved Design Standards and Material Specifications for the Project Road primarily based on IRC Publications, MORTH Circulars and relevant recommendations of the International Standards (American, Australian, British) covering all aspects of Design including Geometric elements, Pavement Design, Bridges and Structures, Traffic Safety and Materials.

Design Standards given in 'Manual of Specifications and Standards for Six Lanes of Highways through Public Private Partnership' IRC:SP:87-2013 shall be used as main guidelines along with other relevant IRC codes, guidelines and special publications, and MORTH circulars as applicable to National Highways. Where the said standards are silent on any topic, following standards shall referenced and the one considered the best and most relevant will adopted:

- American Association of State Highway and Transport Officials (AASHTO) standards;
- British Standards;
- Any other National or International Standard as considered suitable.

6.2 HIGHWAY GEOMETRIC DESIGN STANDARDS

6.2.1 Terrain Classification

Terrain is classified by the general slope of the country across the highway alignment, for which the criteria given in **Table 6.1** are followed. The Geometric Design of a highway is influenced significantly by Terrain conditions.

The % Cross Slope of the Project Road for most of its length is in the range of 0-10% and thereby the Terrain is classified as Plain Terrain.

6.2.2 Design Speed

Design Speed is the basic parameter which determines all other Geometric Design features. Choice of the Design Speed depends on the Function of the road as also Terrain conditions. Design Speeds for National Highways passing through various Terrain Classifications are given in **Table 6.1.**

Table 6.1: Design Speed (from IRC: SP: 87-2013)

No.	Terrain Classification	% Cross Slope of the Ground	Design Speed (kmph)	
			Ruling	Minimum
1	Plain & Rolling	Up to 25	100	80
2	Mountainous and Steep	More than 25	60	40

The Design speed adopted for the design of highway is 100kmph and a minimum Design Speed of 40kmph shall be adopted for Service Roads.

In general, the Ruling Design Speed shall be adopted for various Geometric Design features of the road. Minimum Design Speed shall be adopted where site conditions are restrictive and adequate land width is not available.

As the Project Road is part of National Highway and is passing through Plain Terrain, corresponding Design Speed (as per above **Table 6.1**) values have been adopted.

6.2.3 Sight Distance

For the safety of travel on roads, Sight Distance is an important parameter required to be considered in the Geometric Design of Highways. It is the visible distance required to be available in different situations, to permit drivers enough time and distance to control their vehicles so as to avoid unforeseen accidents.

Three types of Sight Distance are relevant for the design of Summit Vertical Curves and design of Horizontal Curves:

Stopping Sight Distance (SSD) is the clear distance ahead needed by a driver to stop his vehicle before meeting a stationary object in his path on the road. It is the minimum sight distance for which all roads must always be designed, regardless of any other consideration.

Overtaking Sight Distance (OSD) is the minimum sight distance that should be available to a driver on a 2-way road (un-divided) to enable him to overtake another vehicle safely.

Intermediate Sight Distance (ISD) is twice the safe stopping distance and affords reasonable opportunities to drivers to overtake with caution.

The safe stopping sight distance and minimum sight distance for divided carriageway for various design speeds are given in **Table 6.2**. The desirable values of sight distance shall be adopted unless there are site constraints. As a minimum, safe stopping sight distance shall be available throughout.

Table 6.2: Sight Distance for Various Speeds

Design Speed (kmph)	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m)
100	180	360
80	130	260
60	90	180
40	45	90

The Project road in general will be designed for Desirable Minimum Sight Distance (ISD) and wherever it is not practicable to provide the same due to site constraint if any, Safe Stopping Sight Distance (SSD) will be provided as mentioned in Table 6.2.

6.2.4 Horizontal Alignment

The road alignment shall be designed so as to ensure that Standards of Curvature, Visibility, Super elevation etc. are provided for a Design Speed. Geometric Design - Horizontal Alignment Design shall confirm to general principles outlined in IRC: 73-1980, Para 9.

In general, all horizontal curves consist of circular portion flanked by spiral transitions at both ends. The various elements of combined circular and transition curve are shown in **Fig. 6.1**. Design Speed, Super elevation and coefficient of side friction affect the design of circular curves. Length of transition curve is determined on the basis of rate of change of centrifugal acceleration or the rate of change of super elevation. Recommended Values of Curve Elements are given in **Table 6.3** (Minimum Radii of Horizontal curves for different terrain classification) and **Table 6.7** [Minimum Transition Curve Lengths (from IRC: 38-1988, Table 9) for different Speed and Curve Radius].

Table 6.3: Minimum Radii of Horizontal Curves (from IRC: SP: 87-2013 Table 2.6)

Nature of Terrain	Desirable Minimum	Absolute Minimum
Plain and Rolling	400m	250m
Mountainous and Steep	150m	75m

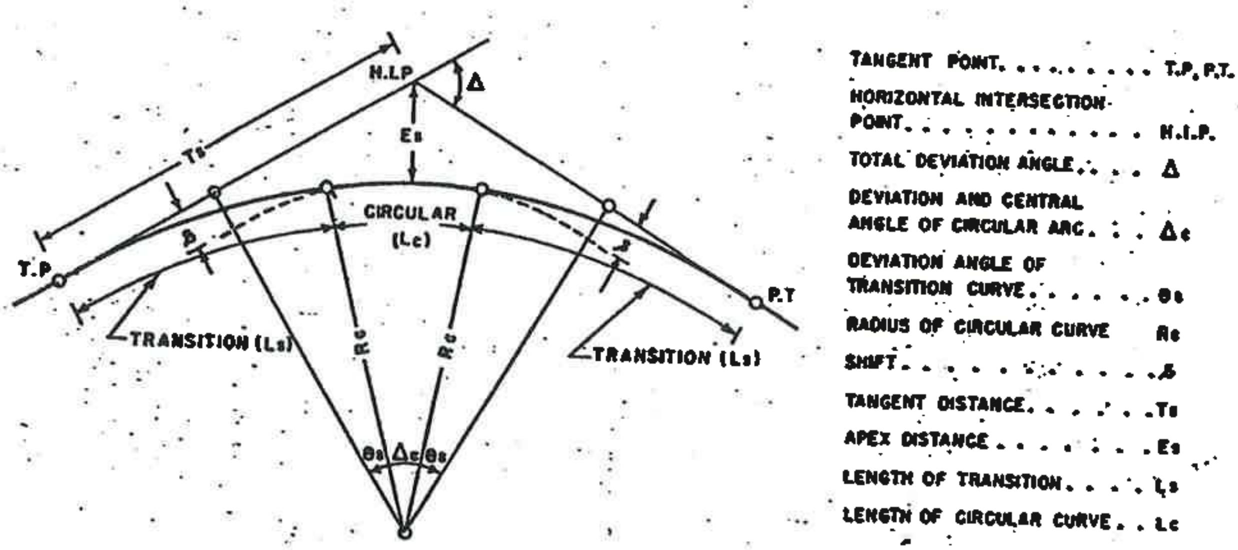

Figure 6.1: Elements of a Combined Circular and Transition Curve

- **Super-elevation**

Super-elevation required on horizontal curves shall be calculated from the following formula as given in IRC: 73-1980 Clause 9.3:

$e = V^2 / 225R$, subject to maximum of 7% in Plain/Rolling Terrain and 10% in Hilly areas not bounded by snow.

Where,

e = super elevation in metre per metre

V = Speed in kmph and

R = Radius in metres

As per IRC: SP: 87-2013 Clause 2.9.3, Superelevation shall be limited to 7%, if radius of curve is less than desirable minimum radius. It shall be limited to 5% if radius is more than desirable minimum.

- **Radius on Horizontal Curves**

The minimum Radius of Horizontal Curves is calculated from the following formula:

$R = V^2 / 127 (e + f)$

Where,

V = vehicle speed in kmph

e = Super elevation in metre per metre

f = coefficient of friction between vehicle tyre and pavement (taken as 0.15)

R = Radius in metres

Based on this equation and the maximum permissible value of super-elevation of 7%, Radii for Horizontal curves corresponding to ruling and minimum design speeds are given in **Table 6.4**.

Table 6.4: Minimum Radii of Horizontal Curves corresponding to Design Speed

Nature of Terrain	Plain and Rolling		Mountainous and Steep	
	Ruling	Absolute minimum	Ruling	Absolute minimum.
Design Speed (kmph)	100	80	60	40
Minimum Radius (m)	400	250	150	75

- **Curves without Super elevation**

When the value of super elevation obtained from the parameters stated above is less than the road camber, the normal cambered sections are continued on the curve portion, without providing any super elevation. Since the project area is under low rainfall area, normal camber (2.5%) has been provided. Radius requiring no super-elevation has been recommended considering camber 2.5%.

Table 6.5 given below indicates the radius of horizontal curves for different rates of camber beyond which super elevation will not be required.

Table 6.5: Radii beyond which Super elevation not required

Design Speed (kmph)	Radius (m)
100	1800
80	1100
65	750
50	450
40	280

- **Transition Curves**

Transition curves are necessary for vehicle to progress smoothly from a straight section into a circular curve or between curves of different radius. The transition curve also facilitates a gradual application of the super elevation and any widening of the carriageway that may be required for the horizontal curves.

The minimum length of the transition curve is determined from the following two considerations and is provided in Table 6.7.

(a) As per Comfort criteria,

$Ls = 0.0215\ V^3 / CR$

Where,

Ls = length of transition in metres

V = Speed in kmph

R = radius of circular curve in metres

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

(b) As per rate of change of Super-elevation,

The rate of change of super elevation will not be steeper than 1 in 150. The formula for minimum length of transitions depending on the terrain (plain/Rolling) is: $L_s = 2.7\ V^2/\ R$

- **Curve Widening**

At sharp horizontal curves, it is necessary to widen the carriageway to provide for safe passage of vehicles. Extra widening required for single and two-lane roads is given in IRC: 73-1980, Table 18. For multi-lane roads, the pavement widening may be calculated by adding half the widening for two-lane roads to each lane. The Extra width of Pavement and Roadway in each carriageway of Road (shall be as per IRC: SP: 87-2013 Table 2.5) is provided in Table 6.6.

Table 6.6: Extra Width of Pavement and Roadway In Each Carriageway (as per IRC: SP: 87-2013 Table 2.5)

Radius of Curve (m)	Extra Width (m) of Pavement
75 to 100	0.90
101 to 300	0.60

Table 6.7: Minimum Transition Lengths for different Speed and Curve Radius

Curve Radius (Rc) (metres)	Transition Lengths (Metres)																		Curve Radius (Rc) (metres)
	100 km/h		80 km/h		65 km/h		50 km/h		40 km/h		35 km/h		30 km/h		25 km/h		20 km/h		
	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	P	H	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
14																	80	30	14
15																NA	75	30	15
20															NA	35	55	20	20
23															75	—	—	—	23
25													NA	NA	70	25	45	20	25
30												NA	80	30	60	25	40	15	30
33												—	75	—	—	—	—	—	33
40											NA	35	60	25	45	20	30	15	40
45		SPEED NOT APPLICABLE		SPEED NOT APPLICABLE		SPEED NOT APPLICABLE				NA	75	30	55	20	40	15	25	15	45
50										40	70	25	50	20	35	15	25	15	50
55									NA	40	60	25	45	20	30	15	20	15	55
60									75	35	55	25	40	15	30	15	20	15	60
70								NA	65	30	50	20	35	15	30	15	15	15	70
80							NA	55	55	25	45	20	30	15	25	15	15	15	80
90							75	45	50	25	40	15	30	15	20	15	15	NR	90
100							70	45	45	20	35	15	25	15	20	15	NR		100
125					NA		55	35	35	15	30	15	20	15	15	NR	—		125
155					80		—	—	—	—	—	—	—	—	—				155
150					80		45	30	30	15	25	15	20	15	15	—			150
170					70		40	25	25	15	20	15	15	NR	NR	—			170
200			NA		60		35	20	25	15	20	15	15						200
230			90		—		—	—	—	—	—	—	—						230
250			90		50		30	15	20	15	NR	NR	NR						250
300	NA		75		40		25	15	NR	NR	—								300
350	130		60		35		20	—		—	—								350
360	130		—		—		—	—	—	—	—								360
400	115		55		30		20	15											400
500	95		45		25		NR	NR											500
600	80		35		20														600
700	70		35		20														700
800	60		30		NR														800
900	55		30																900
1000	50		30																1000
1200	40		NR																1200
1500	35																		1500
1800	30																		1800
2000	NR																		2000

NOTATIONS :

P – PLAIN AND ROLLING TERRAIN
H – MOUNTAINOUS AND STEEP TERRAIN
NA – RADIUS NOT APPLICABLE
NR – TRANSITION NOT REQUIRED

6.2.5 Vertical Alignment

The Vertical Alignment should provide for a smooth longitudinal profile. Grade changes should not be too frequent as to cause kinks and visual discontinuities in the profile. Recommended Gradients (from IRC: SP: 87-2013 Table 2.8) are given in **Table 6.8**.

Table 6.8: Recommended Gradients (from IRC: SP: 87-2013 Table 2.8)

Nature of Terrain	Ruling Gradient	Limiting Gradient
Plain and Rolling	2.5%	3.3%
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

As far as possible, for the project road passing through Plain terrain, Gradients up to the value corresponding to Ruling Gradient have been adopted. A minimum longitudinal gradient of 0.3% is adopted to secure satisfactory drainage.

In general, Vertical Curves shall be provided at all changes in gradient. The Curvature shall be large enough to provide for comfort and, where appropriate, Sight Distance for safe stopping at Design Speed. Curvature shall be derived from the appropriate 'K' value (is length of the curve divided by algebraic change of gradient expressed as a percentage) in **Table 6.9**. The minimum vertical curve lengths can be determined by multiplying the 'K' values shown by the algebraic change of gradient expressed as a percentage (as shown in IRC: SP: 23-1983 Table 6). For satisfactory appearance the minimum length of vertical curve should be as shown in IRC: SP: 23-1983 Table 7.

Vertical Curves

Long sweeping vertical curves shall be provided at all grade changes. These shall be designed as Square Parabolas. Vertical curves are provided at all grade changes exceeding those indicated in IRC: SP: 23-1983 Table 7. The Design of Summit / Crest Curves is based on Visibility; whereas design of Valley / Sag Curves is based on Comfort criteria and Head light sight distance.

A. Summit Curves

Summit curves are designed for safe stopping sight distance.

For safe stopping sight distance the length of summit curve shall be calculated from the following formula:

When the length of curve (L) exceeds the required sight distance (S)

i.e. $L > S$

$L = NS^2 / 4.4$

Where N = Deviation angle

L = Length of parabolic vertical curve

S = Sight distance in metres.

When the length of curve (L) is less than the required sight distance (S)

i.e. $L < S$

$L = 2S – 4.4 / N$

B. Valley Curves

Valley curves are designed for head light sight distance. The length of valley curves shall be calculated by the following two criteria:

When the length of curve (L) exceeds the required sight distance (S)

i.e. L > S

$L = NS^2 / (1.50 + 0.035S)$

When the length of curve (L) is less than the required sight distance (S)

i.e. L < S

$$L = \frac{NS^2}{(1.50 + 0.035S)}$$

When the length of curve (L) is greater than the required sight distance (S)

$$L = 2S - \frac{1.50 + 0.035S}{N}$$

C. K Value

Table 6.9 shows adopted 'K' Values for Vertical Curves.

Table 6.9: Adopted 'K' Values for Vertical Curves (from IRC: SP: 23-1983 Table 6)

Design Speed (kmph)	'K' Values for Vertical Curves			
	Summit Curve			Valley Curve
	for SSD	for ISD	for OSD	
100	73.6	135.0	426.7	41.5
80	32.6	60.0	230.1	25.3
65	18.4	33.8	120.4	17.4
50	8.2	15.0	57.5	10.0
40	4.6	8.4	28.4	6.6

6.2.6 Lateral and Vertical Clearances at Underpasses

Clearance as specified in IRC: SP: 87-2013 Clause 2.10 to be followed.

6.2.7 Cross Sectional Elements

Right-of-Way (ROW) is the total land width required for the Project Road, to accommodate the Roadway (Carriageway and Shoulders), Side Drains and Utilities etc. In general, minimum ROW for non-urban and urban areas should be as per IRC: 73-1980 and IRC: 86-1983 respectively. As per IRC: SP: 87-2013 Clause 2.3"A minimum ROW of 60m should be available for development of the 6 lane highway..

Roadway Width depends upon width of Carriageway, Shoulders etc. The standard **Lane Width** of Project Road is 3.5m. Paved Shoulder width is 1.5m in case of Open country with isolated built-up area; and 2.0m in case of Built-up area. Earthen Shoulder (covered with 150mm thick layer of granular material) width is 2.0m in case of Open country with isolated built-up area. On horizontal curves with radius up to 300m, width of pavement and roadway is increased as per IRC: SP: 87-2013 Table 2.5 to allow swept path of long vehicles.

Camber / Cross fall (as per IRC: SP: 87-2013 Clause 2.8) on Straight Sections of Road Carriageway, Paved Shoulders shall be 2.5% for Bituminous surface and 2% for Cement Concrete surface. The cross fall shall be unidirectional for either side carriageway sloping the shoulder in straight reaches and towards the lower edge on horizontal curves. The cross fall on granular surface shall be minimum 3%.

Cross sectional elements as proposed for this road are provided in **Table 6.10**. Typical Cross Sections are provided in **Chapter-3.**

Table 6.10: Cross Sectional Elements

S. No.	Description	Standards for 6-lane NH (as per IRC:SP:87-2017)	Standards for 6-lane NH (as per Economic Corridor Guidelines)	Standards adopted for STRR
		Plain / Rolling Terrain	Plain / Rolling Terrain	Plain / Rolling Terrain
1	**ROW standard as per IRC**			
	• Minimum ROW	60m	70m	70m
	Proposed ROW Based on the Various types of typical cross sections developed and as per site requirements:			
2	**Main Carriageway**			
	Roadway Width	33m	33m	33m
	• Median	5.0m*	5.0m	5.0m
	• Kerb Shyness	0.5m	0.5m	0.5m
	• Lane Width (Carriageway)	3.5m	3.5m	3.5m
	• Paved Shoulder	1.5m*	1.5m	1.5m
	• Earthen Shoulder on outer side	2.0m	2.0m	2.0m
	Extra width of Pavement and Roadway			
	• Curve Radius 75m to 100m	0.9m	NA	0.9m
	• Curve Radius 101m to 300m	0.6m	NA	0.6m
	Service Road			
	Roadway width	10m	9m	10m
	• Separator (Raised Footpath) between Main Road and Service Road	1.5m**	1.5m**	NA
	• Carriageway	7.0m	7.5m	7.0m
	• Earthen Shoulder	1.5m*	1.5m	1.5m
	• Lined Drain at the end of Service Road	1.5m**	1.5m	1.5m

** Open Country – Plain / Rolling Terrain*; ***Built-up area*

6.3 PAVEMENT DESIGN CRITERIA / STANDARDS

Flexible Pavement:

Designs for new pavement have been dealt in accordance with Indian and international practice. The Preliminary Designs will be carried out on the basis of sub-grade 4 day soaked CBR at 97% MDD. Flexible pavement for new carriageways will be designed in accordance with the guidelines of IRC: 37-2018. The structural coefficients of various layers shall suitably modified to suit the Indian conditions. The resulting pavement compositions from both the methods along with suggested future overlays have compared based on their performance as reflected in life cycle cost analysis.

The new flexible pavement structure will comprise of Bituminous Concrete wearing course on bituminous base course of Dense Bituminous Macadam (DBM) and Bituminous Course. Below the bituminous layers, a Granular base with well-graded aggregates in the form of Wet Mix Macadam (WMM) base will be laid on top of GSB layer. All these layers shall be constructed to the requirements of MORTH specifications. The drainage layer, which is a part of the Granular Sub Base (GSB) layer, shall be provided extending over the full width of formation to the embankment slope, which will also act as drainage layer both for surface and capillary water that would affect the structural performance of the pavement.

Flexible Pavement shall be designed for a minimum design period of 20 years or operation period, whichever is more. Stage construction will be permissible subject to condition that the thickness of sub-base and base is designed for full design period (20 years or operation period, whichever is more) and the bituminous surfacing for a minimum design period of 10 years.

Rigid Pavement:

New rigid pavement will be plain-jointed type and shall be designed in accordance with the method prescribed in IRC: 58 -2015, "Guidelines for the Design of Plain Jointed Rigid Pavements for Highways

Rigid pavement shall be designed for a minimum design period of 30 years. Stage construction shall not be permitted.

The Pavement Quality Concrete (PQC) shall rest over Dry Lean concrete (DLC) and Granular sub-base of 150mm thickness.

ROADSIDE DRAINAGE

An effective drainage system shall be planned for the drainage of roadway as per stipulations of IRC SP: 42-2014 and IRC SP: 50-2013 for maintaining structural soundness and functionality of the project road. The following types of drains shall be provided for surface drainage of roadway and ROW:

- Longitudinal unlined / lined drains with outfalls at cross-drainage structure in rural sections. The drain size shape and material shall be adequate to take design run off and prevent soil erosion and stagnation of water.
- Covered RCC drains in built-up areas.
- Combination of longitudinal drains and chute drains in high embankments of 3m and above.
- Providing catch pits (wherever required) with provision of outflow at suitable location through buried Hume pipes.

Part of drain water needs to be allowed to percolate or be lost by evaporation. Thus alongside drains, natural depressions and waterways and artificial ponds are recommended to drain out the water in rural stretches.

In super elevated sections, proper arrangement for drainage of raised carriageway and median shall be made without allowing water to drain on the other carriageway.

6.4 EMBANKMENT

Side Slopes:

For earthen embankments the side slopes recommended from consideration of safety of traffic as per IRC: 36-2010.

Slope shall be designed for embankment height greater than 6.0m using software for High Embankment design and as per IRC: 75-2015.

However, where costs of construction and land forbid the use of such liberal slopes, the slope will be generally kept as IV: 2H and pitched wall will be proposed after toe of such embankment. This slope is considered adequate from stability point of view. The reaches having embankment height more than 3m shall have W Beam Metal Crash Barriers on the outer edge of the highway to meet the safety standards.

Slope Protection:

Slopes on embankment height less than 3m shall be turfed and those above this height shall be protected with stone pitching.

6.5 CAPACITY STANDARDS

Capacity analysis is a fundamental aspect of planning, design and operation of roads, and provides, among other things, the basis for determining the carriageway width to provide with respect to the volume and composition of traffic.

Capacity and design service volumes for various lane configurations specified by IRC-64-1990 "Capacity of Roads in Rural areas " has been adopted for determining the Level of Service offered by the road sections during design period. Level of service 'B' proposed to design the capacity of the project road. For the purpose of augmentation of the facilities and upgradation of the Project Highway, the Design Service Volume (as per IRC: SP: 84-2014 Clause 2.18) for different Terrain conditions and Level of Service shall be as given in **Table 6.11**.

Table 6.11: Design Service Volume for 6-lane Highways

Nature of Terrain	Design Service Volume in PCU per day	
	Level of Service 'B'	Level of Service 'C'
Plain and Rolling	60,000	n/a
Mountainous & Steep	30,000	n/a

6.6 STANDARDS FOR INTERSECTIONS AND GRADE SEPARATORS

There shall be no direct access to the main highway and all access shall be interconnected through underpasses, overpasses or grade separators.

At-Grade Intersections:

There shall be no At-Grade Intersection of any road with the main highway.

Grade Separated Intersections and Interchanges:

The Geometric design standards for various elements of grade separators shall be as given in IRC: 92-1985.

Following locations has been proposed for grade separated structure/interchange.

S No.	Road	Road type	Cross road Crossing (km)	Proposed STRR (km)
1	NH 207	2L	131.250	0.000
2	NH 4/48	4L	50.400	8.900
3	NH 75/48	4L	42.230	30.360
4	SH 85	2L	47.112	44.485
5	NH 275	4L	318.130	70.258
6	NH 209	4L	431.310	95.678
7	SH 35	2L	51.500	132.185
8	SH 17B	2L	14.790	139.295
9	SH 17A	2L	12.220	144.820
10	SH 85	2L	25.930	152.070
11	SH 17	2L	14.990	155.820
12	NH 44	4L	48.020	161.128

Note: All the Grade Separated Structures/Interchanges shall be further modified to minimize the land acquisition.

6.7 TRAFFIC CONTROL DEVICES / ROAD SAFETY DEVICES / ROAD FURNITURE

For safety and operational reasons, it will be necessary to provide suitable safety features, road furniture, and other facilities along the project road. These features will include safety barriers, road signs, road markings, road lighting, route markers, kilometer and hectometer stones, road delineators, ROW pillars, parking areas & rest areas, bus stops/bays, and landscaping. Where possible these features will provided in accordance with relevant IRC or other standard, as detailed below. If no IRC, Codes or the MORTH Specifications are available, international standards such as BIS /AASHTO / ASTM /British Standards should use in detail design.

Road Signs - The color, configuration, size and location of road signs shall be in accordance with IRC: 67-2012.

Road Markings – Road markings shall be as per IRC: 35-2015. These markings shall applied to road center lines, edge line, continuity line, stop lines, give-way lines, diagonal/chevron markings, zebra crossing and at parking areas by means of an approved self-propelled machine which has a satisfactory cut-off value capable of applying broken lines automatically. The approach noses of the traffic islands will be marked for additional guidance of traffic by means of diagonal markings and chevrons.

Route Markers - The design and location of route marker signs shall be as per IRC: 2-1968.

Overhead Signs - Standards prescribed by MORTH and IRC: 67-2012 Clause 7.4 shall followed for overhead signs.

Road Delineators - The design and location for road delineators shall be as per IRC: 79-1981.

Safety Barriers - The Safety Barrier shall conform to NHAI/MORTH Circulars. Safety barriers shall be located at sharp horizontal curves, high embankments and at bridge approaches.

Roadside and Median Safety Barriers shall be as per guidelines given in IRC: SP:87-2013 Clause 9.7.

Pedestrian Guard Rail - The design shall be as per IRC: 103-2012.

Kilometer/Hectometer Stones/Posts - The design and placement of Highway kilometer stones, their dimensions, size, color, and arrangement of letters shall be as per IRC: 8-1980. For the 200-metre stones, IRC: 26-1967 shall applied. These stones are to be made of precast M-15 grade reinforced cement concrete and lettering / numbering as per the respective IRC codes.

ROW Pillars / Boundary Stones - Should any land be acquired for the project then new ROW pillars at 200 m interval on each side to be established in accordance with IRC: 25-1967.

Fencing – Chain Link fencing confirming to ASTM F 1553-06 shall fixed on GI pipe / RCC posts.

6.8 PROJECT FACILITIES

Bus-Bays & Shelter -The layout, design and location of the bus stops in rural areas shall be as per IRC: 80-1981. In urban/semi-urban areas the recommendations given in IRC: 70-1977 will considered, taking into account land availability. Typical Layouts given in IRC: SP: 87- 2013 will also be consider while developing the Layout. The bus stop layout shall provide safe entry and exit of buses from the service road and safe movement of passengers.

Truck Parking Areas - The proposed layout of truck lay bye is generally based on the recommendations of "Planning Norms and Guidelines on Wayside and Terminal Facilities" (MORTH sponsored study). Also, as per guidelines given in IRC: SP: 87-2013.

Toll Plaza – shall be design based on the guidelines given in IRC: SP: 87-2013 and as per circulars of MORTH.

Highway Landscaping - IRC: SP: 21-2009 "Manual on Landscaping" shall guide the plantation of rows of trees with staggered pitch on either side of the road. The choice of the trees shall also made as per the same code. Local, indigenous species that grow in the project area microclimate shall planted. Indicative arrangements for plantation of trees shall be in accordance with the MORTH Technical Circular No. NHI-41 (34)/69 dated. A spacing of 10-15m c/c recommended for spacing of trees parallel to the roads. Setback distance of trees needed in different situations shall be as per the IRC: SP: 21-2009 and the IRC: 66-1976.

Street Lighting – shall designed based on the guidelines given in IRC: SP: 87-2013.

6.9 SPECIFICATIONS

The General Technical Specifications shall be as per MORTH Specifications for Road and Bridge works (Fifth revision, April 2013) issued by the Ministry of Road Transport and Highways, Govt. of India and published by the Indian Roads Congress along with its updating/amendments/ addendum issued from time to time.

6.10 STANDARDS AND METHODOLOGY FOR DESIGN OF STRUCTURES

Structures Design Standards / Criteria

The Design Standards and the loading to be consider are generally based on the requirements laid down in the latest editions of IRC/ IS codes of practices & standard specifications, and guidelines of Ministry of Surface Transport. Additional technical references would be used wherever the provisions of IRC/IS codes are found inadequate. Following IRC / IS codes proposed to be use in the design:

Table 6.12: List of IRC Codes / MORTH Publications used in Structures Design

No.	Code of Practice / Title of Publication
1	IRC: 5-2015 Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design (Eighth Revision)
2	IRC: 6-2017: Standard Specifications and Code of Practice for Road Bridges, Section-II Loads and Load Combinations (Seventh Revision)
3	IRC:112-2011: Code of Practice for Concrete Road Bridges
4	IRC:22-2015 Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite
5	IRC:24-2010 Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)Third Revision)
6	IRC:78-2014 Standard Specifications and Code of Practice for Road Bridges, Section VII- Foundations and
7	IRC:83-2015: (Part II)Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings
8	IRC: 83 (Part III)-2002: Standard Specifications and Code of Practice for Road bridges, Section IX - Bearings, Part III: POT, POT- CUM-PTFE, Pin and Metallic Bearings.
9	IRC:SP-84-2014 Manual for Specifications & Standards for Four Laning of Highways Through Public Private Partnership (First Revision)
10	IRC:SP-87-2013 Manual of Specification & Standards for Six Laning of Highways through Public Private Partnership (First Revision)
11	IRC: SP: 33-1989: Guidelines on Supplemental measures for Design, Detailing, and Durability of Important Bridge Structures. (Second Revision)
12	IRC: SP: 35 Guidelines For Inspection and Maintenance of Bridges
13	IRC: SP: 37 Guidelines For Evaluation of Load Carrying Capacity of Bridges
14	IRC: SP: 40 Guidelines On Techniques for Strengthening and Rehabilitation of Bridges
15	IRC: 89-1997: Guidelines for Design & Construction of River t2raining and Control works for Road Bridges. (First Revision)
16	IS: 2911(Part1/Sec2): 2010 Code of Practice for Design and Construction of Pile foundation for Bored Cast in situ Piles.
17	IS 2062:2011 Hot Rolled Medium and High Tensile structural steel-Specification (Seventh Revision)
18	IS 1786:2008 High Strength Deformed Steel Bars and wires for concrete Reinforcement Specification (Fourth Revision)
19	IRC: SP:65-2005 Guidelines For Design and Constructions of Segmental Bridges
20	IS 14593:1998 Design and Construction of Bored Cast-in-situ Piles founded on Rocks- Guidelines

No.	Code of Practice / Title of Publication
21	IS 1343:2012 Prestressed Concrete-Code of Practice (Second Revision)
22	IRC:SP:51-2015 Guidelines for Load Testing of Bridges (First Revision)
23	IS 13920:1993(Reaffirmed 2008) Ductile Detailing of Reinforced concrete structures subjected to seismic forces – Code of Practice
24	IRC:SP:69-2011, Guidelines & Specifications for Expansion Joints (First Revision)
25	MOST Specifications for Road and Bridge Works published by Ministry of Surface Transport (Roads Wing), Government of India (Fifth Revision)
26	IRC:SP:90-2010 Manual for Grade Separators & Elevated Structures
27	IRC:SP:67-2005 Guidelines for use of External and Un-bond Prestressing Tendons in Bridge Structures
28	IRC:SP:71-2006 Guidelines for Design And Construction of Precast Pre-Tensioned Girders for Bridges

6.11 TYPE OF BRIDGES

Types of New Bridges shall envisaged of following types

Super structure

1. Cast-in-situ Solid for span ranges from 10m to 13
2. RCC I girder brides with cast in-situ deck for spans of 14 m to 25m span.
3. PSC I girder with cast-in-situ deck for the span ranges 26 to 45m
4. PSC box girder for the spans over 33m

Type of Bridge Foundation

Based on reconnaissance survey of existing bridges the foundations encountered are of well foundation, pile foundation and open foundation. It envisaged that either pile or open foundation shall proposed for new bridge

However, the type of foundation shall finalized based on the results of sub-soil investigation. In case open foundation provided for some minor bridges in the approach, the same shall place adequately below the scour depth.

Proposed Type of Super-Structure for Proposed Bridges

It is propose to provide any of the following type of super-structure for the proposed bridges based on the site conditions, aesthetics, and economy.

Pre-cast post tensioned I girders.

The pre-cast post-tensioned girder superstructure has the following advantages-

- The girder may cast in standard lengths in a casting yard under the strict quality control as a parallel activity with the construction of substructures thus reducing the overall period of construction.

- After the pier and pier caps constructed, the girders may transported at site and erected in position using a suitable crane or incremental launching method in case number of span are more.
- Spans varying from 25m to 45m are feasible.
- The whole operation of lifting and positioning of all the girders for a particular span can completed in a short span of time.
- Deck slab can be concreted cast-in-situ by supporting the shuttering directly from the pre-cast girders.
- Cost towards staging and shuttering reduces substantially.

However, the post-tensioned girders has the following disadvantages-

- Girder length are fixed and cannot adjusted at site even during execution of works some adjustments are necessary.
- Use of Pre-cast girders is not feasible for curved super-structures with sharp radius.
- Specialized contractors are required for the construction of pre-stressed bridges.

Cast-in-situ Pre-stressed box girders

- Pre-stressed box girders has the following advantages-
- Box girders can be constructed for any span length and shape
- Economical for large spans i.e. greater than 30m.
- Overall depth of the super-structure is much less, than the pre-stressed T beam girder and reinforced concrete T beam girder. It thus reduces the formation level of bridges which in turn reduces the length of approach road.
- Feasible for curved continuous super-structure
- However the cast-in-situ pre-stressed box girder has the following disadvantages-
- Construction of super-structure has to wait till the completion of foundation and sub-structure
- Cost towards staging and shuttering is substantial
- Specialized contractors are required for the construction of pre-stressed bridges.

Precast/Cast-in-situ reinforced concrete bridges

The cast-in-situ reinforced concrete girders has the following advantages-

- Girders can be concreted for any span length and shape
- Specialized contractors are not required for the construction of reinforced concrete super-structures.
- Economical for span length varying from 16m to 25m.

However, the reinforced concrete has the following disadvantages-

- Depth of super-structure is large and thus it increases the formation level of bridge, which in turn increases the length of the approach road.
- Un-economical for length larger than 25m.

- Construction of super-structure has to wait till the completion of sub-structure.
- Difficulty in using in urban areas as it is necessary to provide shuttering and staging which will create difficulty in movement of traffic during construction of super-structure.

Composite steel structure

This type of superstructure proposed over Railway crossing as per the RDSO circular. Recently RDSO issued standard superstructures drawings for the spans 18m, 24m, 31m and 35m in the month of December 2016. These standard drawings designed in limit state method as per IRC: 24-2010 and IRC: 22-2015. It is mandatory to follow the standard superstructure drawings to get the easy approval GAD from the Railway authority.

Advantages

- Fabrication of structure may done in workshop and assembly in site, to achieve fast progress of work.
- Dismantling of the superstructure is easy.
- Deck Slab shall be casted over steel girders

Disadvantages

- Steel Fabrication must be at RDSO approved workshop, may not be available at the project site.
- Rail blocks required at the time of erection.

Grade Separators

In this project Grade, separated structures shall envisaged like Flyover, VUP, PUP, ROB etc. The requirement of grade separator, its shape , size, type and configuration at any location is decided by collecting sufficient relevant data and information and analyzing it with respect to volume, intensity and type of traffic, loadings, climatic conditions and geo-technical investigations, space restraints and limitations because of underground and overhead utilities services and available geometrics, traffic regulation during construction etc.

Sub-Structure

Piers shall avoided in the mid-stream where velocity of water is high. Piers shall place normal to the flow direction.

Circular/cellular circular/wall type piers with semicircular ends shall use after considering the aesthetics and economy. Circular piers shall be preferred in high seismic zone areas as they have the same stiffness in all the directions.

Solid wall type abutments/counter fort type abutments shall selected based on the height. Counter fort type abutments shall generally provide if height of the abutments is more than 12.0metres.

6.12 TYPE OF CULVERTS

It is propose to provide following type of new culverts for the project roads-

a) Pipe Culverts

b) Box/Slab Culverts

In accordance with clause number 12.5 of IRC:SP:13-2004, to facilitate inspection and carrying out repairs, the minimum vent height should not be less than 1500mm. and minimum diameter of pipe culverts should be 1200mm.

In case of slab/box culverts, minimum height shall be 1.90m assuming the vertical opening of box as 1.50m.

6.13 RETAINING WALLS

Retaining walls will be required to confine the embankment slope by keeping in view the available right of way. The type of retaining wall shall decide based on the cost of reinforced concrete retaining wall with reinforced earth wall.

It is very important to accurately consider the following factors for the design of retaining wall to avoid the failure-

- Angle of the slope of the backfill above the retaining wall as the active earth pressure increases rapidly with the increase in angle of the backfill.
- Quality of backfill as poor backfill results in high seepage pressure while no pore pressure is consider in the design.
- Weep holes shall be provided as per IRC code provisions in order to avoid water pressure behind the wall.

6.14 HYDROLOGIC AND HYDRAULIC STUDIES

To find out the actual needed linear waterway needed for any structure, there are two steps to follow. First, to find out the actual discharge or flow that shall be flowing through the structure. Through Hydrologic, studies contributing catchment area shall be delineated and suitable methods as prescribed in IRC 5 and based on CWC reports and based on the prescribed return period, tentative discharge shall calculated.
Hydraulic studies shall be carried out to ascertain the carrying capacity of new bridge or any structure, based on the Manning's method and topography of the upstream and downstream levels and the design discharge calculated through Hydrologic calculations. Further based on these calculations of linear waterway of bridges, scour calculations and design of protection works shall designed.

All efforts shall made to find the discharge data of the river from government departments. However if the above data is not available then rain fall data for relevant areas shall be obtained and used for calculating the discharge. Catchments are delineated using contour data obtained from SRTM 3 arc sec data using standard GIS platforms.

Following methods shall use for calculating discharge (Hydrology) for bridges-

- Empirical Formulae for peak run-off from catchment as per IRC 5
- Rational Formulae for peak run-off from catchment
- Hydrograph method using CWC reports

For Hydraulic design of the linear waterway needed, Manning's method is adopt.

The flood discharge calculated from the above methods shall compared with each other and the highest of these values shall be adopted as the design discharge Q, provided it does not exceed the next highest discharge by more than 50 per cent. In case the difference is more than 50 per cent then the design discharge shall be restricted to the limit of 50 per cent.

The length of the proposed bridge shall fixed based on hydraulic studies and the length of old bridge.

Cross –Sections and Longitudinal Sections

Minimum three cross sections of the stream/river shall take at bridge location i.e. one at up-stream, one at down-stream and one near proposed bridge location for calculating discharge by Manning's formula. Cross sections of the channel shall take up-to following distances from the proposed bridge location based on the catchment area.

No.	Catchment Area	Distance at u/s and d/s for cross sections
1	Up-to 3 sq.km.	100.0m
2	From 3.0 to 15.0 sq.km.	300.0m
3	Over 15 sq.km.	500.0m

Longitudinal section of river for bridges shall take for a length of 300.0m up-stream and 300.0m on down-stream side from center line of proposed bridge location. The longitudinal section shall use to calculate the slope of the stream.

Discharge for Calculation of Scour and Design of Protection Works

River beds of mountainous terrain have boulder strata and it is very difficult to estimate the scour depth for such strata. It generally seen the actual scour depth in such beds is less than those calculated by conventional formulae.

Scour depth for foundations and protection works shall designed for a larger discharge in order to give adequate factor of safety. The percentage increase in discharge based on catchment area shall be as follows-

a. 30% increase in discharge for catchments area up to 500 square kilometers
b. 25% to 20% for medium catchments of 500 to 5000 square kilometers
c. 20% to 10% for larger catchments of 5000 to 25000 square kilometers
d. 10% for larger catchments above 25000 kilometers

Protection works shall be required to avoid scour in case shallow foundations are proposed. Protection work shall include the following-

a. Rigid Apron
b. Curtain wall
c. Flexible Apron

a. Bore hole Location Plan

Bore hole Plan shall prepared for the geotechnical investigation of proposed bridge. The drawing show the borehole location plans prepared and submitted to client for approval.

b. Sub-soil Investigation

Detailed sub-soil investigations shall carried out at bridge locations which are to be constructed

One borehole at abutment location shall drilled

The sub-soil exploration and testing shall carried out through the sub-soil consultant. Sub-soil investigation report shall be prepared as per IRC 78-2000.

c. Preparation of General Arrangement Drawings

General arrangement drawings of the bridge shall be prepared based on preliminary design of bridge. The general arrangement drawings submitted shall clearly show the proposed type of super-structure, sub-structure, foundations, bearings, and expansion joints.

d. Preparation of Preliminary Designs and Drawings

Preliminary design of culverts and bridges shall carried out based on design standards. Adequacy of the size of proposed sections for super-structure, sub-structure, and foundations shall verified based on preliminary design.

e. Detailed design of cross drainage structures

Detailed designs shall be prepared based on IRC loadings. Detailed drawings shall be prepared based on the structural designs.

f. Cost

Cost for structures shall worked out based on per sqm basis based on preliminary design and drawings.

6.17 DESIGN METHODOLOGY AND DESIGN STANDARD FOR STRUCTURES

In this context, it noted that this particular area falls in restricted area defined by the Geological survey of India for which topo maps are not readily available. Client shall cooperate to help getting those topo maps. Also, hydrological data for various roads shall obtained from PWD department or other concerned department shall make available to us by the help of client

The type of structural arrangement shall finalized based on detailed survey and sub-soil investigations.

The design of proposed structures shall be based on the following materials and loading Materials.

Concrete Grade

Grade of concrete in various elements shall be as under for moderate conditions of exposure:

- All PSC members - M50/M45 (Precast/Cast-in-situ)
- All RCC members - M35 for all bridges
  - M30 for Culverts
- All PCC members - M20/M15
- Retaining Wall - M30
- Culverts - M30

Reinforcement Steel

- High yield strength deformed bar shall be of grade Fe500 D as per IS: 1786-2008
- Mild steel bars shall be of grade Fe240 as per IS: 1786-2008

Exposure Condition

Moderate exposure/Severe conditions shall be considered while designing various components of all the structures depending on the location of road.

Concrete Clear Covers:

For all reinforcement	-	As per Cl. 14.3.2.1 of IRC 112
For prestress cable	-	As per clause 13. 4 of IRC: 112 duct to outer most Fibre of girder

Pre-Stressing System

a) System (Post tensioning)	:	Multipull strand system of "Freyssinet" or "ISMALCCL" or equivalent
b) Cables (Post tensioning)	:	12T13/19K13 cables with strands of 12.7mm and 15.2 mm nominal dia.
c) High Tensile Steel	:	(for both post/pre tensioning)
Strands	:	Nominal 12.7mm dia. 7 ply low relaxation strands conforming to class 2 of IS: 14268-1995
Area	:	98.7 sq.mm per 12.7mm strand and 140 sq mm. per 15.2mm dia. (nominal cross sectional area)
Ultimate load	:	183.71 KN per strand per 12.7mm and 265.92 KN per 15.2mm
Modulus of Elasticity	:	1.95×10^5MPa
d) Sheathing (Post tensioning)	:	75mm OD /90mm/100mm/125mm OD Bright
e) Friction Coefficient (Post tensioning)		0.25/radian
f) Wobble Coefficient (Post tensioning)		0.0046/m
g) Anchorage Slip (Post tensioning)		6mm average
h) Loss of force due to relaxation	:	2.5% at 0.7 UTS after 1000 hrs. The final relaxation value for design shall be 3.0 times the 1000 hr. value as per cl. 6.4.1 of IS 14268:1995
j) Nominal Mass of strand	:	0.73 kg/m for 12.7 mm strand, 1.094kg/m for 15.2mm strand

Stressing shall be carried out simultaneously from both ends. All the strands of a cable shall be stressed in one go. Provisions for 4% emergency cables will be provided. If they are not utilised during construction, they will be pulled out and cable ducts will be grouted and plugged suitably. Access to the super-structure shall be provided to enable maintenance, inspection and future pre-stressing operations. Stressing may also be carried out at single end also depends on the adaptability.

Structural Steel

Structural steel shall conform to IS: 2062:2011 also confirming to MORTH (Revision V) structural steel of CL: 1900

Grade of steel shall be E 350, and yield stress 350 Mpa as per IS: 2062:2011

HFSG bolts of Grade: 10.2 shall be used

Erection and Fabrication: As per the MORTH Specification

Bearings

Elastomeric Bearings shall be proposed for spans up to 30m and the maximum vertical load shall not be exceed as per IRC: 83, Part II-2105

POT, POT/PTFE bearing proposed for long span bride where maximum vertical load moments envisaged. Spherical bearings also proposed for long span simply supported superstructures or continuous superstructures where huge horizontal forces and uplift forces encountered.

These bearings designed and supplied by the approved manufacturers as listed in the MORTH empanelment. The loads and forces on the bearings shall be calculated to enable the manufacturer to design these bearings and these shall conform to MOST CL: 2000 Specifications for Road & Bridge Works (5th Revision).

Expansion Joints

The following types of Expansion Joints shall be adopted as per IRC: SP: 69-2011:

Filler type expansion joints shall be proposed for minor bridges with solid slab superstructures having span lengths not exceeding 10 metres. These type of joints shall conform to Cl. 2609 of MOST Specifications for Road & Bridge Works (5th Revision).

Single Strip seal expansion joints shall be proposed for superstructures having movements up to 80mm. (± 40mm)

Modular strip seal expansion **joints** shall be proposed for continuous superstructures where anticipated movements are more than 80mm. Cl. 2606 of MORTH Specifications (5th Revision).

The strip seal and modular strip seal joints shall conform to Cl. 2607 of MOST Specifications for Road and Bridge works (5th Revision).

Miscellaneous

An asphaltic concrete wearing course provided over the deck slab. It shall consist of a coat of mastic asphalt 6mm thick with a prime coat over the deck before the wearing course laid. The insulating layer of 6mm thick mastic asphalt with 75% limestone dust filler and 25% of 30/40 penetration grade bitumen laid at 375 F. Two layers of 25mm each of asphaltic concrete laid over the mastic asphalt.

Drainage spouts with gratings at the top provided on the bridges to ensure proper drainage of surface water.

An approach slab 3.50m long and 300mm thick resting on the bracket taken out from the dirt wall provided on both sides of the bridge resting on the 150mm thick leveling course. The gap between the approach slab and dirt wall filled with bituminous joint filer sealing compound.

Weep holes shall be provided behind abutment and wing wall to avoid building up of hydrostatic pressure behind them. Weep holes provided 150mm, above the low water level or bed level whichever is higher.

6.18 LOADS AND LOAD COMBINATIONS

- **Dead Loads**

Following unit weights shall be assumed in the design as per IRC Codes.

Pre-stressed Concrete	-	2.5 t/cum
Reinforced Concrete	-	2.5 t/cum
Plain Cement Concrete	-	2.5 t/cum
Structural steel	-	7.85 t/cum
Dry Density of Soil	-	1.80 t/cum
Saturated Density of Soil	-	2.0 t/cum

Superimposed Dead Loads

Wearing Coat	:	65mm thick asphaltic concrete with total weight of 0.2 t/sqm (including allowance for overlay)
Crash barriers	:	From design (i.e. 1.0 t/m to 1.6 t/m per side)

Carriageway Live Load

All the new cross drainage structures shall be designed for the following loading for carriage way width 9.6 to 13.1m

Live Loads for 3-lanes	:	One/Two lanes/Three lanes of IRC Class A. 70R + CL-A (Whichever produces worst effect) or One lane of IRC Class 70R (wheeled/ tracked)+One lane of Class A.

The impact factor shall be as per Cl. 208 of IRC: 6-2014 for the relevant load combinations. For simplicity in design, the impact factor for continuous structures shall be calculated for the smallest span of each module and used for all the spans in that module.

Longitudinal Forces

The following effects shall be considered for calculating the longitudinal forces in the design-

- Braking forces as per the provision of Cl. 211 of IRC: 6.
- Frictional resistance offered to the movement of free bearings due to change of temperature.
- Distribution of longitudinal forces due to horizontal deformation of bearings/ frictional resistance shall be carried out as per Cl. 211.5 of IRC: 6 by assuming stiff supports.

Centrifugal Forces

Bridges on a horizontal curve designed for centrifugal forces based on the following equation-(CL: 212.2 of IRC: 6-2017

$C = WV^2/127R$,

Where C = Centrifugal force acting normal to the traffic

W = Carriageway live load

V = Design speed of the vehicles using the bridge in km per hour

R = Radius of curvature in meters

The centrifugal force considered to act at 1.20m above the formation level of the bridge in the transverse direction. No impact value on carriageway live load shall be considered for calculating the centrifugal force.

Water Current Forces

The effect of water current forces calculated in accordance with clause number 210 of IRC: 6-2017 on sub-structure and foundations. High Flood level and Velocity calculated based on the details received from relevant Government departments or local inquiries.

Impact Forces

All the sub-structure and foundations in the river shall be designed for the impact due to striking of rolling boulders on the sub-structure in mountainous terrain. The magnitude of force shall be decided based on field studies and in consultation with client.

Earth Pressure

Horizontal forces due to earth pressure shall be calculated as per the provision of Cl. 214 of IRC: 6-2017 assuming the following soil properties:

Type of soil assumed for backfilling	:	Dry Density of 1.80 t/cum and Submerged Density of 1.2 t/cum
Angle of Internal Friction	:	$\phi = 30°$
Angle of Wall Friction	:	$\delta = 20°$

Coefficient of Friction `μ' at base: tan ($2/3\phi$), where ϕ is the angle of internal friction of substrata immediately under the foundation

Live load surcharge shall be considered as equivalent to 1.2m height of earth fill in case of abutments and return/wing walls.

The pressure exerted by earth fill will act at 0.42m from the base as per the Coloumb's theory.

Wind Forces

Structures shall be designed for wind effects as stipulated as Cl. 209 of the IRC: 6.

The longitudinal and transverse wind forces shall be considered for plain terrain or terrain with obstructions as per the Table 5 of IRC: 6-2017

The wind pressures generated in the table for a basic wind speed of 33 m/s

Seismic Effect

The seismic forces are calculated as per cl. No 219 of IRC: 6-2017

Different zone factors are to be considered depending on the project roads falls in various seismic zones as the project lies in different states.

Feq = Ah x (Dead Load + Appropriate Live Load)

Where, Ah = horizontal seismic coefficient = (Z/2) x (Sa/g)/(R/I)

Z = Zone factor and is equal to 0.10 for seismic zone II

I = Important factor

R = Response reduction factor

Sa/g = Average response acceleration coefficient depending upon fundamental period of vibration

T = Fundamental period of the bridge in seconds in horizontal vibrations

In zone IV and V to prevent the dislodgement of superstructure, "reaction blocks" (additional safety measures in the event of failure of bearings) or other types of seismic arresters shall be provided and designed for the seismic force.

Temperature Range

The temperature forces are calculated as per the cl.no.215.1 of IRC: 6-2017

The bridge structure/components i.e. bearings and expansion joints, shall be designed for a temperature variation of ± 25°C considering extreme climate.

The super-structures shall be designed for effects of distribution of temperature across the deck depth as per stipulations of BD 37/88 suitably modified for the surfacing thickness.

Temperature effects are of three types-

Effect of non-linear distribution of temperature across the deck depth causes additional tension and compression in the structure. It happens due to the difference in temperature at top and bottom of super-structure. This causes eigen-stress in the structure. In this case the supports do not offer any restrain to the hogging or sagging of beam. The effect of eigen stresses shall be considered for all the proposed bridges.

In case of continuous structures there will be effect of intermediate supports which gives restrain to the free hogging and sagging of structure. The intermediate support prevents the beams to freely hog or sag, which causes continuity stresses. The effect of continuity stresses shall be considered for continuous bridges.

Differential Shrinkage Effects

A minimum reinforcement of 0.2% of cross sectional area in the longitudinal direction of the cast-in-situ slab provided to cater for differential shrinkage stresses in superstructures with in-situ slab over pre-cast girders.

However, effects due to differential shrinkage and/or differential creep shall be duly accounted for in the design.

Construction Stage Loadings

A uniformly distributed load of 3.6 KN/m2 of the form area taken into account of construction stage loadings in the design of superstructure elements, wherever applicable, as per Cl. 4.2.2 of IRC: 87-1984.

The design shall take into account the temporary and locked-in-forces, adjusted by creep effects, resulting from various methods of construction adopted. These forces will include those arriving from each stage of construction.

Differential Settlement Effects

Differential settlement effects for continuous superstructure units appropriately assessed for each structure. However, in any case a minimum differential settlement of ± 12mm accounted for in the design.

The differential settlement effects in continuous superstructures accounted for under following conditions:

- A minimum of 12mm differential settlement of supports with half value of `E'
- To simulate the bearing replacement conditions, a 12mm differential uplift with full value of `E' shall be considered but without any live load on the superstructure.

Buoyancy

Buoyancy forces calculated as per the cl.no.213 of IRC: 6-2017

100% buoyancy shall be considered while checking stability of foundations irrespective of their resting on soil/weathered rock/or hard rock. However, the maximum base pressures shall also be checked under an additional condition with 50% buoyancy in cases where foundations are embedded into hard rock. Pore pressure uplift limited to 15% shall be considered while checking stresses of the substructure elements.

In the design of abutments, the effects of buoyancy considered assuming the fill behind abutments removed by scour.

Load Combination

All members shall be designed to safely sustain the most critical combination of various loads and forces that can coexist. Various load combinations as relevant with increase in permissible stresses considered in the design shall be as per IRC: 6 and IRC: 78

The various load combinations are considered as per annexure B of IRC: 6-2017 as mentioned below.

Table 3.2 for verification of structural strength

Table 3.3 for verification of Serviceability limit state

Table 3.4 Combination of Base pressure and design of foundation.

Chapter-7:
Traffic Survey and Analysis

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CHAPTER-7: TRAFFIC SURVEYS & ANALYSIS

7.1 INTRODUCTION

This report presents the traffic studies and analyses carried out for addressing various objectives and issues pertaining to the design of Balance Portion of Satellite Town Ring Road of Bangalore (West Side) including connection to Hosur town. Feasibility for widening the existing SH between Anekal to Sarjapur for Passenger traffic bound to Attibele/ Sarjapur to ensure ring road connectivity for Bangalore. The results of this analysis will form inputs for forecasting future traffic, forecasting toll traffic and toll revenue, deciding tolling strategy, planning and designing the pavement, developing capacity augmentation proposals, designing the toll plaza and design of interchanges along the project road.

A thorough knowledge of the travel characteristics of the traffic using existing network is essential for future traffic estimation. Hence, detailed traffic surveys have carried out to assess the traffic characteristics on existing routes followed for travel between Dobbaspet and Hosur within the vicinity of proposed STRR in consultation with the Client.

7.2 COMPETING / ALTERNATE ROUTES

Any competing /alternate route or mode will have considerable impacts on the traffic and in turn on the toll expectancy.

This discussed in the subsequent part of this report along with the analysis of diverted traffic.

7.3 IDENTIFICATION OF HOMOGENEOUS ROAD SECTIONS

For the purpose of traffic analysis, based on the reconnaissance survey and study of road network, the project road corridor divided into different homogeneous sections.

The homogeneous sections presented in **Table 7.1** below and **Figure 7.1** below.

Figure 7.1: Homogeneous sections for traffic study

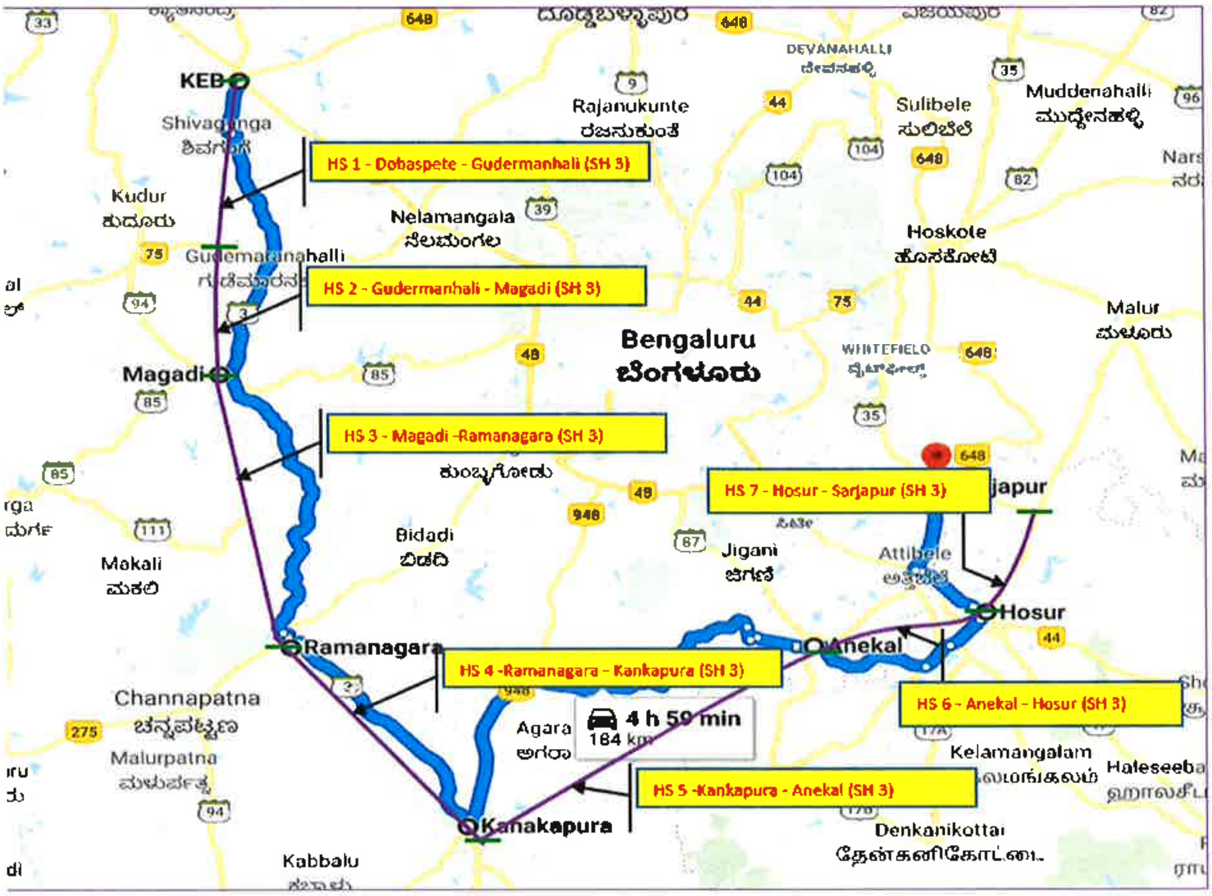


Table 7.1: Homogeneous sections for traffic study

	From	To
HS 1	Junction NH 4 - SH 3	Junction Hassan Road - SH 3
HS 2	Junction Hassan Road - SH 3	Junction SH 85 - SH 3
HS 3	Junction SH 85 - SH 3	Junction Mysore Road - SH 3
HS 4	Junction Mysore Road - SH 3	NH 209 (Chamarajanagar Road) - SH 3
HS 5	NH 209 (Chamarajanagar Road) - SH 3	Junction SH 85/SH35 (Anekal)
HS 6	Junction SH 85/SH35 (Anekal)	Junction NH 7 (Hosur Road) - SH 87
HS 7	Junction NH 7 (Hosur Road) - SH 87	Junction NH 7 (Hosur Road) - NH 648

7.4 SURVEY METHODOLOGY

7.4.1 Primary surveys and considerations

To capture traffic flow characteristics, travel pattern, speed characteristics, users' preference regarding toll imposition on traffic passing through the project road and other characteristics related to miscellaneous requirements on the project road, following primary traffic surveys were conduct.

1. Classified traffic volume count (CTVC)

2. Origin – destination survey (OD)
3. Axle load survey

Traffic survey stations for carrying out CTVC, OD and axle load surveys were select after a site reconnaissance and in consultation with client as per following parameters.

1. The station should represent homogeneous traffic section
2. The station should be free from urban and local traffic influence
3. The station should be located in a reasonably level terrain with good visibility

Figure 7.2 shows the traffic survey map for STRR.

Figure 7.2: Traffic Survey Location Map

7.4.2 *Classified Traffic Volume Counts*

The Traffic Volume Counts were conducted at thirteen locations after due consultation with Client and Nodal Consultant as shown in **Figure 7.2**.

The surveys were as per guidelines illustrated in IRC: SP: 19 – 2001, 'Manual for Survey, Investigation and Preparation of Road Projects'. **Figure 7.3** shows the traffic survey in progress at the Project site.

Figure 7.3: Traffic Survey in Progress

For carrying out the counts, the vehicles grouped under the categories given in **Table 7.2.**

Table 7.2: Vehicle classification system

Category	**Examples of Vehicle Types**
Two Wheelers	Scooters, Bikes, Motor cycles and Mopeds
Three Wheelers	Auto Rickshaw
Car	Car, Jeep, Taxi, and Vans
Bus	Mini Bus, Government Bus, Private Bus
Trucks	Light Commercial Vehicle (LCV), 2, 3, 4, 5, 6 and >6 Axle Trucks
Other	Tractor, Tractor & Trailer
Non-Motorized	Bicycle, Cycle Rickshaw, Animal drawn vehicles, Hand Cart

For the purpose of counts, ATCC Cameras fit at the site locations and traffic count performed using latest software indoors. This traffic data used for working out traffic characteristics analysis and forecast, capacity augmentation and toll analysis. The schedule of survey given in **Table 7.3.**

Table 7.3: Schedule of traffic volume count

S No	**Highway**	**Chainage**	**CTVC**	**OD**	**Axle load**
1	NH 207	Km 138	3/12/17 to 5/12/2017		
2	NH 4	Km 51	3/12/2017 to 9/12/2017	6/12/2017	6/12/2017
3	SH 3	Km 118	3/12/17 to 5/12/2017		
4	NH 48	km 44+200	3/12/2017 to 9/12/2017	7/12/2017	
5	SH 85	12°57'48.98"N	3/12/2017 to 9/12/2017	7/12/2017	
6	NH 275	Km 30.8	3/12/2017 to 9/12/2017	5/12/2017	5/12/2017
7	SH 3		7/12/2017 to 9/12/2017		
8	NH 209	Km 419	3/12/2017 to 9/12/2017	6/12/2017	
9	NH 7	km 49.00	8/12/2017 to 15/12/2017	13/12/2017	13/12/2017
10	NH 7	km 31.00	11/12/2017 to 13/12/2017		

S No	Highway	Chainage	CTVC	OD	Axle load
11	NH 7	Before NICE Road	12/12/2017 to 14/12/2017		
12	NH 275	At NICE Road	11/12/2017 to 13/12/2017		
13	NH 4	At NICE Road	12/12/2017 to 14/12/2017		

7.4.3 Origin-Destination Survey

The origin-destination survey was carried out with the primary objective of studying the travel pattern of goods and passenger traffic along the of the study corridor. The results have also been useful for identifying the influence area of the project road, estimating the growth rates of traffic. The tonnage analysis will form valuable inputs for new pavement design as well as design of overlay on existing pavement.

The survey conducted at seven locations for a day (24 hours) as stated in **Table 7.3**. Roadside interview method adopted for the survey, in accordance with guidelines given by IRC: SP 19 – 2001. Trained enumerators to obtain the required data under the guidance of traffic engineers and supervisors interviewed the road users. During the surveys, the information pertaining to trip length, trip purpose and occupancy as applicable for various vehicle types recorded.

The analysis of daily flow of classified volume counts has been the basis for fixing the sample size of vehicles by type and direction. The substantial sample size obtained for each class of vehicle.

Three types of zones used for the OD Survey and Analysis as follows:

- Small Zones – Zones approximately the STRR segment under package as shown in **Figure 7.4.**
- Major Zones – Districts in Karnataka, other than Bangalore and Zones outside Karnataka as shown in **Figure 7.5**

  A list of zones provided in **Appendix 7.1, *Volume II: Appendix to Main Report.***

Figure 7.4: Zone Map – Small Zones

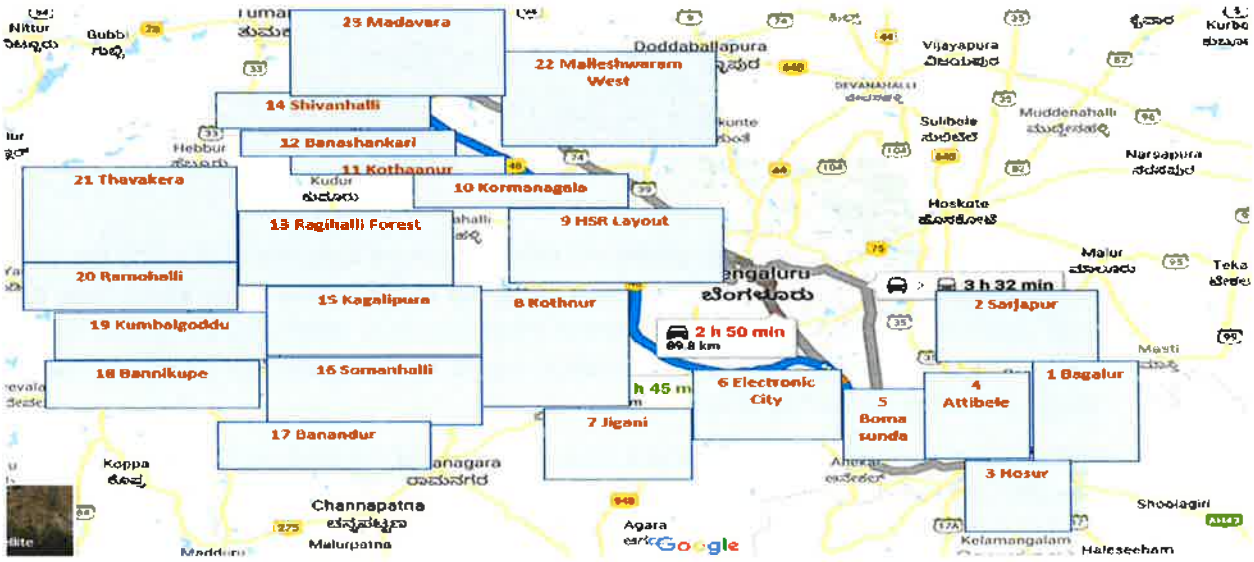
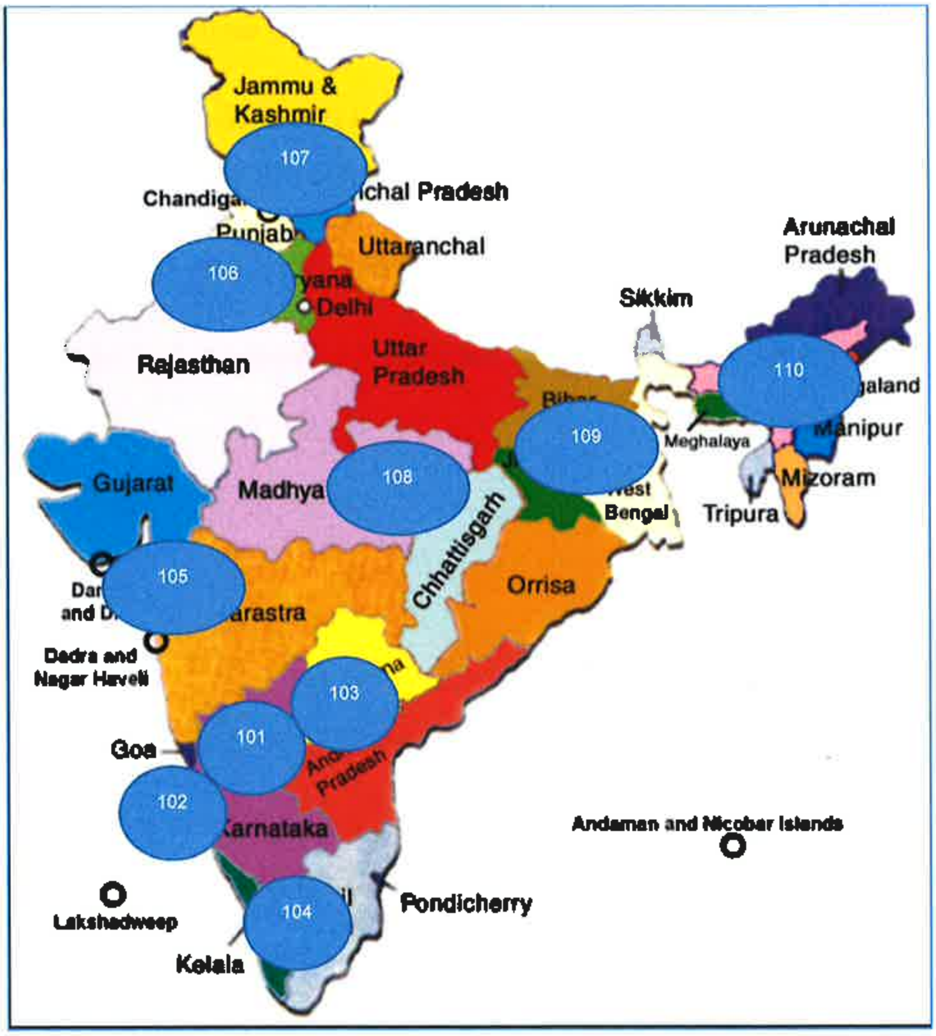


Figure 7.5: Zone Map – Major Zones



7.4.4 *Axle Load Survey*

Axle Load Survey has carried out at three locations in order to estimate vehicle damage factor (VDF) for using in pavement design of proposed Greenfield expressway.

The survey carried out at two locations, using portable weigh pads. Axle loads of LCVs, and two, three and multi axle trucks recorded on random sampling basis. The vehicles were stopped with the help of police and the drivers were directed to stop their vehicles in such a way that wheel of each axle can be weighed using the weighing pad. Trained enumerators for each axle recorded the readings separately. In addition, information about origin, destination and type of goods transported by commercial vehicles recorded.

7.5 DATA ANALYSIS – TRAFFIC VOLUME COUNT

The classified traffic volume data for twelve count locations is analyze in order to obtain the following traffic characteristics:

- Average hourly variation of traffic volume
- Daily variation of traffic volume
- Average Composition of traffic
- Directional distribution of traffic
- Average Daily Traffic (ADT) volume

Daily and hourly variation of classified traffic flow is record by conducting traffic counts at twelve strategically selected traffic count stations. Recorded traffic data has converted into Passenger Car Units using PCU factors as shown in **Table 7.4**. These equivalency factors extracted from IRC: 64 – 1990, 'Guidelines for Capacity of Roads in Rural Areas'.

Table 7.4: Passenger car equivalency factors

S. No.	Vehicle Type	PCU Factors
1.	Two Wheeler	0.50
2.	Auto–rickshaw	1.00
3.	Car / Jeep / Van / Tempo	1.00
4.	Mini Bus	1.50
5.	Standard Bus	3.00
6.	Light Commercial Vehicle (LCV), Agricultural Tractor	1.50
7.	Two Axle Truck	3.00
8.	Three Axle Truck	3.00
9.	Truck Trailer	4.50
10.	Agriculture Tractor-trailer	4.50
11.	Animal Drawn	6.00
12.	Cycle	0.50
13.	Hand Cart	3.00
14.	Cycle Rickshaw	2.00

7.5.1 *Average Daily Traffic (ADT)*

Traffic volume count for 7 days at 6 locations and 3 days at seven locations were carried out to determine Average Daily Traffic (ADT). The location wise ADT by vehicle type is presented in **Appendix 7.2, *Volume II: Appendix to Main Report*** and summarized below in **Table 5a & 5b**

Table 7.5a: Average Daily Traffic

	NH 4 CH 51	SH 85	NH - 275 Km 30.8	NH 209 CH 419	NH 48CH 44+200	NH 7 CH 49+000
Car	16156	2631	13040	2411	11690	15470
Mini Bus	345	48	485	57	275	407
Bus	2855	364	1223	312	1528	2782
LMV	2261	393	1217	341	908	2146
LCV (4 Wheels)	334	36	116	28	76	125
LCV (6 Wheels)	2755	96	863	78	853	2866
2 Axle	1853	47	619	114	583	1847
3 Axle	2837	54	424	69	339	2947
MAV (4 to 6 Axles)	4064	18	179	22	557	3525
MAV (7++ Axles)	1	0	0	0	0	1
JCB/HCM	6	2	2	2	2	3
3 Wheeler	820	1799	2057	475	563	114
2 wheeler	9414	11499	10863	4571	6640	10432
Tractor Without Trailer	6	8	6	4	7	5
Tractor With Trailer	22	58	29	16	22	29
Cycle	3	84	29	22	3	6
Cycle Rickshaw	0	1	0	0	0	0
Animal Drawn	0	3	1	0	0	0
Car Exempt	1	0	2	1	4	3
Mini Bus Exempt	12	0	4	1	7	9
Bus Exempt	0	0	0	0	0	0
LCV Exempt	1	0	1	0	3	1
Truck Exempt	0	0	0	0	0	0
Total	43746	17142	31159	8524	24061	42718
PCU	70014	12648	31660	7426	28247	66747

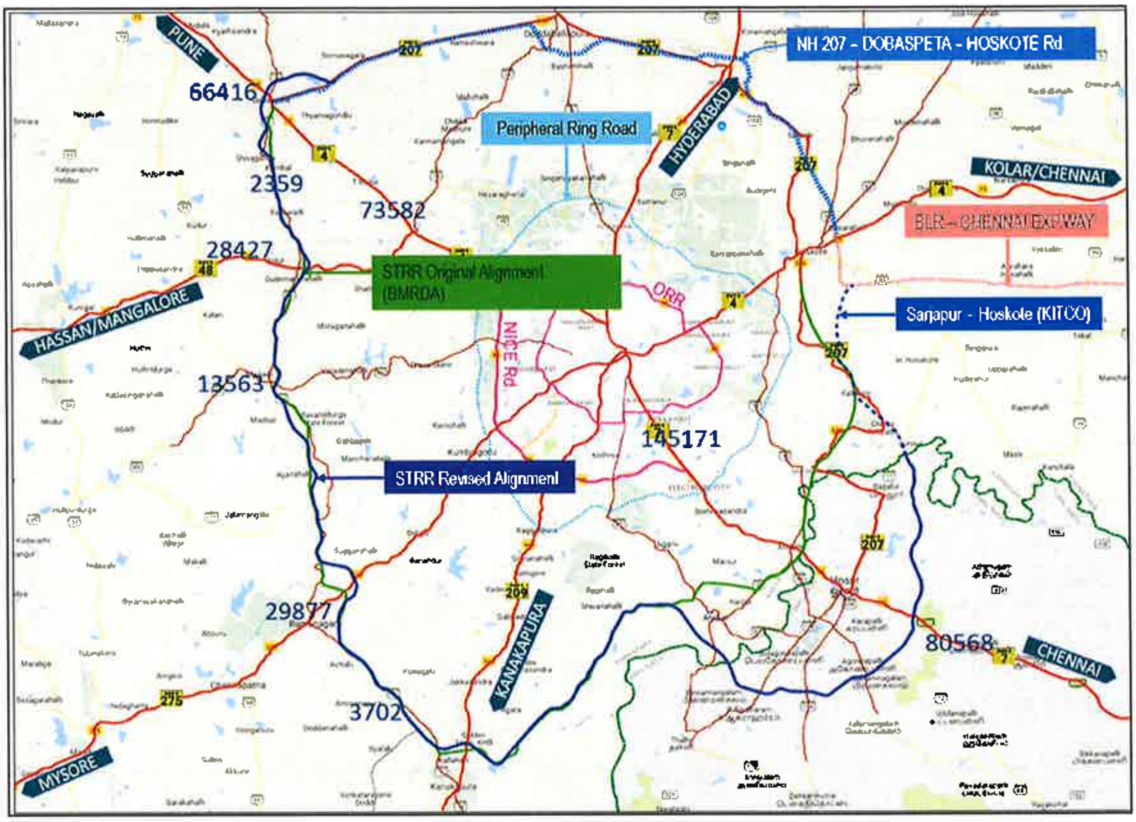
Table 7.5b: Average Daily Traffic

	NH 7 CH 31	SH 3CH 118	NH 207 CH 138	NH-4 NICE ROAD	NH- 7 Before NICE Road	NH -275 NICE Road	SH 3
Car	24582	462	2230	48418	26163	29386	817
Mini Bus	1230	8	119	2040	1617	1834	17
Bus	3889	33	207	6318	3144	3848	117
LMV	3734	78	505	6679	2893	3529	141
LCV (4 Wheels)	553	12	22	1732	478	692	12
LCV (6 Wheels)	4161	51	412	5735	1862	3961	39
2 Axle	2530	54	313	1853	482	1743	18
3 Axle	3828	46	409	1918	787	2384	13
MAV (4 to 6 Axles)	3489	47	357	1818	277	1116	3
MAV (7++ Axles)	1	0	0	0	0	0	0
JCB/HCM	2	1	3	4	9	7	0
3 Wheeler	482	76	957	5935	2910	2747	151
2 wheeler	32099	1386	6642	54862	37086	25670	3527
Tractor Without Trailer	1	4	5	5	2	5	0
Tractor With Trailer	15	11	61	39	12	21	16
Cycle	28	2	7	33	35	5	31
Cycle Rickshaw	0	0	0	1	1	1	0
Animal Drawn	0	0	0	0	0	0	0
Car Exempt	2	0	1	6	3	6	0
Mini Bus Exempt	6	0	0	19	4	15	0
Bus Exempt	0	0	1	1	0	1	0
LCV_Exempt	2	0	0	4	1	2	0
Truck Exempt	1	0	5	0	0	0	0
Total	80635	2273	12255	137418	77766	76974	4903
PCU	100041	2087	12544	140565	70819	87002	3517

Traffic volume count conducted at all thirteen locations shows variations in term of ADT and PCU from 4,903 to 137,418 and 3,517 to 140,565 respectively.

Following figure summarizes the traffic at various locations.

Figure 7.6 : Traffic Volume in PCU



7.5.2 *Annual Average Daily Traffic (AADT)*

The AADT is obtain by adjusting the traffic counts conducted for seasonal variation of traffic in the region. Seasonal variation factor has been derive from sale details of petrol and diesel fuels along the corridor collected from various fuel outlets along the project stretch.

Table 7.6 shows the seasonal factors calculated.

Table 7.6: Seasonal factors

Month	Kankapura		Shivganga		Atibele		Ramanagara	
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel
January	0.84	1.14	1.30	1.01	0.92	1.30	1.27	1.00
February	1.01	1.03	0.98	0.85	0.97	1.00	1.14	0.95
March	1.27	1.01	1.08	0.92	1.04	0.89	1.01	1.04
April	1.13	0.90	0.93	1.07	0.93	0.99	0.90	0.90
May	1.19	0.92	1.04	1.10	0.96	0.93	1.01	1.02
June	0.96	0.96	0.91	1.17	0.99	0.85	0.82	1.15
July	0.84	0.98	0.94	1.04	1.02	0.89	0.92	1.08
August	1.01	1.14	1.00	1.06	1.06	0.99	0.88	1.00
September	0.88	1.09	0.92	0.94	0.99	1.03	1.14	0.88
October	1.35	0.96	0.99	1.01	0.93	1.20	1.04	0.96
November	1.01	0.88	0.88	1.01	1.16	1.12	1.06	0.88
December	0.81	1.05	1.15	0.90	1.08	1.00	0.99	1.26

The traffic volume survey along the project road has been carry out in the months of December 2017. The seasonal factors thus used to convert traffic counts to AADT. The average of SCF for petrol and diesel has been applied for cars and SCF for Petrol has been applied two and three wheeler while SCF for diesel has been used for all other vehicles. The location wise AADT by vehicle type presented in **Table 7.77a &b**.

Table 7.7a: Annual Average Daily Traffic at Count Locations

	NH 4CH 51	SH 85	NH - 275 Km 30.8	NH 209 CH 419	NH 48CH 44+200	NH 7 CH 49+000
Car	16560	2697	12128	2242	10871	17404
Mini Bus	310	43	509	60	289	512
Bus	2570	327	1284	327	1604	3505
LMV	2035	353	1278	358	954	2703
LCV (4 Wheels)	300	33	122	29	80	158
LCV (6 Wheels)	2480	87	906	82	896	3611
2 Axle	1668	43	650	120	612	2328
3 Axle	2554	48	445	73	356	3713
MAV (4 to 6 Axles)	3657	16	188	23	585	4442
MAV (7++ Axles)	1	0	0	0	0	1
JCB/HCM	5	2	2	2	2	3
3 Wheeler	943	2068	1666	385	456	113
2 wheeler	10826	13224	8799	3703	5378	10328
Tractor Without Trailer	6	7	6	5	7	6
Tractor With Trailer	20	53	30	17	23	36
Cycle	3	3	3	22	3	6
Cycle Rickshaw	0	0	0	0	0	0
Animal Drawn	0	0	0	0	0	0
Car Exempt	1	0	2	1	4	3
Mini Bus Exempt	12	13	14	1	7	9
Bus Exempt	0	0	0	0	0	0
LCV Exempt	1	0	1	0	3	1
Truck Exempt	0	0	0	0	0	0
Total	43951	19018	28033	7449	22132	48884
PCU	66416	13563	29877	6845	27323	80568

Table 7.7b: Annual Average Daily Traffic at Count Locations

	NH 7CH 31	SH 3CH 118	NH 207 CH 138	NH -4 NICE ROAD	NH - 7 Before Nice Road	NH -275 Nice Road	SH 3
Car	27655	520	2319	50354	27210	30561	849
Mini Bus	1550	11	119	2040	1617	1834	17
Bus	4900	42	207	6318	3144	3848	117
LMV	4705	98	505	6679	2893	3529	141

	NH 7CH 31	SH 3CH 118	NH 207 CH 138	NH -4 NICE ROAD	NH - 7 Before Nice Road	NH -275 Nice Road	SH 3
LCV (4 Wheels)	697	16	22	1732	478	692	12
LCV (6 Wheels)	5242	64	412	5735	1862	3961	39
2 Axle	3187	68	313	1853	482	1743	18
3 Axle	4823	58	409	1918	787	2384	13
MAV (4 to 6 Axles)	4396	60	357	1818	277	1116	3
MAV (7++ Axles)	1	0	0	0	0	0	0
JCB/HCM	3	1	3	4	9	7	0
3 Wheeler	477	76	1034	6409	3142	2967	163
2 wheeler	31778	1372	7173	59251	40053	27724	3810
Tractor	1	5	5	5	2	5	0
Tractor With Trailer	19	14	61	39	12	21	16
Cycle	28	2	7	33	35	5	31
Cycle Rickshaw	0	0	0	1	1	1	0
Animal Drawn	0	0	0	0	0	0	0
Car Exempt	2	0	1	6	3	6	0
Mini Bus Exempt	6	0	0	19	4	15	0
Bus Exempt	0	0	1	1	0	1	0
LCV_Exempt	2	0	0	4	1	2	0
Truck Exempt	1	0	5	0	0	0	0
Total	89475	2407	12952	144219	82012	80422	5230
PCU	118261	2359	12975	145171	73582	89424	3702

7.5.3 Hourly Variation of Traffic

Average hourly variation of traffic for the 13 count locations shown in **Figure 7.6** through **Figure 7.18**. It is observe that the traffic varies considerably in day and night. Peak hour factor varies from 5.9% to 9.3% for different locations as shown in **Table 7.8.**

Table 7.8: Hourly Variation of Traffic: Peak Hour Factors

Location	Peak Hour	PHF (%)	Peak Hour ADT
NH 4CH 51	18:00-19:00	5.9%	2564
SH 85	17:00-18:00	8.1%	1385
NH -275 Km 30.8	17:00-18:00	7.1%	2203
NH 209 CH 419	17:00-18:00	8.0%	679
NH 48CH 44+200	18:00-19:00	6.5%	1563
NH 7 CH 49+000	17:00-18:00	6.0%	2544
NH 7CH 31	9:00-10:00	6.6%	5315
SH 3CH 118	13:00-14:00	9.3%	212
NH 207 CH 138	17:00-18:00	7.9%	968
NH -4 NICE ROAD	09:00-10:00	7.8%	10733
NH - 7 Before Nice Road	09:00-10:00	7.5%	5800

Location	Peak Hour	PHF (%)	Peak Hour ADT
NH -275 Nice Road	18:00-19:00	7.9%	6065
SH 3	11:00-12:00	8.9%	436

Figure 7.7: Hourly Traffic Variation at NH 4CH 51

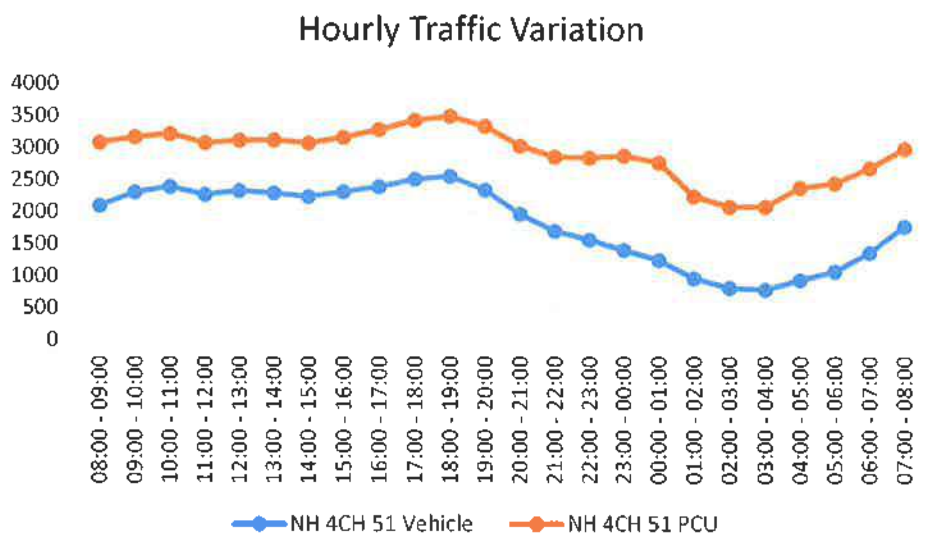


Figure 7.8: Hourly Traffic Variation at SH 85

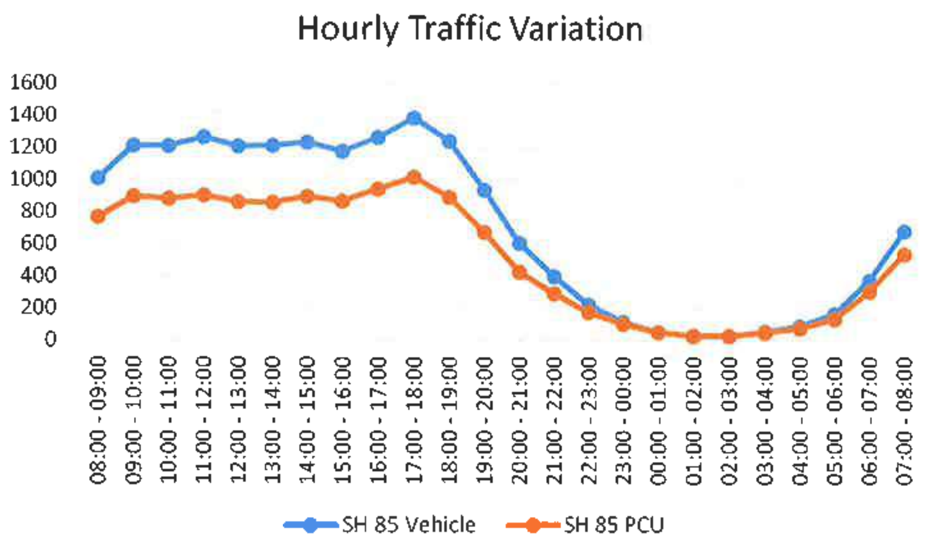


Figure 7.9: Hourly Traffic Variation at NH 275

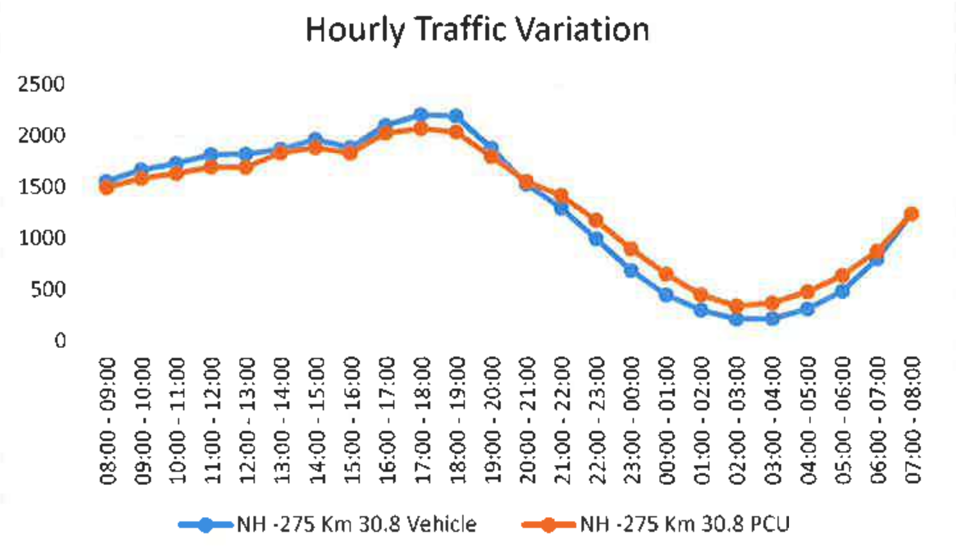


Figure 7.10: Hourly Traffic Variation at NH 209

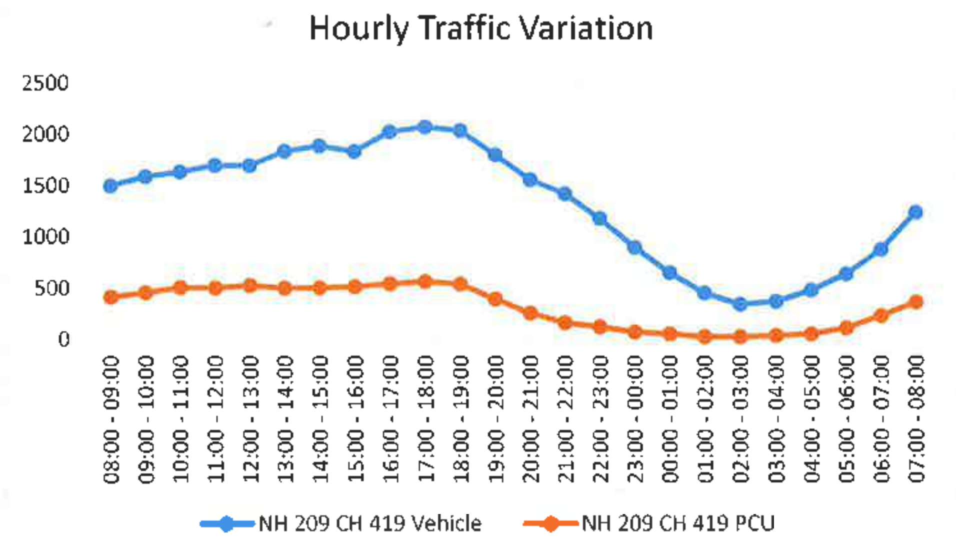


Figure 7.11: Hourly Traffic Variation at NH 48

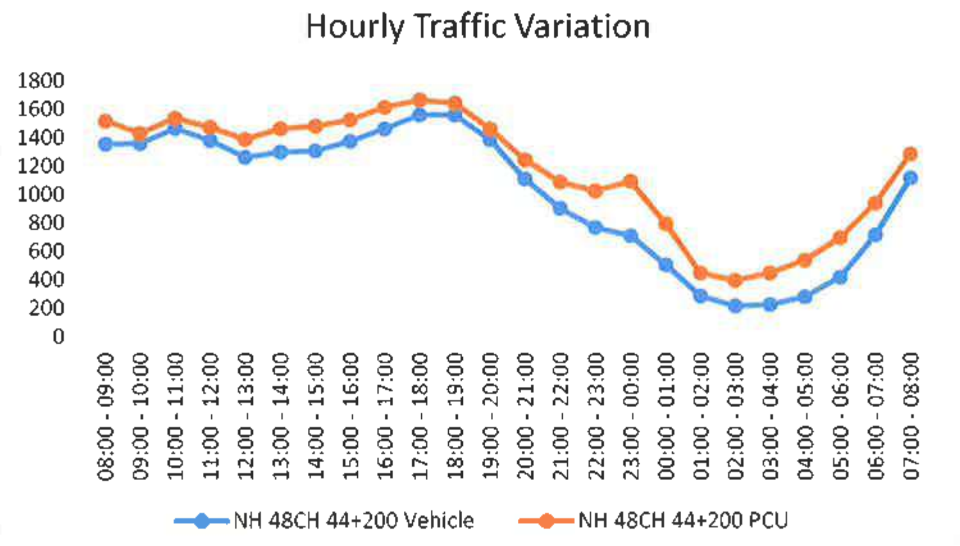


Figure 7.12: Hourly Traffic Variation at NH 7 Ch 49+000

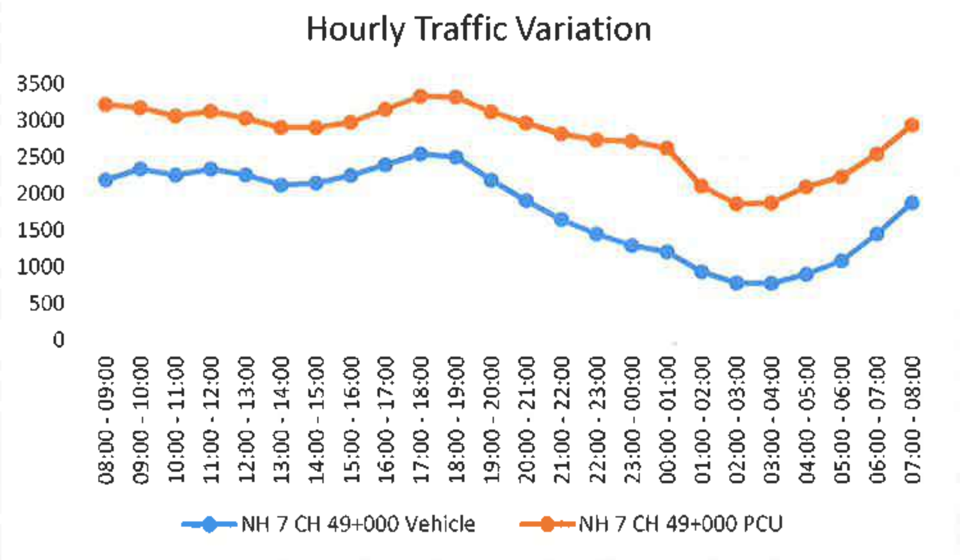


Figure 7.13: Hourly Traffic Variation at NH 7 Ch 31+000

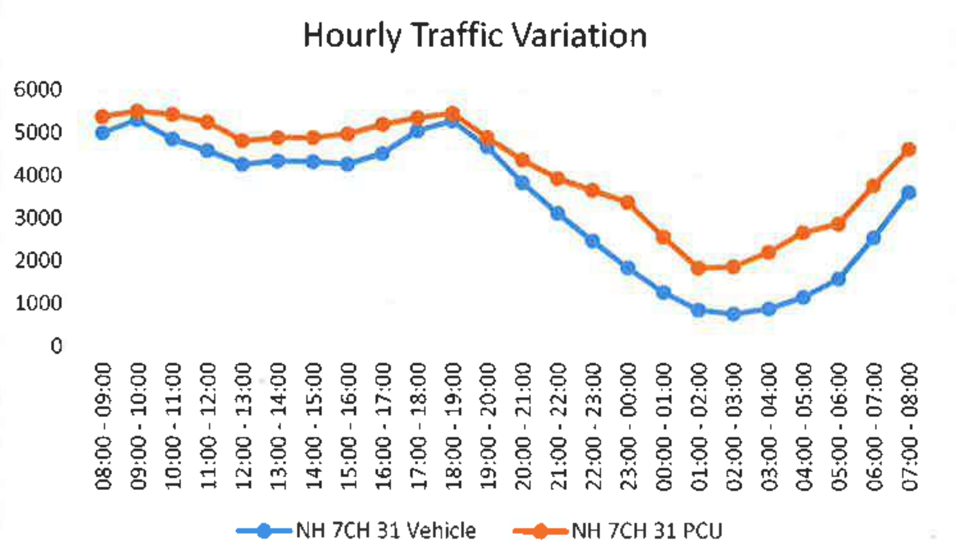


Figure 7.14: Hourly Traffic Variation at SH 3 Ch 118

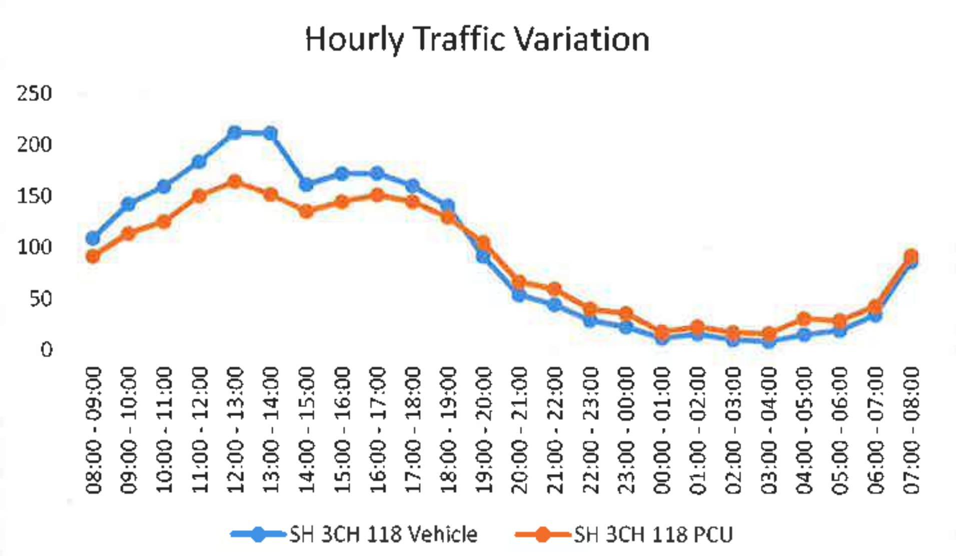


Figure 7.15: Hourly Traffic Variation at NH 207 Ch 138

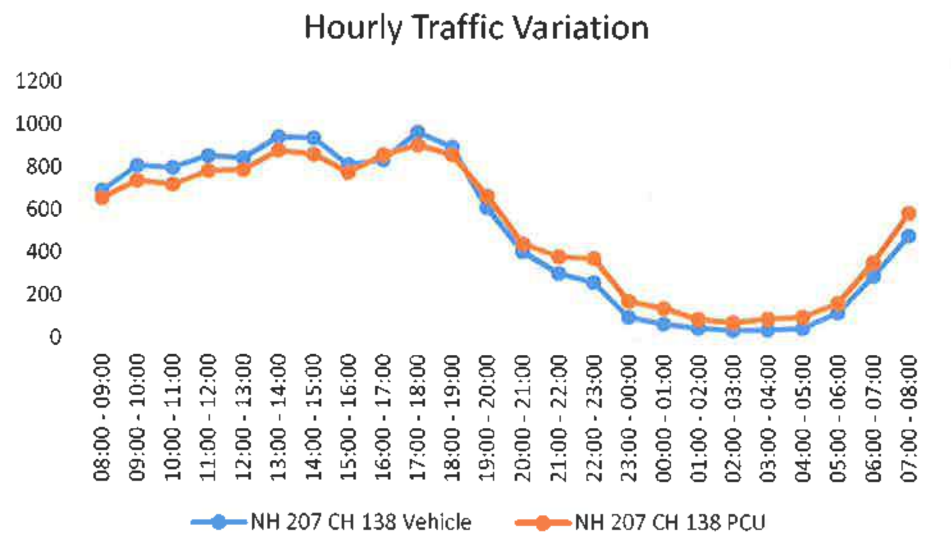


Figure 7.16: Hourly Traffic Variation at NH 4 Nice Road

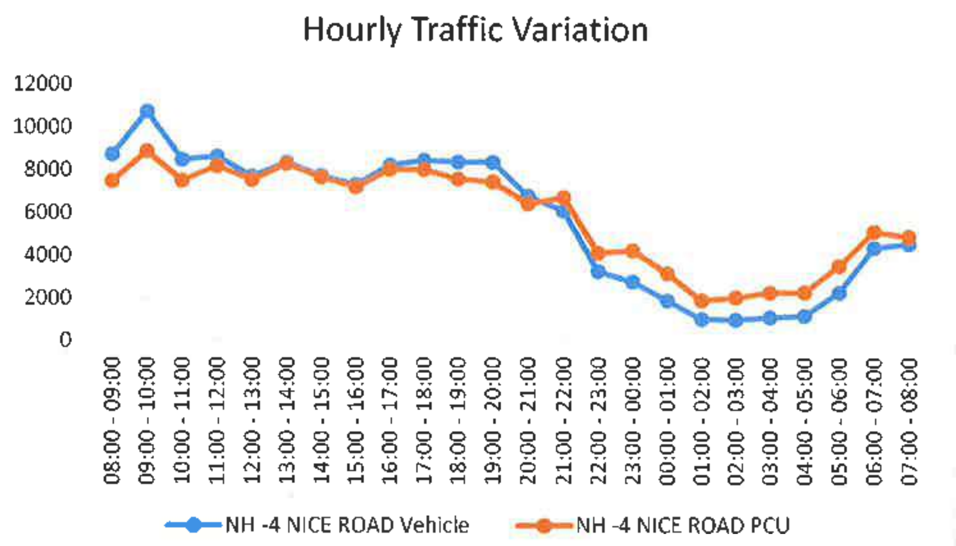


Figure 7.17: Hourly Traffic Variation at NH 7 Before Nice Road

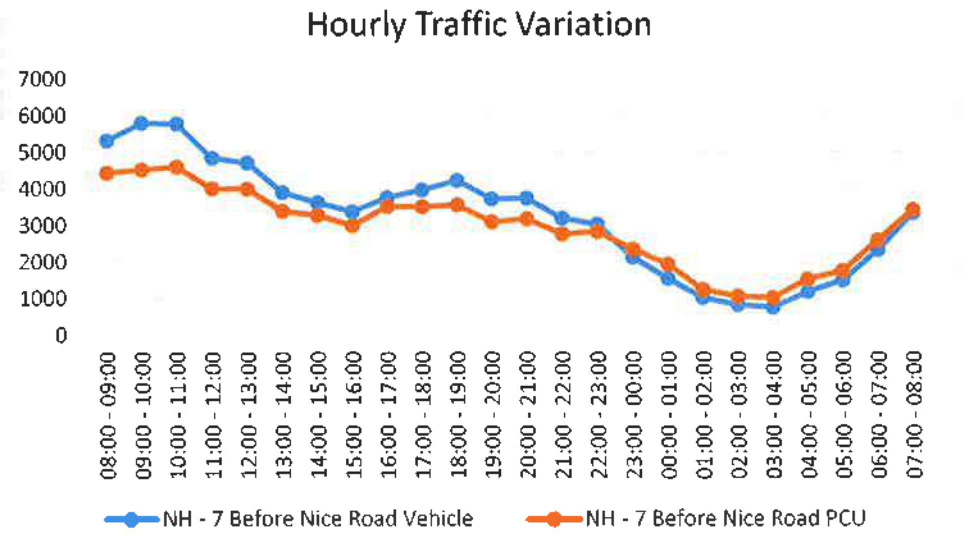


Figure 7.18: Hourly Traffic Variation at NH 275 Nice Road

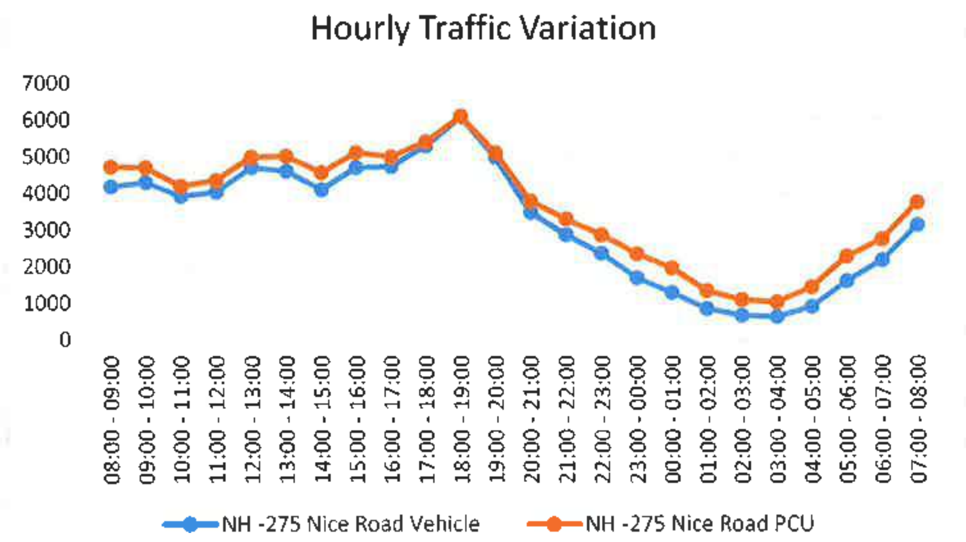
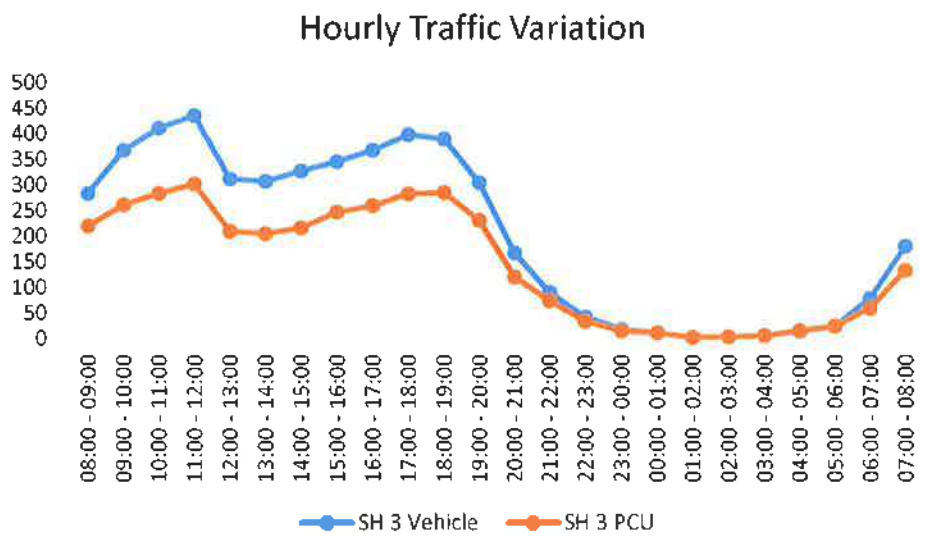


Figure 7.19: Hourly Traffic Variation at NH SH 3



7.5.4 *Daily Variation of Traffic Volume*

Daily variations in Traffic Volume at the count locations are shown in **Figure 7.19** through **Figure 7.31** in both Number of Vehicles (ADT) and Passenger Car Units (PCU).

Figure 7.20: Daily Traffic Variation at NH 4CH 51

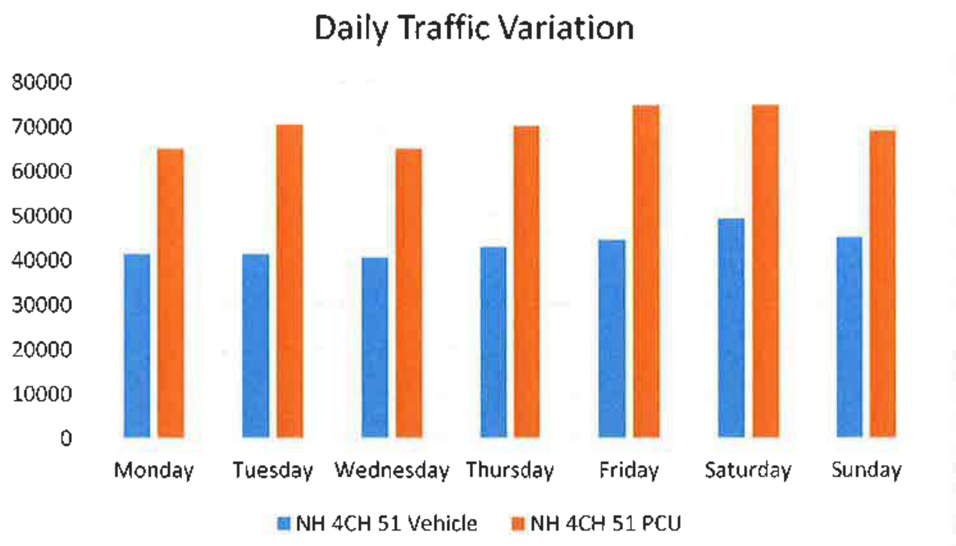


Figure 7.21: Daily Traffic Variation at SH 85

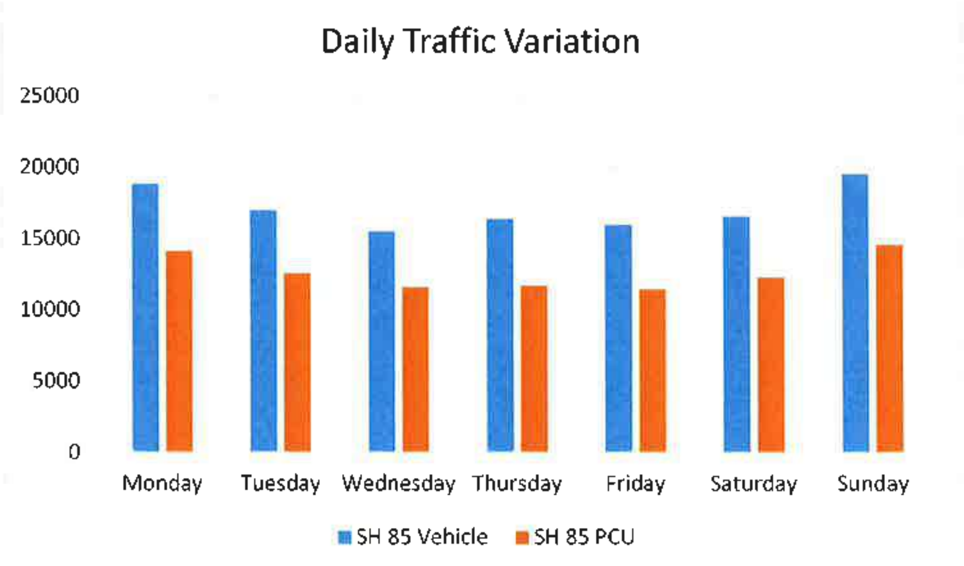


Figure 7.22: Daily Traffic Variation at NH 275 Ch 30+800

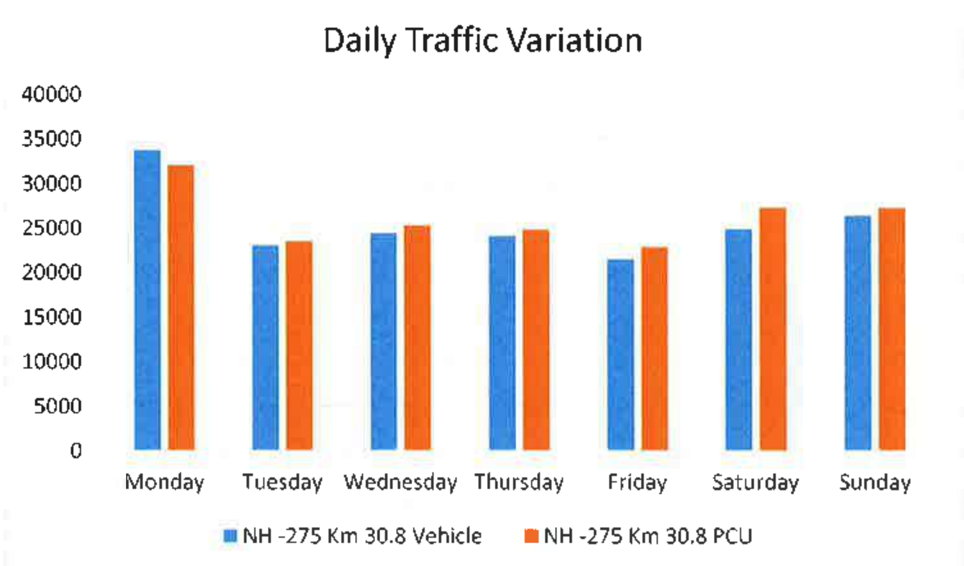


Figure 7.23: Daily Traffic Variation at NH 209

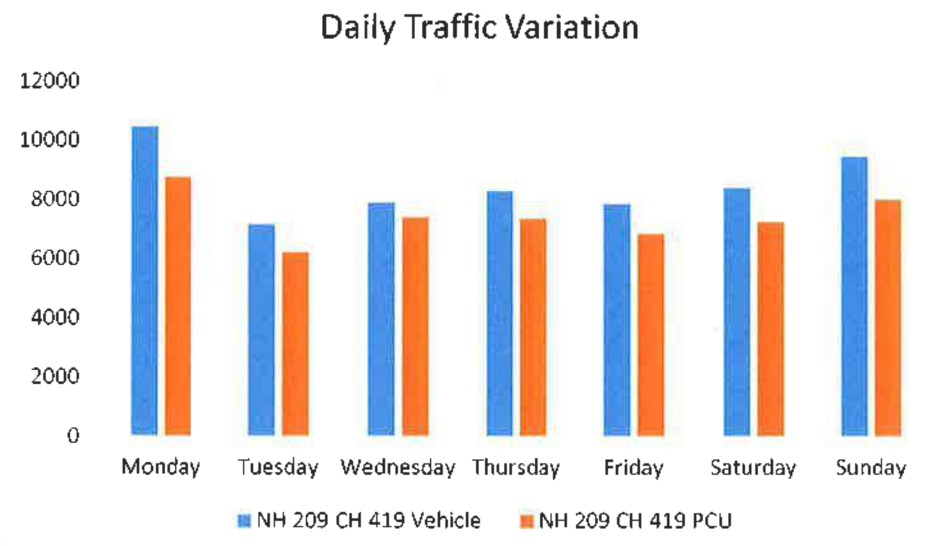


Figure 7.24: Daily Traffic Variation at NH 48

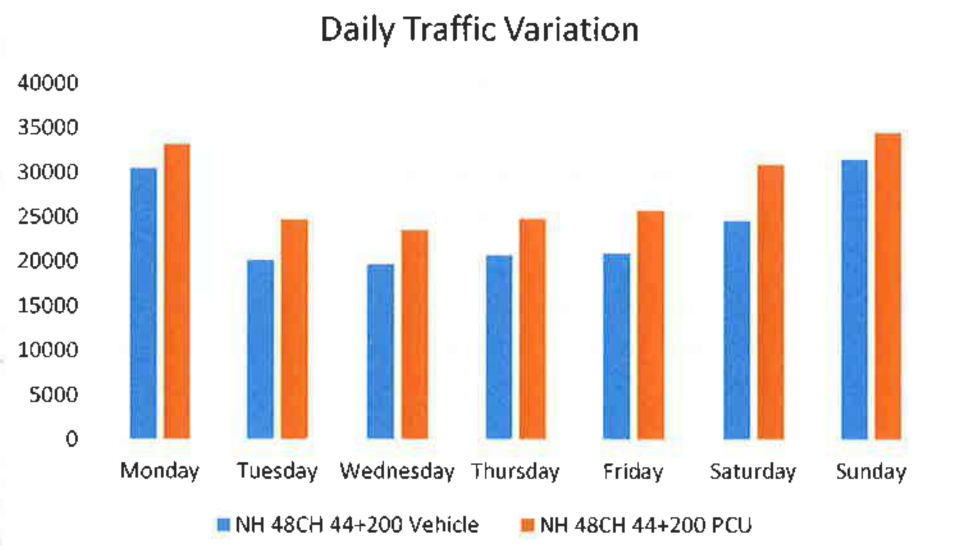


Figure 7.25: Daily Traffic Variation at NH 7 Ch 49+000

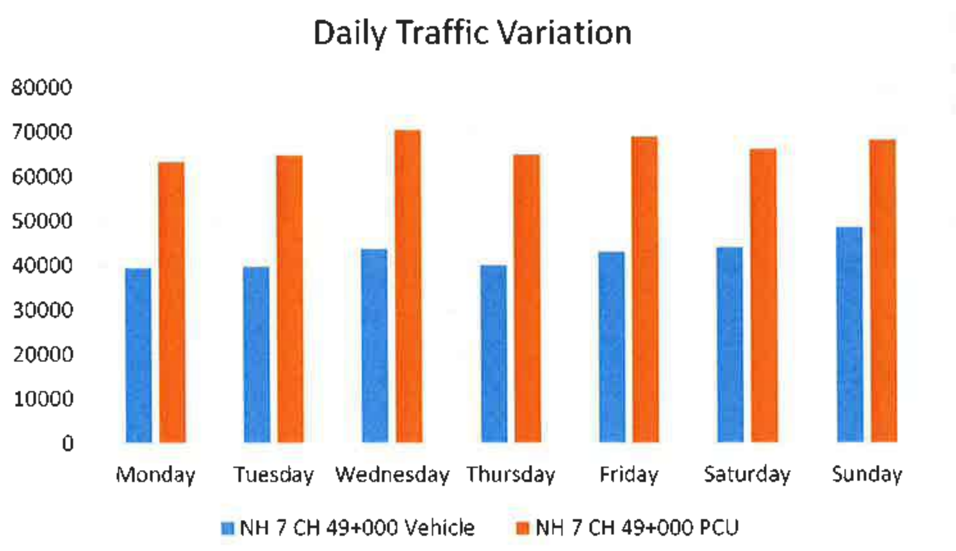


Figure 7.26: Daily Traffic Variation at NH 7 Ch 31+000

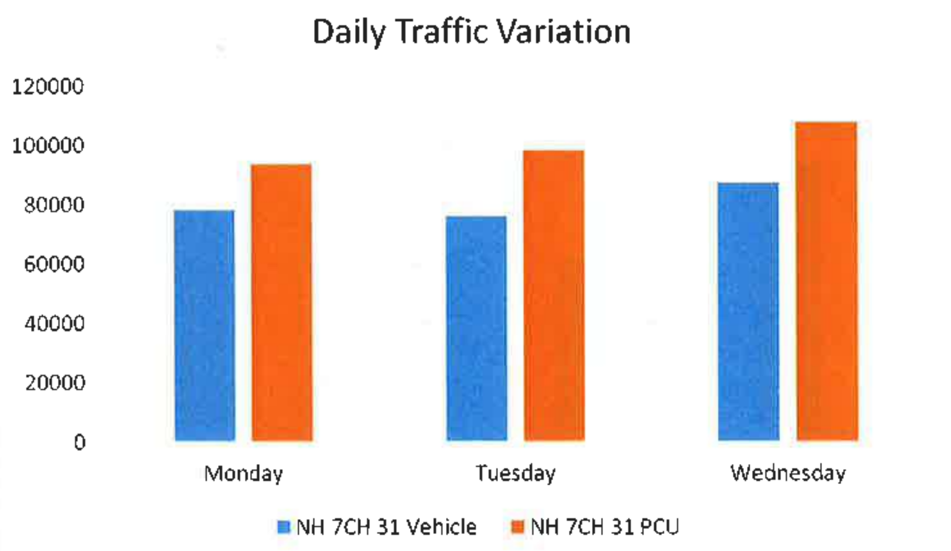


Figure 7.27: Daily Traffic Variation at SH 3 Ch 118+000

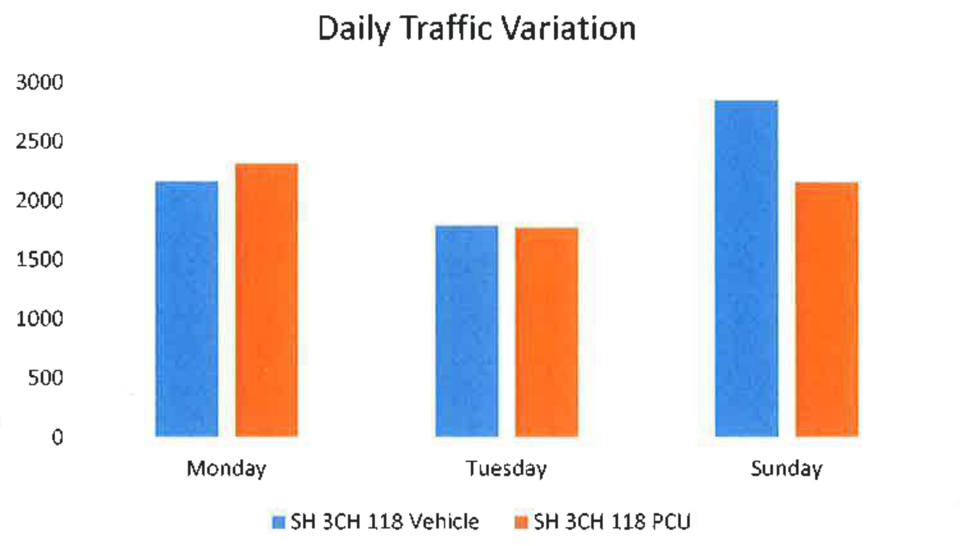


Figure 7.28: Daily Traffic Variation at NH 207 Ch 138+000

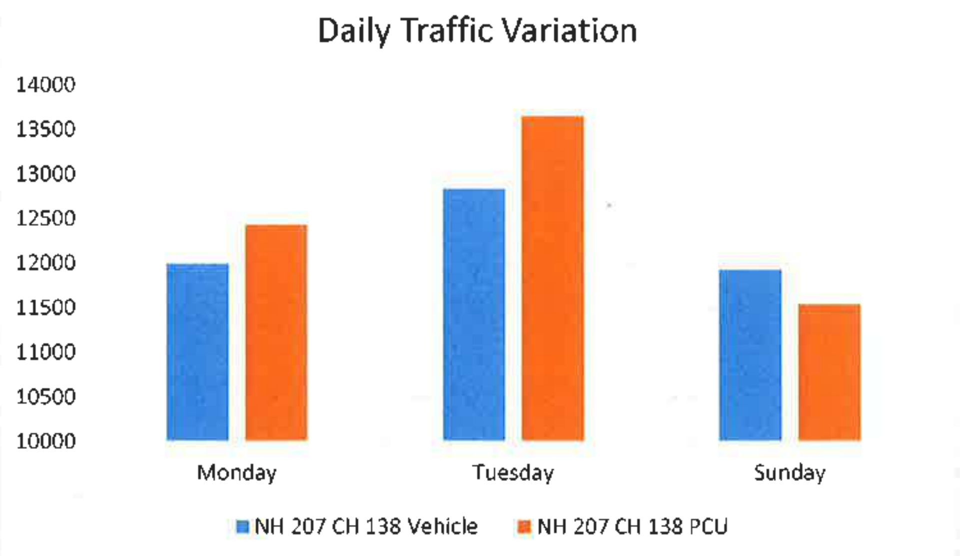


Figure 7.29: Daily Traffic Variation at NH 4 NICE ROAD

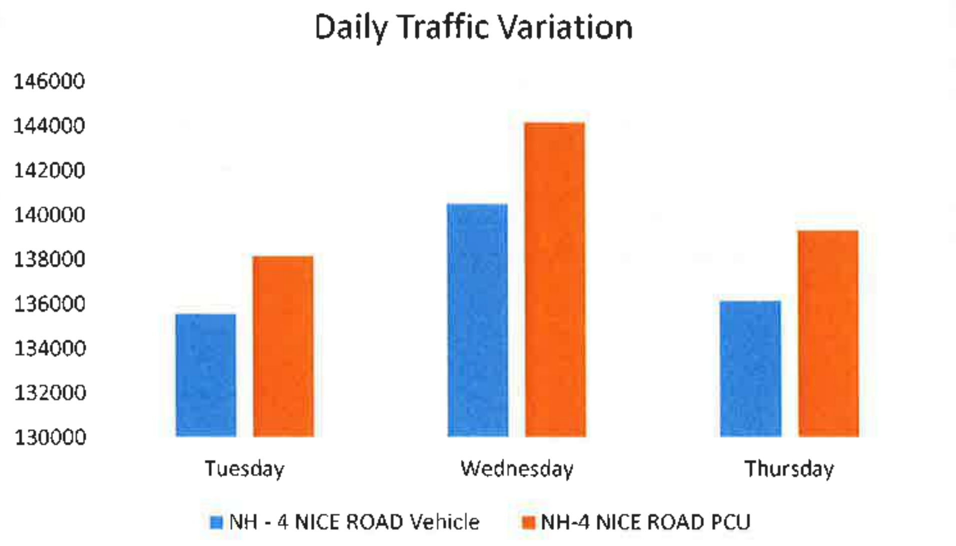


Figure 7.30: Daily Traffic Variation at NH 7 Before NICE ROAD

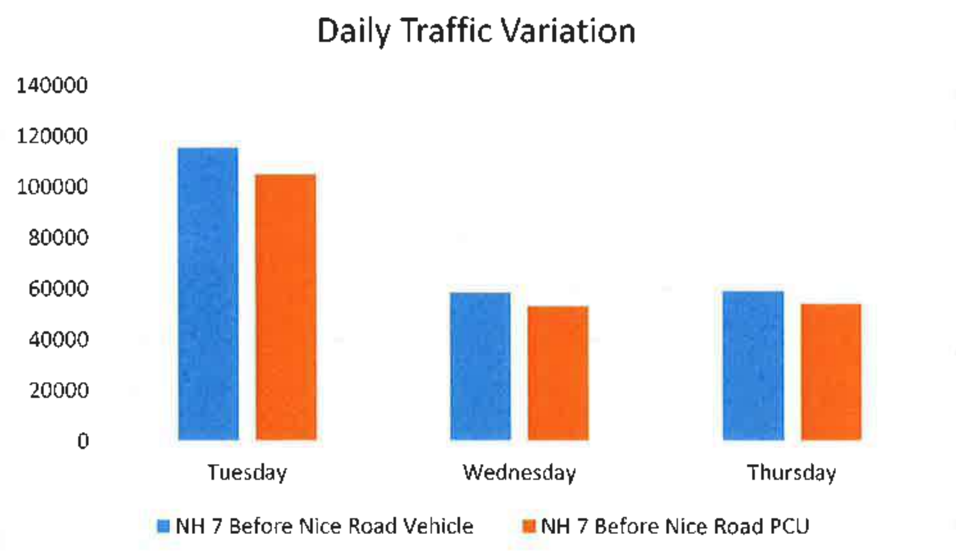


Figure 7.31: Daily Traffic Variation at NH 275 NICE ROAD

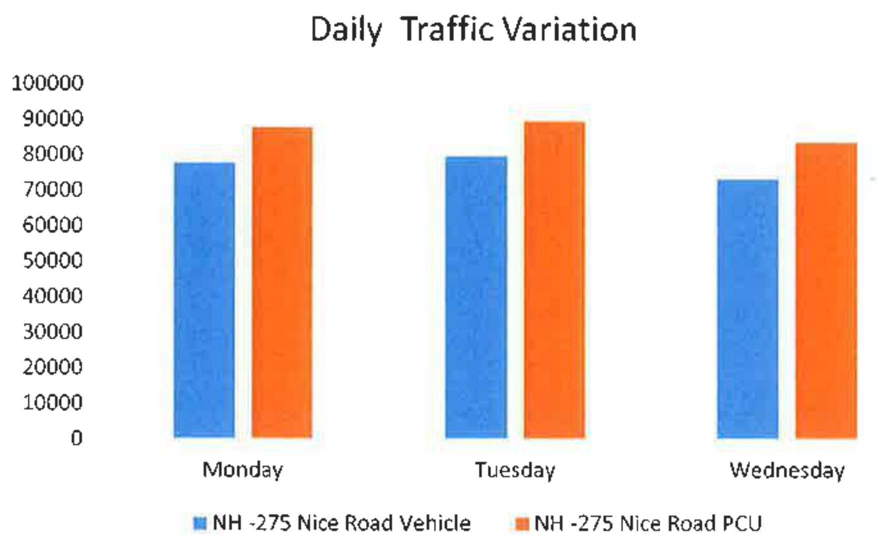
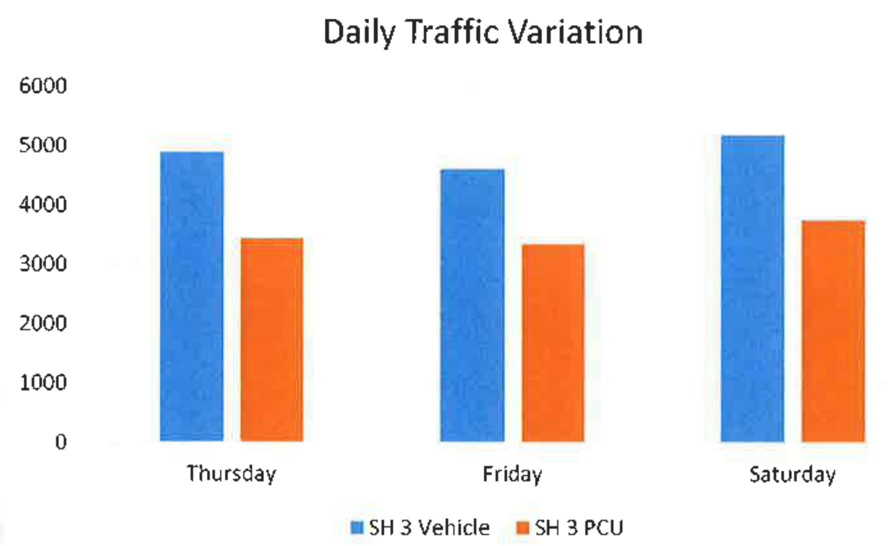


Figure 7.32: Daily Traffic Variation at SH 3



7.5.5 Composition of Traffic

Average composition of traffic at each count location is present in following table.

Table 7.9: Average Composition of Traffic

	NH 4CH 51	SH 85	NH - 275 Km 30.8	NH 209 CH 419	NH 48CH 44+200	NH 7 CH 49+000	NH 7CH 31	SH 3CH 118	NH 207 CH 138	NH -4 NICE ROAD	NH - 7 Before Nice Road	NH - 275 Nice Road	SH 3
Car	37%	15%	42%	28%	49%	36%	30%	20%	18%	35%	34%	38%	17%
Mini Bus	1%	0%	2%	1%	1%	1%	2%	0%	1%	1%	2%	2%	0%
Bus	7%	2%	4%	4%	6%	7%	5%	1%	2%	5%	4%	5%	2%
LMV	5%	2%	4%	4%	4%	5%	5%	3%	4%	5%	4%	5%	3%
LCV (4 Wheels)	1%	0%	0%	0%	0%	0%	1%	1%	0%	1%	1%	1%	0%
LCV (6 Wheels)	6%	1%	3%	1%	4%	7%	5%	2%	3%	4%	2%	5%	1%
2 Axle	4%	0%	2%	1%	2%	4%	3%	2%	3%	1%	1%	2%	0%
3 Axle	6%	0%	1%	1%	1%	7%	5%	2%	3%	1%	1%	3%	0%
MAV	9%	0%	1%	0%	2%	8%	4%	2%	3%	1%	0%	1%	0%
3 Wheeler	2%	10%	7%	6%	2%	0%	1%	3%	8%	4%	4%	4%	3%
2 Wheeler	22%	67%	35%	54%	28%	24%	40%	61%	54%	40%	48%	33%	72%
Agricultural	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%
NMT	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%

As observed passenger vehicles, constitute majorly on the surveyed location.

7.5.6 Directional Distribution of Traffic

Directional split at each of the location shown in **Table 7.10.** This is a useful input for capacity analysis and pavement design. As seen, the directional split for up and down traffic is nearly equal.

Table 7.10: Directional Distribution

Location	Up	Down
NH 4CH 51	50.16	49.84
SH 85	51.59	48.41
NH -275 Km 30.8	52.10	47.90
NH 209 CH 419	47.21	52.79
NH 48 CH 44+200	52.91	47.09
NH 7 CH 49+000	50.26	49.74
NH 7CH 31	48.34	51.66
SH 3CH 118	48.28	51.72
NH 207 CH 138	49.77	50.23
NH -4 NICE ROAD	46.52	53.48
NH - 7 Before Nice Road	47.86	52.14
NH -275 Nice Road	51.48	48.52
SH 3	50.20	49.80

7.6 DATA ANALYSIS – OD SURVEY

Origin-Destination (OD) surveys determine and relate the pattern of traffic flows to trip purpose and commodities transported. The information provided by the surveys enables estimates of the growth of future flows made on a more rational basis. The origin - destination surveys have carried out by means of the roadside interview method at locations selected to capture major trip desires in each section. The surveys have carried out on one working day for 24 hours on a random sampling basis. All categories of motorized vehicles (e.g. Cars, Jeeps, Buses, light as well as heavy goods vehicles), have been surveyed for its trip origin, destination, trip purpose, occupancy and weight of commodity carried. The survey crew was organized into 3 groups by 8-hour shifts with sufficient enumerators in each traffic direction as well as in groups. Classroom training were given to the enumerators in order to be acquainted the work and in the use of standard interview sheets. Police help sought to ensure smooth flow of traffic and stoppage of randomly selected vehicles. Engineers supervised the whole survey activities. The location of OD survey conducted given in **Table 7.11**

Table 7.11: OD Survey Location

S No	Highway	Chainage	OD
1	NH 4	Km 51	6/12/2017
2	NH 48	km 44+200	7/12/2017
3	SH 85	12°57'48.98"N	7/12/2017
4	NH 275	Km 30.8	5/12/2017
5	NH 209	Km 419	6/12/2017
6	NH 7	km 49.00	13/12/2017
7	NH 7	km 31.00	12/12/2017

7.6.1 *Trip Characteristics*

Table 2 provides the trip purposes as reported by the OD Survey respondents.

Table 7.12: Trip Purpose (Passenger Vehicles)

Trip Purpose	NH 4-Km 51	NH 48-km 44+200	SH 85	NH 275-Km 30.8	NH 209-Km 419	NH 7-km 49.00
Work	23%	24%	22%	18%	13%	20%
Business	17%	15%	5%	16%	11%	1%
Education	8%	7%	4%	4%	2%	1%
Social	15%	16%	22%	15%	26%	26%
Shopping	5%	2%	3%	2%	5%	0%
Religious	11%	13%	14%	24%	26%	29%
Hospital	18%	15%	23%	17%	15%	15%
Others	3%	8%	7%	4%	2%	8%

It was observed that the maximum number of trips contributed to Work, social gatherings and religious/tour trips along the corridor by the passenger car vehicle at all OD locations.

Table 7.13 through **Table 7.18** show the trip length for goods vehicles at the OD Survey locations. These has ivided into different trip length categories for each vehicle type.

Table 7.13: Trip Length for Goods Vehicles NH 4-Km 51

Vehicle Type	0-50	50-100	100-150	150-200	>200
2 Axle Trucks	6.97%	2.05%	3.28%	0.82%	86.89%
3 Axle Trucks	3.70%	1.65%	0.41%	0.00%	94.24%
LCV	16.85%	7.87%	6.74%	6.74%	61.80%
MAV	2.83%	0.71%	0.71%	0.47%	95.52%
Total	5.30%	1.80%	1.80%	0.90%	90.10%

Table 7.14: Trip Length for Goods Vehicles NH 48-Km 44+200

Vehicle Type	0-50	50-100	100-150	150-200	>200
2 Axle Trucks	8.33%	29.86%	2.43%	3.13%	56.60%
3 Axle Trucks	6.86%	17.69%	1.81%	3.61%	70.40%
LCV	5.26%	29.82%	4.39%	4.39%	56.14%
MAV	4.05%	18.07%	4.98%	0.62%	71.96%
Total	6.10%	22.70%	3.40%	2.60%	65.30%

Table 7.15: Trip Length for Goods Vehicles SH 85

Vehicle Type	0-50	50-100	100-150	150-200	>200
2 Axle Trucks	9.90%	13.20%	9.90%	4.62%	62.71%
3 Axle Trucks	5.70%	3.63%	6.74%	4.15%	80.31%
LCV	12.05%	3.61%	17.47%	7.83%	58.43%
MAV	1.18%	2.96%	5.62%	3.85%	86.39%
Total	6.50%	6.30%	9.10%	4.70%	73.40%

Table 7.16: Trip Length for Goods Vehicles NH 275-Km 30.8

Vehicle Type	0-50	50-100	100-150	150-200	>200
2 Axle Trucks	8.60%	9.14%	16.13%	9.68%	56.45%
3 Axle Trucks	15.17%	9.91%	8.67%	2.79%	63.78%
LCV	14.44%	10.56%	7.78%	7.78%	59.44%
MAV	6.77%	5.48%	4.52%	0.97%	82.26%
Total	11.10%	8.60%	8.60%	4.40%	67.20%

Table 7.17: Trip Length for Goods Vehicles NH 209-Km 419

Vehicle Type	0-50	50-100	100-150	150-200	>200
2 Axle Trucks	21.14%	25.14%	0.00%	0.00%	54.29%
3 Axle Trucks	11.58%	15.26%	11.58%	11.58%	50.00%
LCV	51.83%	19.56%	3.67%	0.00%	24.94%
MAV	6.64%	22.57%	16.37%	6.64%	48.67%
Total	28.50%	20.40%	7.30%	3.70%	40.20%

Table 7.18: Trip Length for Goods Vehicles NH 7-km 49.00

Vehicle Type	0-50	50-100	100-150	150-200	>200
2 Axle Trucks	13.29%	15.61%	6.36%	9.83%	54.91%
3 Axle Trucks	3.24%	8.27%	6.12%	3.96%	78.42%
LCV	11.06%	19.60%	8.04%	11.06%	50.75%
MAV	5.14%	7.71%	4.29%	6.86%	76.00%
Total	7.10%	11.60%	6.00%	7.40%	68.00%

The survey data indicated that the majority of goods vehicles have trip length more than 200 km at all locations with the increase in trip length with number of axles.

OD Matrices for various vehicle categories provided in **Appendix 7.3, *Volume II: Appendix to Main Report.***

7.7 TRAFFIC ASSIGNMENT

The STRR traffic would consist of three types:

1. Existing Traffic: Existing traffic on SH 3 plying.
2. Diverted Traffic: This is traffic based on trips that already made between various origin and destinations impacted by the STRR route. In this case, the diversion of such traffic to the STRR would estimate.
3. Induced Traffic: This traffic based on trips that were not take earlier due to lack of desired infrastructure.

The following section presents the data, analysis and results for the estimation of diverted traffic followed by generated and induced traffic in the subsequent sections. The subsequent section discusses traffic growth rates for future forecast and the final section presents the traffic forecast for the STRR for a 30-year period.

7.7.1 Existing Traffic

Based on the traffic survey conducted on existing alignment of SH 3 following are the traffic assigned to different homogenous sections.

Table 7.19: Existing Traffic on Homogenous Section (2017)

Vehicle	HS1,HS2,HS3	HS4,HS5,HS6,HS7
Car	520	849
Mini Bus	11	17
Bus	42	117

Vehicle	HS1,HS2,HS3	HS4,HS5,HS6,HS7
LMV	98	141
LCV (4 Wheels)	16	12
LCV (6 Wheels)	64	39
2 Axle	68	18
3 Axle	58	13
MAV (4 to 6 Axles)	60	3
MAV (7++ Axles)	0	0
JCB/HCM	1	0
3 Wheeler	76	163
2 wheeler	1372	3810
Total	2386	5182
PCU	2287	3612

7.7.2 *Diverted Traffic*

A two-step process did the estimation of diverted traffic:

1. Step 1: Estimation of Traffic Trips Pattern (Internal – Internal, Internal-External, External-Internal, External-External)
2. Step 2: Estimation of Diversion Rates – based on generalized cost analysis with respect to competing routes.

The analysis of traffic count and OD survey data has presented in the previous chapter. The share of trip pattern at OD locations thus obtained iven in **Table 7.20.**

Table 7.20: Trip Pattern at OD Locations

	NH 4-Km 51								NH 209 Km 419						
	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV		Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV
I-I	0%	0%	0%	0%	0%	0%	0%	I-I	0%	0%	0%	0%	0%	0%	0%
I-E	33%	36%	38%	54%	27%	44%	42%	I-E	25%	4%	28%	21%	25%	18%	15%
E-I	49%	36%	54%	11%	37%	22%	21%	E-I	22%	0%	14%	25%	27%	22%	31%
E-E	19%	29%	8%	4%	36%	34%	38%	E-E	53%	96%	58%	55%	47%	60%	54%
	SH - 85								NH 48 Km 44+200						
	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV		Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV
I-I	2%	0%	2%	1%	3%	0%	5%	I-I	34%	67%	28%	17%	15%	13%	17%
I-E	42%	33%	39%	25%	41%	50%	43%	I-E	21%	0%	12%	21%	33%	23%	32%
E-I	37%	11%	42%	61%	36%	27%	39%	E-I	21%	33%	31%	32%	39%	25%	25%
E-E	19%	56%	17%	12%	20%	23%	14%	E-E	24%	0%	29%	30.0%	13%	39%	26%

NH 275 - Km 30+800									NH 7 Km 41						
	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV		Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV
I-I	0%	1%	0%	0%	0%	37%	0%	I-I	29%	28%	28%	17%	15%	17%	18%
I-E	38%	29%	41%	45%	42%	5%	35%	I-E	26%	31%	17%	16%	24%	31%	26%
E-I	47%	53%	46%	48%	51%	59%	59%	E-I	16%	23%	31%	29%	29%	33%	29%
E-E	14%	17%	13%	7%	7%	0%	6%	E-E	29%	18%	24%	38%	32%	19%	27%

In order to capture diverted traffic from competing route to STRR following scientific tool adopted in this study.

The Generalized Cost (GC) function used is as follows:

Generalized Cost (GC) = VOC*TL+VOT*TT+TR

Where

VOC – Vehicle Operating Cost (**Table 7.211**)

VOT – Value of Time (**Table 7.22**)

TT – Travel Time

TR – Toll Rates (**Table 7.23**)

TL – Trip Length

Vehicle Operating Cost and Value of Time values based on the IRC: SP: 30 - 2012. These values inflated for current prices as per the tables provided in IRC: SP: 30 - 2012. The Government of India based toll Rates on notifications. Escalation rate used for these analyses are 5%.

Table 7.211: Vehicle Operating Cost (INR/km) FY 17

Vehicle Type	NH/SH	Expressway
Car	11.77	10.33
Bus	48.43	42.19
LCV	17.48	15.98
2-Axle Trucks	19.41	17.30
3-Axle Trucks	31.47	27.96
4-6 Axle Trucks	31.47	27.96
>6 Axle Trucks	31.47	27.96

Table 7.22: Value of Time (INR/Minute) FY 17

Vehicle Type	Value of Time
Car	4.80
Bus	3.90
LCV	1.70
2-Axle Trucks	1.70

Vehicle Type	Value of Time
3-Axle Trucks	1.70
4-6 Axle Trucks	1.70
>6 Axle Trucks	1.70

Table 7.23: Toll Rates (INR/km)-FY 17

Vehicle Type	NH/SH	Expressway
Car	1.06	1.41
Bus	3.60	4.79
LCV	1.71	2.28
2-Axle Trucks	3.60	4.79
3-Axle Trucks	3.93	5.23
4-6 Axle Trucks	3.93	5.23
>6 Axle Trucks	5.64	7.51

Further, the diversion rates calculated using the Cost Ratios given below.

This analysis based on the guidance provided by the Road User Cost Study 2000 for India, and the diversion curve equations derived under the Technical Assistance Program funded by ADB for Ministry of Transport.

CR = Cost of Alternate Route/ Cost of Expressway Route

Car

$CR \leq 0.634$ Diversion Rate = 98.750 - (CR/0.634) * 8.125

$0.634 \leq CR \leq 1.465$ Diversion Rate = 90.625 - ((CR-0.634)/0.831) * 84.375

$1.465 \leq CR \leq 2.0$ Diversion Rate = 6.25 - ((CR-1.465)/0.535) * 5.25

Truck & Bus

$CR \leq 0.750$ Diversion Rate = 100 - ((CR/0.75) * 5)

$0.750 \leq CR \leq 1.250$ Diversion Rate = 95 - ((CR-0.75)/0.5) * 90

$1.250 \leq CR \leq 2.0$ Diversion Rate = ((2-CR)/0.75) * 5

Table 7.24: Divertible Percentage from Alternate Route

Vehicle	STRR
Car	14.0%
Bus	6.4%
LCV	12.2%
2 AT	14.6%
3 AT	5.8%
MAV	5.8%

For the convenience of study above, percentage applied to all the homogenous section of the project road. 10% of I-I trips, 70% of I-E, E-I trips and 100 % E-E trips are consider as potential divertible traffic on the project road. 10% of non-toll able vehicles are assigned to take STRR due to absence of OD data.

Further to diversion, traffic from competing routes northeast side of STRR is also develop. This will further reduce diverted traffic southwest part of STRR.

Based on diversion analysis and various OD pair analysis following are the traffic plying on various homogenous section of STRR.

Table 7.25: Diversion Traffic from Alternate Route

	STRR										
	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV	2 W	3 W	Total	PCU
HS 1	1994	16	119	149	197	120	174	541	94	3404	4695
HS 2	2194	17	107	135	177	132	191	487	104	3543	4876
HS 3	2413	19	96	121	160	145	210	438	114	3716	5104
HS 4	2123	27	169	450	340	164	209	395	45	3921	6040
HS 5	2235	28	188	409	309	172	216	355	46	3958	6092
HS 6	2352	30	208	372	281	181	222	320	48	4015	6176
HS 7	1510	47	223	407	363	234	304	320	48	3455	6225

1.7.3 Traffic Assignment

Based on diverted traffic and existing traffic following table give total traffic on various homogenous section of STRR for both scenarios.

Table 7.26: Total Traffic on Homogenous Section

STRR											
	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV	2 W	3 W	Total	PCU
HS 1	2628	27	161	213	265	178	234	1913	170	5789	6978
HS 2	2828	28	149	199	245	190	251	1859	180	5928	7159
HS 3	3047	30	138	185	228	203	270	1810	190	6101	7387
HS 4	3125	44	286	489	358	177	212	4205	208	9103	9651
HS 5	3237	45	305	448	327	185	219	4165	209	9140	9704
HS 6	3354	47	325	411	299	194	225	4130	211	9197	9787
HS 7	2512	64	340	446	381	247	307	4130	211	8637	9836

7.8 INDUCED TRAFFIC

Induced traffic consists of trips that people 'wanted' to make but did not due to the lack of desired infrastructure or trips that people now 'want' to make because of the availability of desired infrastructure. For present study, 5% additional trip is consider to be induced after introduction of STRR in a ratio of 30%, 40%, and 30% for the year 2021, 2022, and 2023 respectively. Further, in 2021 due to Mangalore Port upgradation further 15 % in commercial and 5% in passenger traffic will be induce in HS1, HS2 and HS3.

7.9 ESTIMATION OF TRAFFIC GROWTH RATES

This section presents the data and results for the estimation of traffic growth rates.

7.9.1 Past Vehicle Registration Details

Vehicle registrations in the state of Karnataka used to calculate traffic growth on the project locations. **Table 7.27** give the time series data of vehicle registration of Karnataka.

Table 7.27: Vehicle Registration Data of Karnataka

	2011	2012	2013	2014	2015
Two Wheeler	7033045	7737366	8575104	9533892	10644368
3 Wheeler	209967	233063	258701	294266	331381
Car	985736	1151566	1420767	1572521	1741831
Mini Bus + Bus	58012	62501	69718	75529	80911
LCV	121089	136830	154619	180768	208002
2,3 Axle Truck	169945	183540	198224	206973	215027
MAV	42365	45754	49415	54016	59944

Source: Road Transport Year Book 2016.

7.9.2 Past Growth of the Economy

Table 7.28 shows the historical annual data for NSDP and PCI for the state of Karnataka. These are indicators of economic activity in the region. Generally, PCI indicates the lifestyle growth of population while NSDP indicates the growth of commercial/industrial areas.

Table 7.28: Economic Data of Karnataka

Per Capita Income				
2011	2012	2013	2014	2015
83806	89899	94082	102519	108908
Net State Domestic Product				
2011	2012	2013	2014	2015
247590	272721	282784	298241	314356

Source: des.kar.nic.in

7.9.3 Projected Traffic Growth Rates

Annual growth rates were estimated separately for each vehicle type (car, bus, LCV, 2-axle trucks, 3-axle trucks, multi axle trucks based for the following Elasticity Values and corresponding future year growth rate estimates:

1. NSDP elasticity values based on vehicle registration data for commercial vehicle.
2. PCI elasticity values based on vehicle registration data for passenger vehicle.

Following table gives the traffic growth rate derived for various vehicles upto year 2052.

Table 7.29: Traffic Growth Rate Estimate

	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV	2 W	3 W
Elasticity	1.57	1.29	0.815	1.43	1.03	1.03	1.47	1.58	1.74
2017 - 2020	10.2%	6.3%	6.3%	9.4%	7.1%	7.1%	8.7%	10.2%	11.3%
2021 - 2025	10.0%	6.2%	6.2%	9.1%	6.8%	6.8%	8.3%	10.1%	11.1%

	Car	Mini Bus	Bus	LCV	2 AT	3 AT	MAV	2 W	3 W
2026 - 2030	9.9%	6.1%	6.1%	8.7%	6.6%	6.6%	8.0%	9.9%	11.0%
2031 - 2035	9.7%	6.1%	6.1%	8.4%	6.3%	6.3%	7.6%	9.8%	10.8%
2036 - 2040	9.6%	6.0%	6.0%	8.1%	6.1%	6.1%	7.3%	9.6%	10.6%
2041 - 2045	9.4%	5.9%	5.9%	7.7%	5.9%	5.9%	6.9%	9.5%	10.5%
2046 - 2050	9.3%	5.8%	5.8%	7.4%	5.6%	5.6%	6.6%	9.3%	10.3%
2051- 2052	9.1%	5.7%	5.7%	6.1%	5.4%	5.4%	6.2%	9.2%	10.1%

7.10 DIVERTED AND INDUCED TRAFFIC FORECAST

Table 7.30 provides the forecasted expressway traffic for each vehicle type based on the methodology and data presented in this report.

Table 7.30: Traffic Forecast for STRR

STRR														
	HS 1		HS 2		HS 3		HS 4		HS 5		HS 6		HS 7	
	ADT	PCU	ADT	PCU	ADT	PCU	ADT	PCU	ADT	PCU	ADT	PCU	ADT	PCU
2021	11351	13837	11634	14210	12087	14780	17083	17762	17811	18518	17260	18015	15845	17671
2025	23538	27766	24136	28555	25100	29757	36014	36610	38201	38854	36395	37143	32566	35424
2030	37071	42326	38042	43604	39613	45548	56909	56090	60422	59693	57533	56944	51249	53731
2035	58075	64225	59637	66272	62177	69385	89426	85571	95033	91322	90448	86948	80232	81159
2040	90486	97019	92981	100264	97057	105209	139728	129993	148621	139118	141398	132213	124938	122081
2045	140217	145928	144168	151022	150666	158816	217072	196638	231085	211024	219791	200213	193506	182896
2050	216085	218581	222294	226509	232582	238707	335280	296197	357213	318730	339679	301933	298066	272931

7.11 CAPACITY AND LEVEL OF SERVICE ANALYSIS

Capacity analysis for the project corridor 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 adopted for determining the Level of Service offered by road sections during the design period. The capacity and design service volumes for various lane configurations in case of plain terrain presented below.

Table 7.31: Design Service Volume

Lanes	(PCU/Day) LOS B	(PCU/Day) LOS C
4 Lane	40000	60000
6 Lane		120000

The Consultants have attempted to assess upgradation requirement to the existing road based on the projected traffic in horizon years. Comparison of projected traffic with the DSV indicates the following upgradation requirement show in **Table 7.32.**

Table 7.32: Assessment of Upgradation Requirement

Homogenous Section	4 to 6 Lane (LOS B)	6 to 8 Lane
HS 1	2029	2042
HS 2	2028	2042
HS 3	2028	2041
HS 4	2025	2040
HS 5	2025	2038
HS 6	2025	2039
HS 7	2026	2040

7.12 RECOMMENDATION & CONCLUSION

The proposed STRR newly declared NH 948A road is about 180km road and falling about 134.331km length in Bangalore Rural, Bangalore Urban and Ramanagara districts of Karnataka state and the balance portion of 45.331km length pass through Hosur town of Krishnagiri district of Tamil Nadu state.

A comprehensive set of traffic surveys conducted along the project road. The traffic surveys included classified traffic volume counts, OD surveys, and axle load surveys. The project road divided in 7 homogeneous sections. Traffic volume count conducted at all thirteen locations shows variations in term of ADT and PCU from 4,903 to 137,418 and 3,517 to 140,565 respectively. The base year count and its projection to future year show, that homogenous section HS4, HS5 and HS6, HS7 of STRR need to developed as six lane immediately. Other three sections HS1, HS2, and HS 3 require six lanes in later part of next decade as per analysis.

In order to ensure safe, smooth, efficient, and high-speed transport corridor to Bangalore city, it is impetus that the infrastructure of city and adjoining towns anticipated the development. National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of this traffic are not intend to pass through the Bangalore city. Hosur is an automobile industry town located near about 7km away from Karnataka state border. This city generates huge amount of through traffic and currently experiencing massive traffic congestion

Therefore, in order to maintain smooth and uninterrupted flow of traffic to Bangalore and Hosur cities it recommended developing a six lane Satellite Town Ring Road to the entire corridor of 180km length.

Chapter-8 :

Environmental Screening and Preliminary Environmental Assessment

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CHAPTER-8: ENVIRONMENTAL SCREENING AND PRELIMINARY ENVIRONMENTAL ASSESSMENT

8.1 INTRODUCTION, OBJECTIVE AND LEGAL FRAMEWORK

8.1.1 Introduction

The National Highways Authority of India (NHAI) has been entrusted with the assignment of preparation of Detailed Project Report for Development of Economic Corridors, Inter Corridors, Feeder Routes to improve the efficiency of freight movement in India under Bharatmala Pariyojana - Lot 3/ Andhra Pradesh, Karnataka, GOA & Kerala /Package 1.

The proposed project road of west side STRR, starts from NH 207 (at km 131.250) in Dobbaspet and terminates near Bagalur in Tamil Nadu/Karnataka border. The STRR alignment is totally a Greenfield alignment totalling the length of 179.969km. The alignment passes through Bangalore Rural, Bangalore Urban and Ramanagara districts of Karnataka state and Krishnagiri district of Tamil Nadu state.

The road passes through several habitat areas viz. Dabaspet. Banawadi, Gudemaranahalli, Rangenahalli, Magadi, Attimgere, Melehalli, Ramanagara, Kunagal, Kanakapura, Banavasi, Indalawadi, Anekal, Perandapalli, Devaripalli, Kalkunte Agrahara.

8.1.2 Objective of Environmental Screening and Preliminary Environmental Assessment

Environmental Screening study determines the environmental sensitivity of the project road that in turn helps the level of planning in terms of time, budget and effort required to take up the particular project for development.

Environmental Screening and Preliminary Environmental Assessment of the study area has the following major objectives:

- To identify the potential environmental impacts;
- To categorize the project;
- To ensure that environmental considerations are given adequate weightage for carrying out proposed road improvement;
- Policy, legal and institutional issues for planning and for getting all approvals and for implementation of Environmental Management Plan during Design, Construction and Operational phases; and
- Scoping and future course of work for Environmental Impact Assessment Study

The preliminary environmental assessment for the proposed STRR subproject undertaken as a parallel exercise with the Engineering Analysis, to bring out the environmental concerns in planning and the proposed design.

8.1.3 Applicable Environmental Acts and Guidelines

Environmental regulations and legislations relevant to this project, along with their competent authority for implementation presented in **Table 8.1**.

Table 8.1: Summary of Relevant Environmental Acts and Guidelines

Sl. No	Act/Rules	Year	Objective	Applicable Yes/No	Reason for applicability	Authority
1.	Environmental (Protection) Act	1986	To protect and improve overall environment	Yes	As all environmental notifications, rules and schedules are issued under this act	MoEFCC, GoI, Forest, Ecology & Environment Department, GoK, CPCB, KSPCB
2.	Environmental Impact Assessment (EIA) Notification	2006	To provide environmental clearance to new development activities following environmental impact assessment	Yes	STRR subproject being a green filed alignment attracts the conditions of EIA Notification 2006 and further amendments	MoEFCC, SEIAA
3.	Forest (Conservation) Act	1980	To check deforestation by restricting conversion of forested areas into non- forested areas	Yes	Reserved and Protected Forest along the STRR alignment to be avoid. Deemed Forests patches shall assessed later.	Forest Department, GoK, GoTN, MoEFCC
4.	Water (Prevention and Control of Pollution) Act and cess Act of 1977 as amended in 1988	1974	To control water pollution by controlling emission & Water pollutants as per the prescribed standards	Yes	This act will be applicable during construction, for establishments of hot mix plant, stone crusher, Batching and WMM Plants, construction camp, workers' camp, etc.	KSPCB & TNPCB
5.	Air (Prevention and Control of Pollution) Act as amended in 1987	1981	To control air pollution by controlling emission and air pollutants according to prescribed standards	Yes	This act will be applicable during construction; for obtaining NOC for establishment of hot mix plant, stone crusher, Batching and WMM Plants, workers' camp, , construction camp, etc.	KSPCB & TNPCB

Sl. No	Act/Rules	Year	Objective	Applicable Yes/No	Reason for applicability	Authority
6.	Noise Pollution (Regulation and Control) rules	2000	Noise pollution regulation and controls	Yes	This act will be applicable as vehicular noise on proposed STRR route alignment required assessing for future years and necessary protection measure need to be consider in design.	
7.	Karnataka & TN ground water (regulation and control of development and management) act	2011	Conservation of ground water and for the regulation and control of its extraction and use in the State of Karnataka	Yes	This act will be applicable during construction for extraction of use of groundwater	Karnataka & TN Ground water Authority
8.	The Ancient Monuments And Archaeological Sites And Remains (Amendment And Validation) Act	2010	Conservation of Cultural and Historical remains found in India	No	The proposed STRR route alignment is not close to any Ancient Monument, declared protected under the act.	Archaeological Survey of India (ASI), GoI, Department of Archaeology, Museums and Heritage, Karnataka, Tamil Nadu, Indian Heritage Society and Indian National Trust for Art and Culture Heritage (INTACH).
9.	Notification for use of fly ash	2016	Promoting the utilization of fly ash in the manufacture of building materials and in construction activity within a specified radius of 300 kilometers from coal or lignite based thermal power plants	Yes	KPCL Bidadi power corporation Pvt. Ltd., Jindal Thermal Power Company Limited, Hassan Thermal Power Limited, Karnataka Power Corporation Ltd. Karnataka are located within 300 km.	MoEFCC

Sl. No	Act/Rules	Year	Objective	Applicable Yes/No	Reason for applicability	Authority
10.	The Explosives Act (& Rules)	1884	An Act to regulate the manufacture, possession, use, sale, transport, import and export of Explosives	Yes	For transporting and storing diesel, bitumen etc.	KSPCB & TNPCB
11.	Public Liability Insurance Act	1991	Insurance for the purpose of providing immediate relief to the persons affected by accident occurring while handling any hazardous substance and for matters connected therewith or incidental thereto	Yes	Contractor need to stock hazardous material like diesel, Bitumen, Emulsions etc. safely	KSPCB & TNPCB
12.	Coastal Regulation Zone	2011	To regulate activities in the coastal zone to protect ecologically sensitive areas	No	The proposed STRR alignment does not passes through CRZ areas	MoEFCC
13.	Hazardous and Other Wastes (Management and Transboundary Movement) Rules	2016	Storage, handling, transportation and disposal of hazardous waste	Yes	Storage and handling of hazardous waste during construction	KSPCB & TNPCB
14.	Solid Waste Management Rules	2016	Management and handling of solid waste	Yes	For disposal of solid waste generated during construction	KSPCB & TNPCB
15.	Construction and Demolition Waste Management Rules	2016	Management of construction and demolition waste	Yes	For disposal of solid waste generated due to construction and demolition	KSPCB & TNPCB
16.	Batteries (Management & Handling) Amendment Rules	2010	Management and handling of used lead batteries	Yes	Safe disposal of used lead batteries	KSPCB & TNPCB

Sl. No	Act/Rules	Year	Objective	Applicable Yes/No	Reason for applicability	Authority
17.	E-Waste (Management) Rules	2016	Effective mechanism to regulate generation, collection, storage, transport, import, export, recycling, treatment and disposal of e-wastes	Yes	Handling of e-waste	KSPCB & TNPCB
18.	Central Motor Vehicles Act	1988	To control vehicular air and noise pollution.	Yes	This rule will be applicable to road users and construction machinery	Motor Vehicle Department
19.	Minor Mineral and concession Rules	1960	For opening new quarry	Yes	Regulate use of minor minerals like stone, soil, river sand etc.	District Collector
20.	The Mining Act	1952	The mining act has been notified for safe and sound mining activity	Yes	The construction of project road will require aggregates. These will be procured through mining from quarries	Department of mining, GoK
21.	National Forest Policy(Revised)	1988	To maintain ecological stability through preservation and restoration of biological diversity	No	The proposed STRR alignment crosses Bannerghatta National Park.	Forest Department, GoI, GoK, GoTN
22.	The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act	2013	Set out rules for fair compensation and acquisition of land	Yes	STRR being a green field alignment, hence this act will be applicable as there will be acquisition of land.	Revenue Department State Government
23.	The National Highways Act	1956	For Land Acquisition	Yes	This act will be applicable as there will be acquisition of land for STRR alignment.	NHAI Revenue Department, GoK

8.2 BASELINE ENVIRONMENTAL SETUP

8.2.1 Study Area

The study area for the environmental screening categorized in two influence areas:

i. Direct influence area: PROW of the STRR alignment i.e. 70m

ii. Indirect influence area: 10km around the project road

Sensitive environmental components along the corridor of impact recorded during reconnaissance survey. Those were, trees along the alignment, water bodies, public utilities, religious structures, hospitals/health centers, community resources etc.

Secondary data collected on physiography, land use pattern, soil & geology, seismicity, meteorology, demography and related other environmental aspects.

8.2.2 Physiography

The STRR alignment starts from starts from NH 207 near Dabaspet (Latitude: 13°15'07.09" & Longitude: 77°18'42.11") and ends in NH 44 (Latitude: 12°51'16.02" & Longitude: 77°48'31.88"). The entire corridor length of road is passing through rolling and hilly terrain. The land use by the side of the corridor includes agriculture activities, residential use, and commercial purpose. The altitude varies between 640 m and 950 m above mean sea level. The physiography of the project districts and physiographical map of Karnataka state (**Figure 8.1**) Tamil Nadu state (**Figure 8.2**) showing the project area is as follows:

<u>Karnataka:</u>

Bangalore Rural District,

Ramanagara District

Bangalore Urban District

Physiographical, the project area can be divided in to rocky upland, plateau and flat-topped hills at an elevation of about 900 m average mean sea level

The major part of project area sloping towards south and south east forming Pedi plain interspersed with hills. The Pedi plains form the major part underlain by granites and gneisses with the highest elevation of 850 to 950m average mean sea level

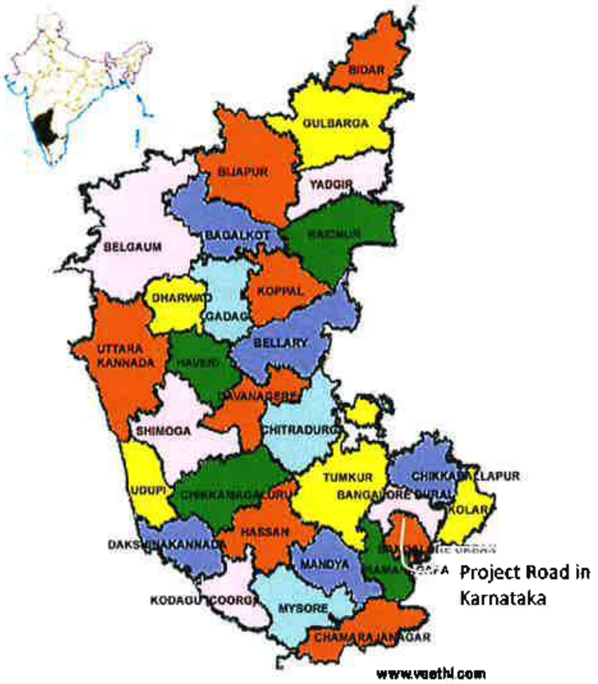


Figure 8.1: Physical Map of Karnataka showing Project Area

Tamil Nadu

Krishnagiri District,

The district forms part of the upland plateau region with many hill ranges and undulating plains. The western part of the district has hill ranges of Mysore plateau with a chain of undulating hills and deep valleys extending in NNE-SSW direction. The plains of the district have an average elevation of 488m average mean sea level. The plateau region along the western boundary and the northwest part of the district has an average elevation of 914m average mean sea level. The Guthrayan Durg with an elevation of 139 m average mean sea level is the highest peak in the district.

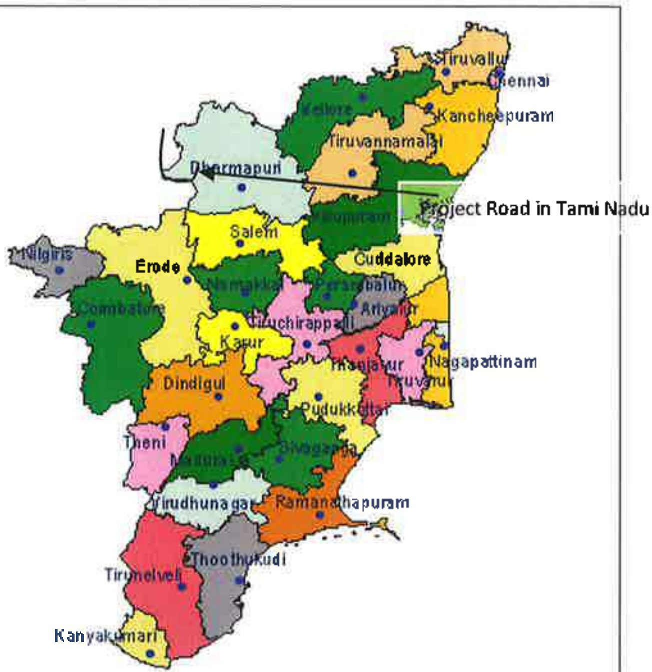


Figure 8.2: Physical Map of Tamil Nadu showing Project Area

As evident from the above information and map, the project road passes through northern high land to southern low land of district.

8.2.3 Geology & Soil

The prevailing rock of these districts is a light to dark-grey or whitish biotic granite gneiss, which varies considerably from place to place, in texture, structure and appearance, according to the fitness or coarseness of its constituent grains and the relative abundance or scarcity, and mode of deposition of the darker Ferro-minerals. These complex Gneissic masses have been styled as "Peninsular Gneiss".

The soil in the valleys is good and loamy and is form of finer particles of the decomposed rocks. The soil on the higher grounds is gravelly and reddish in colour.

8.2.4 Seismicity

According to 2014 seismic zoning map of India, the state of Karnataka and Tamil Nadu falls in Zone II & III, least active zone and moderate active zone of seismic hazard respectively (**Figure 8.3**). The coastal districts as well as the northern interior districts of Karnataka along the border with Maharashtra and parts of Thiruvallur, Thiruvannamalai, Salem districts of Tamil Nadu, lie in Zone III, rest part of state falls in zone II. The STRR corridor falls in Zone II. This zone classified as Low Damage Risk zone, which is liable to MSK VI.

In addition, as per Global Seismic Hazards Assessment Program (GSHAP) data (**Figure 8.4**) the state of the Karnataka & Tamil Nadu falls in a region of low to moderate seismic hazard. The project road falls in low to moderate hazard zone.

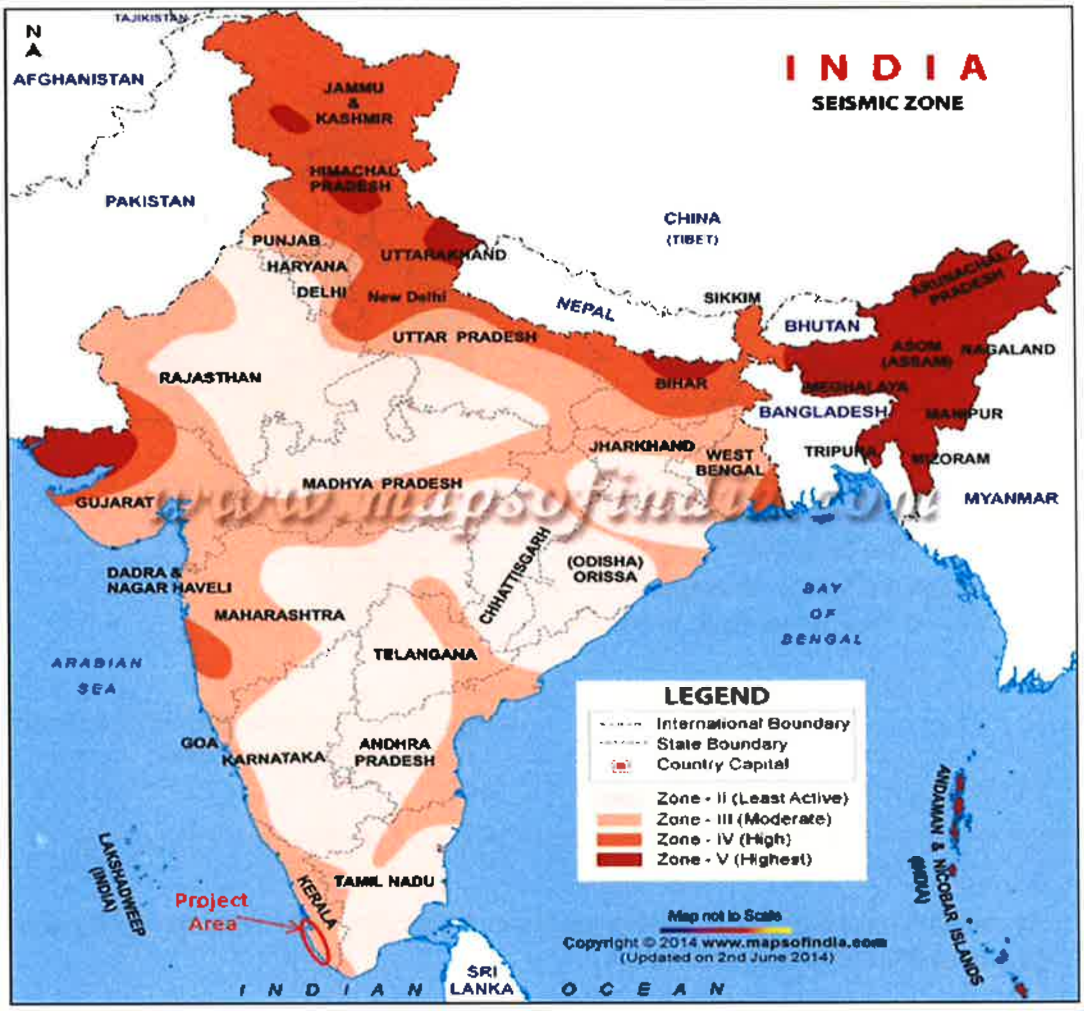


Figure 8.3: Seismic Zonation Map of India

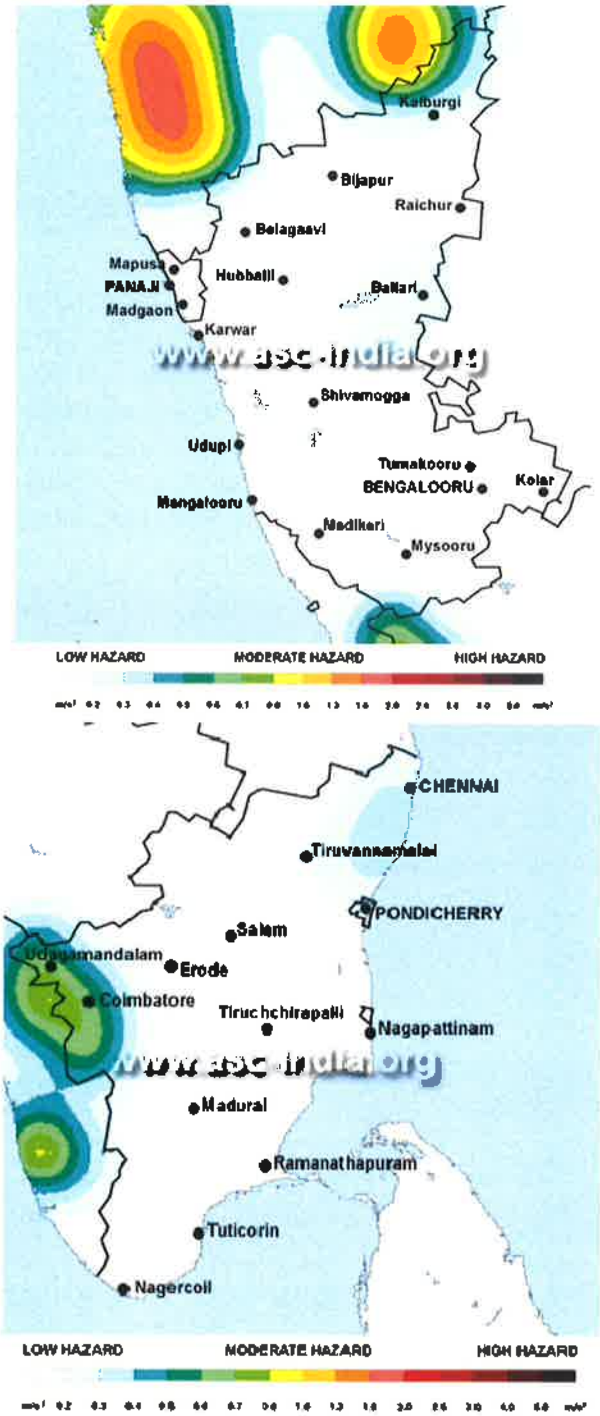


Figure 8.4: Seismic Zone Map of Karnataka & Tamil Nadu (GSHAP)

8.2.5 Climate and Meteorology

Climate

The State enjoys three main types of climates. For meteorological purposes, the State has divided into three sub-divisions namely (a) Coastal Karnataka (b) North Interior Karnataka and (c) South Interior Karnataka.

The Tropical Monsoon climate covers the entire coastal belt and adjoining areas. The climate in this region is hot with excessive rainfall during the monsoon season i.e., June to September. The Southern half of the State experiences hot, seasonally dry tropical savanna climate while most of the northern half experiences hot, semi-arid, tropical steppe type of climate.

The climate of the State varies with the seasons. The winter season from January to February followed by summer season from March to May. The period from October to December forms the post-monsoon season.

The period from October to March, covering the post-monsoon and winter seasons, is generally pleasant over the entire State except during a few spells of rain associated with northeast monsoon, which affects the southeastern parts of the State during October to December. The months April and May are hot, very dry and generally uncomfortable. Weather tends to be oppressive during June due to high humidity and temperature. The next three months (July, August and September) are somewhat comfortable due to reduced day temperature although the humidity continue to be very high. The climate of project districts is generally dry throughout the year, except during the southwest monsoon.

Rainfall

The annual rainfall in the State varies roughly from 50 to 350cm. The rainfall increases significantly in the western part of the State and reaches its maximum over the coastal belt. The south-west monsoon is the principal rainy season during which the State receives 80% of its rainfall. The monthly rainfall data of project districts in last 5 years provided in following **Table 8.2 (a) to 8.2 (d)**.

Table 8.2 (a): Rainfall in Bangalore Rural District (Karnataka) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0	0	0	19	8.9
February	0	6.9	0.1	0	0
March	4.3	2.3	19.6	28.4	17.6
April	57.7	38.9	11	112	2.3
May	108.2	119.6	92.5	162.1	146.8
June	20.4	81.5	61.4	107.5	141.3
July	73.2	83.7	90.1	55.8	226.6
August	138.3	75.8	162.6	99.9	32.3
September	47.6	268.5	202.3	238.2	48.8
October	79.6	130.7	267.2	78.8	51.6
November	106.8	59.8	35.4	189.4	9.1
December	14.4	5.1	3.9	11.2	68.7
Average	**650.5**	**872.8**	**946.1**	**1102.3**	**754**

Source: India Meteorological Department (IMD)

Table 8.2 (b): Rainfall in Ramanagara District (Karnataka) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0	0	0	1.5	2.2
February	0	1	0.3	0	0
March	0	6.6	46.4	17.2	0.2
April	65.8	61.7	32.4	139.5	3.8
May	60	87.5	88.8	161.3	113.4
June	10	90.7	91	80.2	72.9
July	76.1	48.6	32.5	28.8	184.6
August	85.3	112.8	111.4	136	70.7
September	42.9	263.7	186.3	226.8	29.2
October	89	88	189.2	81.1	49.9
November	96.7	32.9	26.9	196.5	7.6
December	14.3	5.5	5.1	2.9	57.5
Average	**540.1**	**799**	**810.3**	**1071.8**	**592**

Source: India Meteorological Department (IMD)

Table 8.2 (c): Rainfall in Bangalore Urban District (Karnataka) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0.1	0	0	7.7	4.9
February	0	4	0.1	0	0
March	0.6	2.6	12.9	21.8	18.2
April	21.1	28.9	7.2	131.4	6.2
May	108.1	110.1	83.2	124.4	132.3
June	9.2	93.1	93.7	80.4	164
July	63.7	76.2	80.6	71.7	187.9
August	130.5	72.6	118.1	102	45.1
September	41.3	249.3	181.8	190.7	48.1
October	60	95.5	247.3	109.4	31.7
November	100.6	63.3	27.8	231.2	2.9
December	17.2	1.4	2	4	73.3
Average	**552.4**	**797**	**854.7**	**1074.7**	**714.6**

Source: India Meteorological Department (IMD)

Table 8.2 (d): Rainfall in Krishnagiri District (Tamil Nadu) in mm (2012-2016)

Month	Bangalore Rural				
	2012	2013	2014	2015	2016
January	0	0	0	-	0.2
February	0	7.2	1.7	-	0
March	4.9	1.2	7.7	-	1.9
April	40.5	39.1	6.5	-	3.8
May	107.2	105.1	189.6	-	144.4
June	13	47.2	77.1	-	87

Month	**Bangalore Rural**				
	2012	**2013**	**2014**	**2015**	**2016**
July	85.3	22.4	39.6	-	185.5
August	98.9	95.7	71.1	-	49.1
September	45.3	212.9	84.8	-	5.2
October	196.5	143.6	213.1	-	34.7
November	78.7	83.7	33.5	-	8.5
December	24.8	7.9	32.9	-	76.9
Average	**695.1**	**766**	**757.6**	**-**	**597.2**

Source: India Meteorological Department (IMD)

Humidity

Relative humidity is high during the period from June to December, being between 85-90% on the average. Humidity decreases thereafter and in the period from February to April, the air is comparatively drier, relative humidity in the afternoon being 25-35%. The relative humidity increases from May and has a large diurnal Range. The maximum is at 6 AM and the minimum is at 3 PM. Relative humidity is as low as 8.3% during the afternoons of March and as high as 100% during the rains and late nights and early morning hours from October to February when dew deposits and fog mist occur.

Temperature

The region fall in eastern dry zone of state where the climate is drier in the major parts of the districts. The year may be divide into four season. The period from January to March is dry season; April and May are summer season. This followed by southwest monsoon season from June to Sept. and northeast monsoon season from October to December. During summer season (April to May); the maximum temperature is about 37°C, and the mean daily minimum temperature of about 25°C in the plains. In Dec, the mean daily maximum temperature is about 30°C and the mean daily min. is about 19°C in plains. The climate of Krishnagiri district is comparatively more pleasant than that of the surrounding districts due to general dryness of atmosphere and appreciable drop in temperature in the monsoon season.

8.2.6 Land Use Pattern

Land use pattern along the project road is predominantly agricultural area followed by built-up areas. The land use by the side of this road includes agriculture activities, residential use, and commercial purposes. The establishments on both sides of the road are in general are outside the available ROW. However, some built-up stretches also noticed at some location.

Representative photographs of the Project road sections indicated below:

near 0.700
43P 743042 1462431

Project Start Road (Km. 0.700)

mazar
43P 743302 1436627

Religious Structures falling adjacent to proposed alignment (Km. 14.366)

near km 27500
43P 743175 1438654

Existing road condition of SH-3 (Km 27.500)

savandurgq forest 37800
43P 746817 1428291

Savanadurga Forest (Km 37.800)

near 49400
43P 747787 1418110

Plantation along the greenfield alignment

(Km 49.400)

BNP point
43P 778400 1417766

Entry Point of Bannerghatta National Park

(Km 141.77)

forest near 107500
43P 779884 1403131

Karadikkal – Madeswara Elephant Corridor along the existing road (Km 107.500)

at Anekal atebili rd
43P 796512 1409398

Road Site Plantation along the Road

(Km 140.93)

8.2.7 Water Resources

All the project area district are part of Cauvery basin drained by its two major tributaries the Arkavati and the Vrishabhawati Rivers. The study area falls under Arkavati River near Madnagar village. A large number of people depend on these water resources for their livelihood through agriculture. The list of water bodies crossing the project road given below in **Table 8.3**:

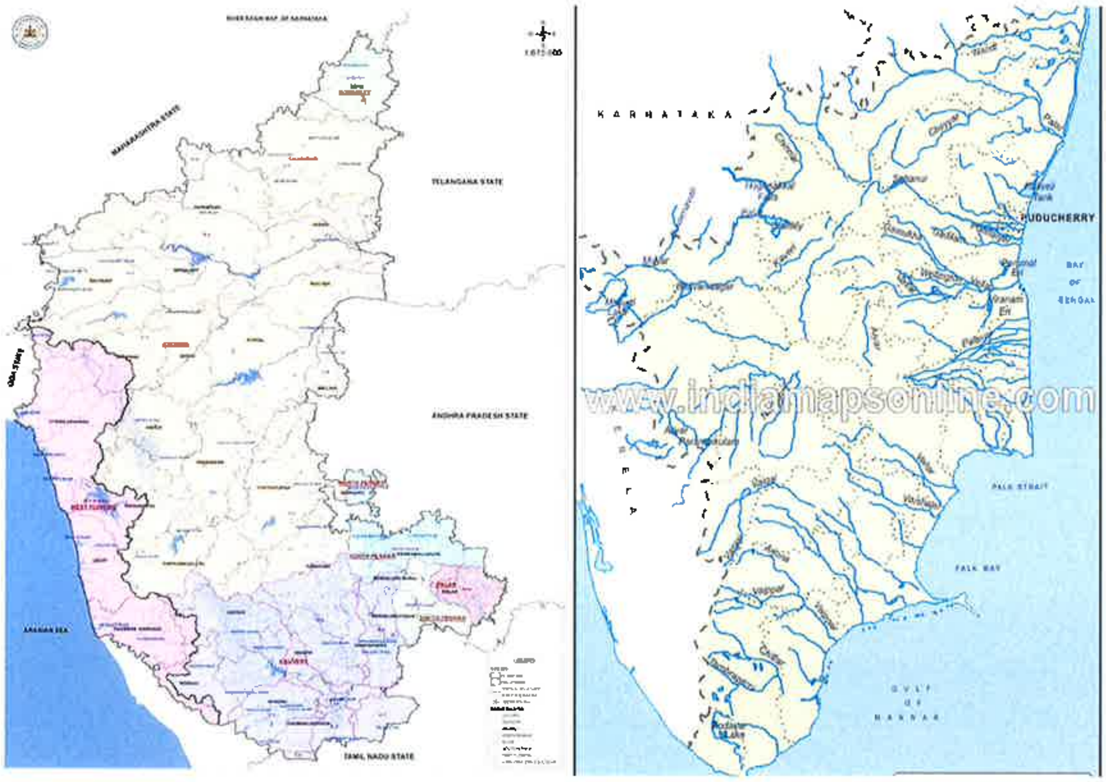
Table 8.3: Water Bodies crossing the project road

Sl. No.	Chainage (Km)	River/Canal/ Nallah/Lake
1.	68+100	Arkavati River
2.	79+300	
3.	95+400	

Source: Primary Survey, July 2017

Rivers:

The River Arkavathi, Kanva, Dakshina Pinakini are the main rivers of the project districts. They flow in the general direction from north to south. The river Arkavathi flowing north to south entering the Division in Magadi taluk and forms several large tanks at Manchanabele which passes through Ramanagara taluk and then merge with Cauvery River at Sangam in Kanakapura taluk. Apart from these prominent rivers, there are other semi-perennial rivulets, which are mostly tributaries to these rivers. Number of coconut gardens found on the lower parts of the river where the soil is well suited for the purpose. The drainage pattern in the area can be describe as semi dendritic to dendritic. The river basin maps of Karnataka and Tamil Nadu given below in **Fig 8.5**.



Source: Karnataka & Tamil Nadu Water Resources Department

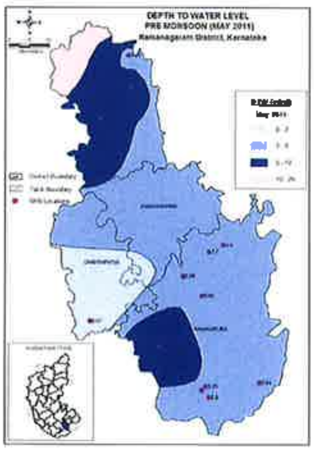
Figure 8.5: River Basin Map of Karnataka and Tamil Nadu

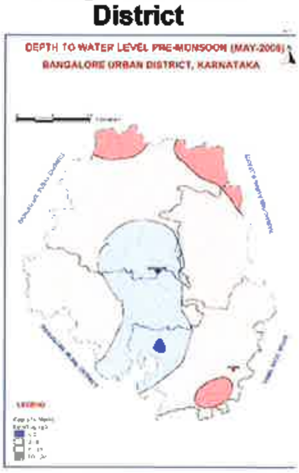
Ground Water:

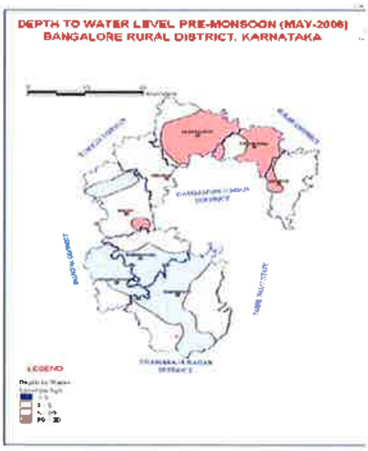
Ground water occurs in weathered and jointed zones of gneisses, granites, Charnokite, and alluvium along river courses in unconfined or water table conditions where as it occurs in semi confined to confined conditions in fractured formations at deeper depths.

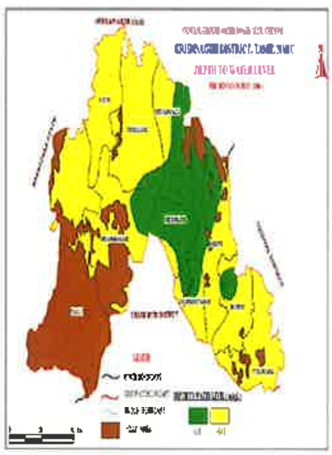
The thickness of weathering in major part of the district ranges from 5-10m and more than 10m in rest of the district. Unconfined aquifer system taped by dug wells and shallow bore wells. This zone extends down to 25mbgl. Pre and Post Monsoon trends of Water level in all the project districts given below under **Fig 8.6**

Ramanagara District	Bangalore Urban District	Bangalore Rural District	Krishnagiri District



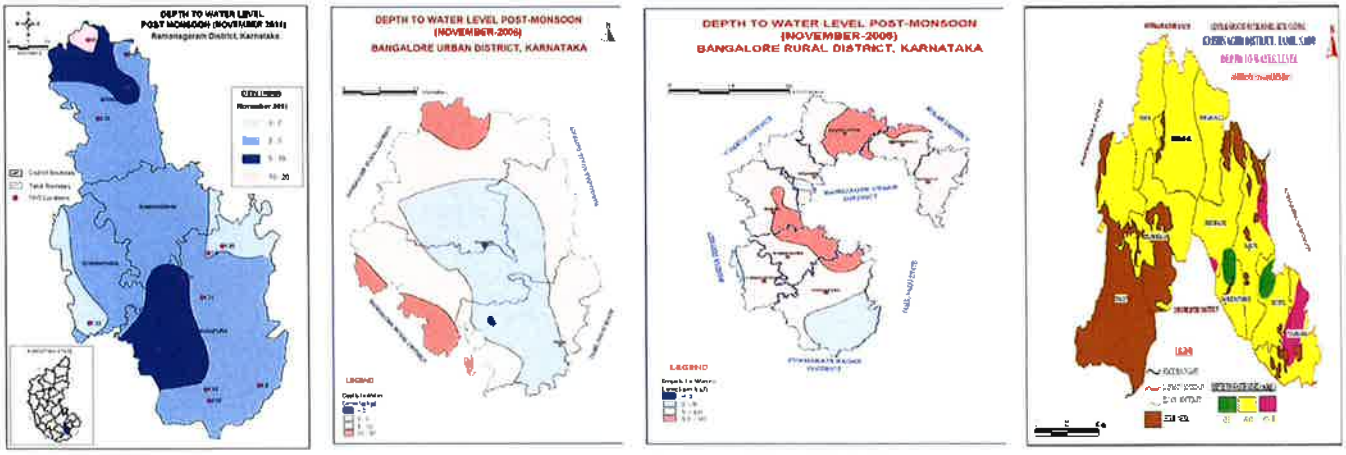






Pre-Monsoonal Ground Water Level

Ramanagara District	Bangalore Urban District	Bangalore Rural District	Krishnagiri District



Post-Monsoon Ground Water Level

Source: Ground Water Information Booklet of project districts, Central Ground Water Board, Government of India

Figure 8.6: Water level trend in project districts

8.2.8 Ecological Environment

a) **Forest Cover:** The recorded forest area of the Karnataka state is 191,791 sq. km., which constitutes 18.99% of its geographical area whereas recorded forest area of the Tamil Nadu state is 130,058 sq. km., which constitutes 20.226% of its geographical area. The forest cover in project districts presented in **Table 8.4** and the forest cover map with marked project area presented in **Figure 8.7.**

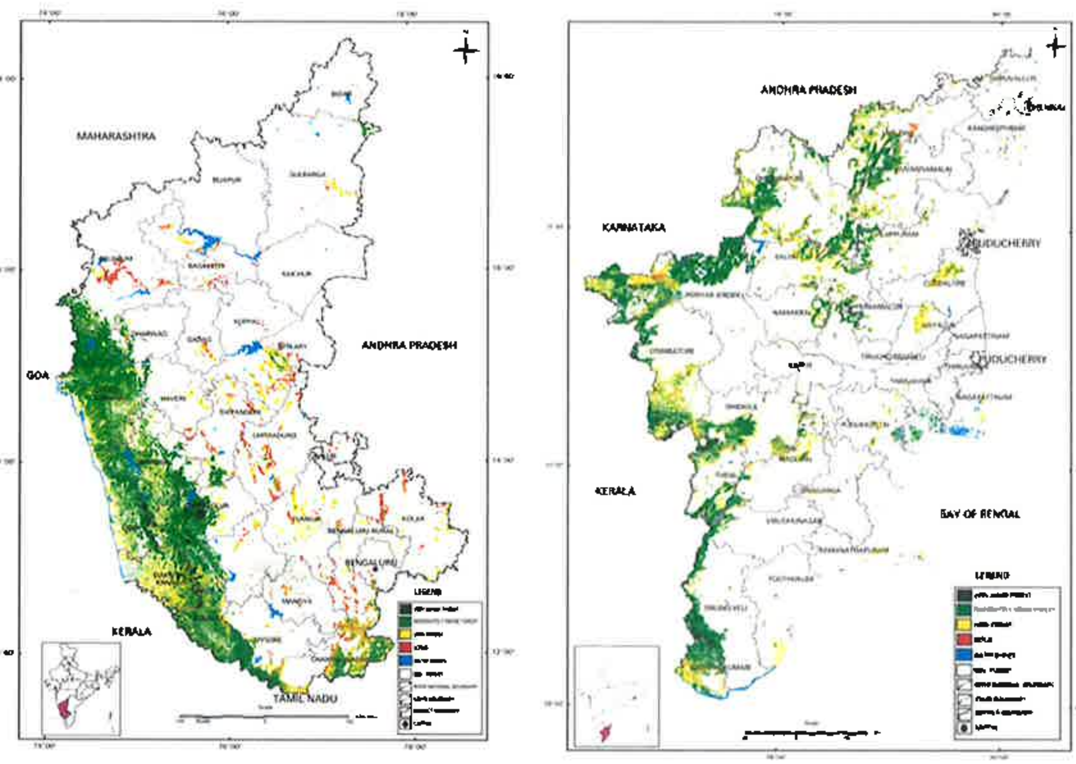
Table 8.4: Forest Cover in the Project Districts (km^2)

District	Geographical Area (GA)	VDF	MDF	OF	Total	% of GA
Bengaluru Rural	5,815	7	122	690	819	14.08
Bengaluru Urban	2,190	0	26	94	120	5.48
Karnataka State	**191,791**	**1,781**	**20,063**	**14,577**	**36,421**	**18.99**
Tamil Nadu State	**130,058**	**2,993**	**10,469**	**12,883**	**26,345**	**20.226**

Source: India State of Forest Report, 2015

VDF: Very Dense Forest, MDF: Moderately Dense Forest, OF: Open Forest

Above information shows that the Bengaluru Urban district has minimal forest cover. Also, the percentage of forest cover in the project districts is less than the Karnataka and Tamil Nadu State.



Source: India State of Forest Report, 2015

Figure 8.7: Forest cover map of Karnataka and Tamil Nadu

b) Flora

The major ecological component in the project corridor is represent by the roadside vegetation all along the stretch varying in densities and composition.

All the project districts majorly possess dry deciduous forest. The forests of Ramanagara forest division primarily consists of deciduous species topping thorny undergrowth. The main forest types of Bangalore Urban Division are Dry deciduous and scrub jungle with Eucalyptus and Acacia plantations. In Bangalore Urban District, forest lands proposed for deemed forest consists of thick growth of forests and has all the characteristics of forests.

Bangalore rural forest division is divide into four territorial ranges with a multitude of Reserve Forests, Plantations, Reserves and protected forests lying scattered all over the division. As the number of Reserve Forests is very high and these are lying scattered all over the division, the total length of the boundaries to be maintain is very high. Lack of maintenance of the forest boundaries has resulted in number of petty to serious encroachments.

The trees rarely attain any great size. Due to scanty rainfall, the growth is very less. Most of the species found in this area are valuable only as firewood except Wrightia tinctoria (Hale) and Santanum album (Sandalwood). *Santalam album* found almost throughout the forests division. Trees of *Terminalia paniculata* (Hunalu) *Dalbergia latifolia* (Beete), *Pterocarpus marsupium* (Honne), *Hardwickia binata* (Karacha), *Vitex altissima* (Lakki) etc. found in reserve forests. Several pure patches of Shorea talura occur in some reserve forests where the soil is clayey in nature (Savanadurga, Siddadevarabetta and Ramadevarabetta areas) No valuable timber species occur in the Division in workable quantities. However, most of them species are unfit to be use as Timber in the traditional sense. However, Sandalwood and bamboo found in good quantities over considerable areas of the Division. The forests under division developed to its natural equilibrium with climate and soil.

c) Fauna

The district forest have significant areas that are ecologically fragile and bio-diversity rich. The Bio-diversity of the forests is abundant in variety. The reserve forests are scattered all around the Division and are located in neighborhood of wildlife protected areas- Bannerghatta National park and Cauvery wildlife Sanctuary. In addition, land use in private lands is mostly that of Horticulture crops, which provide a good corridor for movement of wildlife. Also due to the rocky terrain and availability of corridors in private lands many wild animals such as Elephants, Leopard, sloth bear, Jackal, Spotted Deer, Wild Boar, Hare etc. are present in the Division.

The movement of wild animals is very common in to the private lands adjoining forests areas causing a lot of damage to the crops. Wild animals like elephants, leopards, sloth bear and wild boar etc. stray into villages and fields which causes the Man-animal conflict. Human deaths occasionally occur in the Ranges i.e Magadi, Kanakapura, and Ramanagara. Cattle/sheep kills by leopards is quite common in the Division.

d) National Park/Wildlife Sanctuary/ Eco Sensitive Zone

The proposed project road follows the existing road alignment which passes through Bannerghatta National Park (Notified by Government of Karnataka vide its notification AFD 61 FL74 dt. 06.09.1974). MoEFCC also notifies the ESZ of the Bannerghatta National Park, Government of India vide its notification S.O. 2116(E) dt. 15.06.2016. The alignment will pass through the National park and it's ESZ, which is unavoidable.

The proposed alignment is also passing through the eco-sensitive boundary of Ramadevarabetta Vulture Sanctuary, a notified WLS vide MoEFCC S.O no. 74.S.O. 2993 (E) on 12.09.2017. Since the sanctuary is, home of endangered and endemic Indian White backed Vulture (*Gyps benghalenisis*) and Long Billed Vulture (*Gyps indicus*) and various forms of flora and fauna. It is recommend avoiding the proposed road within the eco-sensitive boundary of Ramdevara Betta Vulture Sanctuary. Subsequently, the alignment is re plan to avoid Protected Area and its ESZ.

8.2.9 Community Structures

The impacts on community structures on the both sides of the existing road have estimated based on visual assessment within 30.0 m on either side of the centerline. The final design will avoid the community structures as much as possible. The detailed list provided in **Table 8.5.**

Table 8.5: Structures along the project road

Sl. No.	Type of Structure	No of Likely Affected Structures
1.	Religious Structure	2 Temple
2.	Bus Shelter	3
3.	School	0
4.	Other	1 Hospital
	Total	**6**

Source: Reconnaissance Survey by Consultant, January 2018

8.2.10 Built up Sections

The chainage wise built up areas detailed as below in **Table 8.6**:

Table 8.6: Built up sections along the Project Road

S. No.	Location along STRR (km)	Village
1	10.000	Dabaspet
2	23.000	Banawadi
3	32.000	Gudemaranahalli
4	35.000	Rangenahalli
5	44.000	Magadi
6	54.200	Attimgere
7	62.000	Melehalli
8	75.000	Ramanagara
9	81.000	Kunagal
10	95.400	Kanakapura
11	114.500	Banavasi
12	129.500	Indalawadi
13	135.000	Anekal
14	166.300	Perandapalli
15	180.000	Devaripalli

Source: Inception Report, LBC, July 2017

8.2.11 Demographic Pattern

The project road passes through four district. As per Census of India 2011, the population details of the project districts given in **Table 8.7.**

Table 8.7: District Wise Population

Districts/ State	Population		
	Total	Male	Female
Bengaluru Rural	990,923	509172	481751
Bengaluru Urban	9,621,551	5,022,661	4,598,890
Ramanagara	1082,636	548,060	534,576
Karnataka State	**61,095,297**	**30,966,657**	**30,128,640**
Krishnagiri	1879,809	960,232	919,577
Tamil Nadu State	**72,147,030**	**36,137,975**	**36,009,055**

Source: Census of India, 2011

The detailed socio- economic data is presented separately in subsequent chapter.

8.3 ENVIRONMENTAL SCREENING

The environmental expert conducted the environmental screening to identify the hot spots along the project road. Special care will be needed for the sensitive stretches during designing and construction phase as well. Formulation of specific mitigation measures has to be done for adverse impacts in those sections during the detailed environmental assessment study.

The project road was subject to screening considering the following identified *Valued Environment Components (VECs):*

Table 8.8: Findings of Environmental Screening

S.No.	Valued Environment Components (VECs)	Along Project Road
A	**Physical environment**	
a)	Land use	Predominantly Agricultural Area
b)	Wetlands, Rivers, Rivulets and other Surface water bodies	Crosses various surface water bodies including Arkavati and the Vrishabhawati Rivers etc. The details of water bodies crossing the project road listed in Table 8.3.
c)	Soil erosion	Mainly at river bank during monsoon
d)	Natural hazards	Moderate drought conditions
e)	Air/Water/Noise pollution	Relatively clean environment. Pollution levels may be low.
B	**Bio-Environment**	
a)	Number of trees	It will assessed after finalization of alignment
b)	Wildlife/nesting places/migratory routes and other habitats	Nil
c)	Ecologically sensitive areas	Nil
d)	Biosphere Reserve, National Parks and Wildlife Sanctuaries	The proposed project road passes through Bannerghatta National Park (Notified by Government of Karnataka vide its notification AFD 61 FL74 dated. 06.09.1974). MoEFCC also notifies the ESZ of the Bannerghatta National Park, Government of India vide its notification S.O. 2116(E) dated. 15.06.2016 and The proposed project road adjacent to eco-sensitive boundary of Ramadevarabetta Vulture Sanctuary, a notified WLS vide MoEFCC S.O no. 74.S.O. 2993 (E) on 12.09.2017.
e)	Protected Forests and Reserved Forests	The project road pass through protected/reserved forest
	Unprotected and Community Forests	NA
C	**Socio-Economic Environment**	
a)	Drinking water sources	Mainly through government water supply
b)	Schools/hospitals/college (declared silence zones)	A number of educational institutes are located adjacent to the project corridor. The details shall provide based on the detailed impact assessment of structures falling with in the proposed right of way.
c)	Cultural and Religious properties	A number of religious structures are located along the project corridor. These structures are socially critical issue and hence make the section containing them as high sensitive impact zones.
d)	Archaeological monuments and properties	No archeological site listed under Archeological Survey of India, has identified in close vicinity of the project road. However, Savanadurga a pre-historic site in Bangalore circle is falling approx. 3.5 km to proposed project.
e)	Medical Facilities	Few medical facilities are located along the project corridor. These structures are socially critical issue.

S.No.	Valued Environment Components (VECs)	Along Project Road
f)	Common Property Resources	A number of CPRs are located along the project corridor.
g)	Settlement /built up	16 settlements along the project road.
h)	Tourism locations	Important tourist places falling in the project area: i. Shivagange Betta near Dabaspete ii. Vijayavittal Temple at Arasinakunte iii. Fort and International Airport in Devanahalli taluk, iv. Ghati Subramanya Swamy Temple in Doddaballapura Taluk v. Confluence of the rivers Arkavathy, and Kaveri, (the sangama), nearly 33 km from Kanakapura. vi. Rocks of Ramanagara vii. Jayaprakash Narayan Biodiversity Park, Cubbon Park, Tipu Sultan's Summer Palace in Bangalore Urban district

All sensitive road stretches shall carefully analyzed during Environmental Impact Assessment study and accordingly safeguard measures will be provide in Environmental Management Plan.

8.4 CLEARANCES AND PERMISSIONS REQUIRED

8.4.1 Environmental Clearance

The Environment Impact Assessment (EIA) Notification 2006, Ministry of Environment, Forests & Climate Change, Government of India, came into effect from 14th September 2006. The EIA Notification, 2006 specifies the requirement of prior clearance from MOEF&CC for few development projects specified under the schedule of the Notification. The projects and activities under the Notification have classified into two categories- Category A and Category B, based on the spatial extent of potential impacts on human health, natural and fabricated resources. As per Schedule of the Notification, the Highway project has classified under Physical Infrastructure including Environmental Services and listed under item no. 7(f), including new highways or expansion of existing highways. The categorisation related to highway projects are as follows:

Category A: New National Highways and Expansion of National Highways greater than 100 Km involving additional right of way or land acquisition greater than 40 m on existing alignments and 60 m on re-alignments or by-passes.

Category B: All new State Highway projects and State Highway expansion projects in hilly terrain (above 1000 m AMSL) and or ecologically sensitive areas.

Moreover, any project or activity specified in Category B will be treated as Category A if located in whole or in part with in 5 km from the boundary of:

i) Protected areas notified under the Wild Life (Protection) Act, 1972,

ii) Critically Polluted areas as notified by Central Pollution Control Board from time to time,

iii) Eco sensitive areas as notified under section 3 of Environment Protection Act, 1986 such as Mahabaleshwar, Panchangi, Matheran, Pachmarhi, Dahanu, Doon Valley and

iv) Inter State boundaries and international boundaries.

Provided that the requirement regarding distance of 5 km of the inter-state boundaries can be reduced or completely done away with by an agreement between the respective States or U.Ts sharing the common boundary in the case the activity does not fall within 5 kilometres of the areas mentioned at item (i), (ii) and (iii) above.

The proposed project is a green field alignment and the new national highway having length greater than 100km and involving additional right of way/ land acquisition greater than 40m on existing alignments and 60m on re-alignments and by-passes therefore fall under Category-A and attract conditions of obtaining prior Environmental Clearance from Ministry of Environment, Forests & Climate Change (MOEF&CC).

8.4.2 Forest Clearance

The project passes through forest area, Bannerghatta Wildlife divisions in Karnataka and Krishnagiri forest of Dharmapuri Circle of Tamil Nadu. The Forest Conservation Act 1980 shall be applicable for diversion of forestland to the non-forestry purposes. Permission and clearance for cutting and transportation of trees will be required from Divisional Forest Office of the Forest Department.

8.4.3 Wildlife Clearance

The proposed project road passes through Bannerghatta National Park (Notified by Government of Karnataka vide its notification AFD 61 FL74 dated. 06.09.1974) and ESZ of the Bannerghatta National Park is also notified by MoEFCC, Government of India vide its notification S.O. 2116(E) dated. 15.06.2016. The proposed road is also adjacent to eco-sensitive boundary of Ramadevarabetta Vulture Sanctuary which was notified vide MoEFCC S.O no. 74.S.O. 2993 (E) on 12.09.2017. Thus, recommendation from National Board for Wildlife may be required for the project.

8.4.4 Roadside Tree Felling Permission

Roadside tree felling permission is to be obtain from Department of Forest, Karnataka & Tamil Nadu before the commencement of construction.

8.4.5 Clearances/Permission to be obtained by Contractor

Following clearances/permissions are to be obtain by the Contractor for the project before commencing the construction work:

Table 8.9: Clearances/Permissions to be obtain by Contractor

Sl. No.	Type of Clearance / Permission	Statutory Authority	Applicability	Project stage
1.	Consent to Establish under the Air (Prevention & Control of Pollution) Act, 1981 and the Water (Prevention & Control of Pollution) Act, 1974	KSPCB & TNPCB	For establishment of construction camp, construction plant, crusher, batching plant etc.	Pre-construction
2.	Consent to Operate under the Air (Prevention & Control of Pollution) Act, 1981 and the Water (Prevention & Control of Pollution) Act, 1974	KSPCB & TNPCB	For operating construction plant, crusher, batching plant etc.	Construction stage (Prior to initiation of any work

Sl. No.	Type of Clearance / Permission	Statutory Authority	Applicability	Project stage
3.	Permission to withdraw water for construction from surface water sources such as Rivers/Ponds	Karnataka & TN Irrigation Department	Use of surface water for construction	Construction stage (Prior to initiation of any work)
4.	Permission to withdraw ground water for construction from new sources	State and Central Ground Water Boards	Extraction of ground water	Construction stage (Prior to initiation of any work)
5.	Permission for storage, handling and transport of hazardous materials	KSPCB & TNPCB	Manufacture storage and Import of Hazardous Chemical	Construction stage (Prior to initiation of any work
6.	Explosive License	Chief Controller of Explosives,	For storing fuel oil, lubricants, diesel etc. at construction camp	Construction stage (Prior to initiation of any work)
7.	Quarry Lease Deed and Quarry License from State Department of Mines and Geology	Dept. of Mining; Concerned District Administration SEIAA; KSPCB, TNPCB	Quarry operation (for new quarry) Environmental Clearance from SEIAA and CTE/CTO from KSPCB/ TNPCB.	Construction stage (Prior to initiation of any work)
8.	PUC for vehicles for construction under Central Motor and Vehicle Act 1988	Motor Vehicle Department of Karnataka & TN State	For all construction vehicles	Construction stage (Prior to initiation of any work)
9.	Labour license	Labour commissioner office	Engagement of Labour	Construction stage (Prior to initiation of any work)

8.5 POTENTIAL ENVIRONMENTAL IMPACTS

After studying the existing baseline environmental scenario, initial field surveys, reviewing the process and related statutory norms, an attempt has made to identify the probable impacts on different environmental parameters due to planning, construction and the operation of the proposed road improvement.

Road construction related impacts occur at three stages of the project:

i) Design and Pre-construction

ii) Construction

iii) Operation

Matrix of potential environmental impacts due to the project and preliminary mitigation measures has developed and presented in **Table 8.10.**

Table 8.10: Matrix of Potential Environmental Impacts due to the project and Preliminary mitigation measures

Environmental Components	Impacts	Direct/ Indirect	Significance (High/ Medium/ Low)	Duration of Impacts (Long/ Short)	Mitigation
Design & Preconstruction					
Land	Land Acquisition	D	H	L	• The alignment finalization should be in such manner to minimize the acquisition of land. As far as possible, the productive land area should be avoid to acquire.
Trees	Tree cutting	D	H	L	• Cut only those trees affected by permanent works • Compensatory plantation
Socio-Economic	Problem of Resettlement and Rehabilitation	D	H	L	• Adjustment in alignment to avoid displacement • Early identification and entitlement of the project affected people • Early planning of rehabilitation and resettlement
	Impact on public utilities , cultural sites	D	H	L	• Utility shifting as per R&R Plan • Alignment to be finalized considering minimum damage to the cultural properties
Construction					
Physical Resources					
Soil	Loss of top soil due to site clearance and excavation	D	H	L	• Top soil should be remove & stored separately during excavation. • Re-vegetate the disturbed slope as early as possible
	Soil compaction due to storage of quarry materials and other heavy equipment, movement of heavy vehicles at the site	D	H	L	• Regulation of movement and parking of vehicles and equipment outside ROW. Storage of materials should be allow only at wasteland or barren area.
Air Quality	Reduced buffering of air pollutants, hotter, drier microclimate due to tree felling and vegetation loss during site clearance	I	L	L	• Tree plantation
	Localized increase in pollutants due to increase in number of construction vehicles and equipment	D	L	S	• Vehicles should be maintained such that exhaust emissions are minimum

Environmental Components	Impacts	Direct/ Indirect	Significance (High/ Medium/ Low)	Duration of Impacts (Long/ Short)	Mitigation
	Dust generation due to earth excavation, transportation & heavy vehicles maintenance or operation, Construction of structures and earth works, asphalt & crusher plants	I	L	S	• Vehicles delivering materials should be covered • Regular water sprinkling over exposed surfaces
	Toxic gas emission during asphalt preparation, bituminous heating	D	M	S	• The asphalt mixing plant should be located in conformity with the statuary requirements • Consent to Establish and Consent to Operate from SPCB should be obtained prior to operation of plant
Noise Quality	Increased noise level due to excavators/ machinery etc., operation and maintenance of heavy vehicles and equipment's, Asphalt preparation and crushing	D	M	S	• Noise standards of industrial enterprises shall be strictly enforce. Proper scheduling of the operation of equipment. • The stationary noise generating equipment should be install sufficiently away from habitation area.
Surface Water	Additional pressure on water demand due to the water requirement for construction works	D	M	S	• Alternative water supply system for construction should be ensured in such a way to prevent the additional pressure on public water supply system
	Blockage of water flow channels due to unmanaged excavation and earth filling	D	M	S	• Proper excavation and disposal of the extra fill material away from stream • Provision of cross drainage during construction along the water bodies
	Contamination of water due to spillage, construction wastes	I	M	L	• Strict regulation of traffic flow, waste disposals, bunding around fuel storage site, proper disposal system at equipment and vehicle service stations
	Impairment of surface water bodies, new water bodies due to Quarries/ borrow pits	I	H	L	• Controlled quarrying and borrowing
Ground water	Ground water exploitation for construction works and workforce camp	I	L	S	• Regulation of ground water extraction • Surface water should be used for construction

Environmental Components	Impacts	Direct/ Indirect	Significance (High/ Medium/ Low)	Duration of Impacts (Long/ Short)	Mitigation
Drainage Pattern	Interference with natural drainage flow due to earth excavation dumping, disposal of wastes and surplus earth materials, and construction of structures and earthworks	D	M	S	• Regulation of dumping of waste materials and proper care should take at the site of construction to minimize the wastage. Clean fill material devoid of soil particles to prevent siltation and deposition on the way of natural drainage
Ecological Resources					
Vegetation	Fire risks during vegetation clearance and asphalt preparation	I	H	L	• Kerosene or gas cylinders should be supplied to campsite to avoid use of firewood • Prohibition of clearing of trees for firewood
Wild Fauna	Disturbance or hunting of fauna	I	I	S	• construction camps to be located away from forest areas • Control workforce, awareness program for the workforce, strict enforcement of Wildlife protection Act, • Prohibition of hunting of animals
Aquatic fauna	Adverse impact due to increased turbidity and alkalinity	I	H	S	• Sediment flow will be kept at minimum level through a mix of management measures during construction near water bodies or construction of bridges • Prohibition of unauthorized fishing
Social Environment					
Livelihood	Economic losses as a result of property loss due to land take for widening	D	M	L	• The widening should be done in a way to minimize the land acquisition
Employment	Employment on road construction, and resultant flow	D	H	S	• Encourage local recruitment
Religious / Cultural feature	Impact on religious/ cultural structure	D	H	L	• Shifting and restoration of structures through public consultation

Environmental Components	Impacts	Direct/ Indirect	Significance (High/ Medium/ Low)	Duration of Impacts (Long/ Short)	Mitigation
Health	Health problems to the local people settled near the construction sites because of toxic gaseous emissions due to asphalt preparation and crushing	D	M	S	• Appropriate siting of plant establishment • Strict adherence to the emission standards laid by the Central Pollution Control Board, regular monitoring of emissions. • Provision of emergency medical facility
	Asphalt odour and dust due to asphalt and crusher plant and laying of pavement	D	M	S	
	Insanitation condition at Campsite	D	H	S	• Suitable medical facilities for workers • First Aid facilities at camp/ construction site
Safety at Work site	Accidents at work and on the road	D/I	M/H	S	• Safe working techniques; safety clothing; proper training to workers and drivers
Operational Phase					
Air Quality	Deterioration of air quality due to stimulation of traffic flow, intense human activity, congestion	D	L	L	• Providing lateral buffer zones in design, regular regulation of air pollution by legislation and public awareness • Regulate development activities along the corridor
Noise	Noise generation due to increased traffic flow and congestion	D	L	L	• Noise level for different automobiles has been prescribed in Environment (Protection) Rules, 1986 • Signs will be posted to restrict blowing of horns in front of sensitive locations • With the establishment of strip plantations along the project corridor the noise level will get attenuated
Surface runoff	Deterioration of surface water quality due to surface run off	D	M	L	• Surface runoff from the road will not be disposed directly in the water bodies used by people for bathing etc. This will also not disposed directly in to any watercourse with good water quality.

8.6 PROJECT BENEFITS

The proposed widening of KA SH-3 and its adjacent area shall provide various benefits to the region and people. It will enhance economic development, provide employment opportunities to locals, strengthen tourist development, ensure road safety, and provide better transportation facilities and other facilities such as wayside amenities. Vehicle operating cost will also reduce due to improved road quality. The proposed road-widening project will ensure the smooth flow of traffic, which will reduce the emissions and noise level. The compensatory plantation and roadside plantation done will further improve the air quality of the region.

8.7 ENVIRONMENTAL BUDGET

The budgetary cost estimates for environmental management activities shall be about 2% of the project cost. The details will be furnish in the environment Impact assessment report for all 3 phases separately.

Chapter-9 :

Initial Social Assessment and Preliminary Land Acquisition/ Resettlement Plan

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

9.1 INITIAL SOCIAL ASSESSMENT

9.1.1 Introduction

The proposed project road section of Satellite Towns Ring Road Bangalore west side (STRR) in Bangalore rural, Ramanagara, Bangalore and Krishnagiri district of the state of Karnataka and Tamil Nadu. The project influence area (PIA) of the project has identified in Chapter 5 Socio-economic profile: (1) Direct PIA as the vicinity on both sides of the project road, (2) Indirect PIA of the district of Bangalore rural, Ramanagara, Bangalore and Krishnagiri. The socio-economic profile of the indirect project influence area has been prepared based on secondary official sources of information and discussed in Chapter 5: Socio-economic profile. The present chapter provides with a screening report on possible social impacts of the vicinity of the project based on an initial assessment from the reconnaissance survey and Preliminary Land Acquisition/ Resettlement Plan.

9.1.2 Social Screening

The project expected to bring quite a few benefits, viz.

- Connectivity to the important towns namely Dobbaspet, Doddaballapura, Devanahalli, Sulibele, Hoskote, Sarjapur, Attibele, Anekal, Tattekere, Kankapura, Ramanagara and Magadi.
- Lower transport costs for freight and passengers of motorised and non-motorised vehicles;
- Improved Road network connectivity to the villages in the vicinity of the road;
- Enhanced traffic facilities and volume in the project road;
- Enhancement in economic opportunities/activities of the local people;
- Enhanced basic amenities to the villages along the proposed road;
- Rural prosperity of the project influence area;

Although such benefits were not quantify, the project also expected to help alleviate development constraints in tourism, agriculture, commerce, education, health, social welfare, and public safety and contribute to general expansion and diversification of development activities.

Preliminary survey activities have carried out to assess the potential impacts of the proposed project for the direct influence area. Features and properties along the Corridor of Impact (COI) and Right of Way (ROW) and distance from the road to habitations and their distance from the centre line observed, recorded, analysed, and presented.

9.1.3 Existing Road

The proposed project road of west side STRR, starts from NH 207 in Dobbaspet and terminates in NH 44 (old NH 7) in Sarjapur (border of TN/Karnataka). The STRR alignment mainly following along the existing KA SH 3 alignment with geometric improvements and improvements by bypass provisions in built up locations at Magadi, Ramanagara and in Kanakapura. From Kanakapura to Anekal the proposed project road passes through Greenfield and amalgamates with KA SH 35 after crossing the Anekal town. The alignment proposed to include Hosur and connecting it to NH 207 near Sarjapur in Tamil Nadu/ Karnataka border.

9.1.4 Terrain and Land Use

The entire length of road is passing through plain and rolling/hilly terrain. The land use by the side of the project road includes agriculture activities, residential use, and commercial purpose. The establishments on both sides of the road are in general are outside the available ROW. However, encroachments also noticed in the built-up locations of the road. The road runs on embankment generally at a height of about 0.5m to 1m except in the portion of approaches to bridges and some culverts. The land use of the roadside presented in **Table 9.1**.

Table 9.1: Land use Pattern along the Existing Road

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
1	0.000	1.000	Agriculture	Agriculture
2	1.000	2.000	Agriculture	Agriculture
3	2.000	3.000	Agriculture	Agriculture
4	3.000	4.000	Vacant	Vacant
5	4.000	5.000	Agriculture	Agriculture
6	5.000	6.000	Agriculture	Agriculture
7	6.000	7.000	Agriculture	Agriculture
8	7.000	8.000	Agriculture	Agriculture
9	8.000	9.000	Agriculture	Agriculture
10	9.000	10.000	Agriculture	Agriculture
11	10.000	11.000	Agriculture	Agriculture
12	11.000	12.000	Hilly	Vacant
13	12.000	13.000	Vacant	Agriculture
14	13.000	14.000	Agriculture	Agriculture
15	14.000	15.000	Agriculture	Agriculture
16	15.000	16.000	Agriculture	Agriculture
17	16.000	17.000	Agriculture	Agriculture
18	17.000	18.000	Vacant	Vacant
19	18.000	19.000	Agriculture	Agriculture
20	19.000	20.000	Agriculture	Agriculture
21	20.000	21.000	Agriculture	Agriculture
22	21.000	22.000	Agriculture	Agriculture
23	22.000	23.000	Agriculture	Agriculture
24	23.000	24.000	Agriculture	Agriculture
25	24.000	25.000	Agriculture	Agriculture
26	25.000	26.000	Vacant	Vacant
27	26.000	27.000	Agriculture	Vacant

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
28	27.000	28.000	Agriculture	Agriculture
29	28.000	29.000	Agriculture	Agriculture
30	29.000	30.000	Agriculture	Agriculture
31	30.000	31.000	Vacant	Agriculture
32	31.000	32.000	Agriculture	Agriculture
33	32.000	33.000	Agriculture	Agriculture
34	33.000	34.000	Agriculture	Agriculture
35	34.000	35.000	Vacant	Vacant
36	35.000	36.000	Agriculture	Vacant
37	36.000	37.000	Agriculture	Agriculture
38	37.000	38.000	Vacant	Agriculture
39	38.000	39.000	Agriculture	Agriculture
40	39.000	40.000	Agriculture	Agriculture
41	40.000	41.000	Agriculture	Agriculture
42	41.000	42.000	Agriculture	Agriculture
43	42.000	43.000	Vacant	Agriculture
44	43.000	44.000	Agriculture	Hilly
45	44.000	45.000	Residential	Hilly
46	45.000	46.000	Agriculture	Vacant
47	46.000	47.000	Agriculture	Agriculture
48	47.000	48.000	Agriculture	Agriculture
49	48.000	49.000	Agriculture	Agriculture
50	49.000	50.000	Agriculture	Agriculture
51	50.000	51.000	Forest	Forest
52	51.000	52.000	Agriculture	Agriculture
53	52.000	53.000	Agriculture	Agriculture
54	53.000	54.000	Agriculture	Agriculture
55	54.000	55.000	Agriculture	Agriculture
56	55.000	56.000	Agriculture	Agriculture
57	56.000	57.000	Vacant	Vacant
58	57.000	58.000	Agriculture	Agriculture
59	58.000	59.000	Agriculture	Agriculture
60	59.000	60.000	Agriculture	Agriculture
61	60.000	61.000	Agriculture	Agriculture

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
62	61.000	62.000	Agriculture	Agriculture
63	62.000	63.000	Vacant	Vacant
64	63.000	64.000	Agriculture	Agriculture
65	64.000	65.000	Agriculture	Agriculture
66	65.000	66.000	Agriculture	Agriculture
67	66.000	67.000	Agriculture	Agriculture
68	67.000	68.000	Hilly	Forest
69	68.000	69.000	Agriculture	Agriculture
70	69.000	70.000	Hilly	Hilly
71	70.000	71.000	Agriculture	Agriculture
72	71.000	72.000	Agriculture	Agriculture
73	72.000	73.000	Agriculture	Agriculture
74	73.000	74.000	Vacant	Hilly
75	74.000	75.000	Agriculture	Hilly
76	75.000	76.000	Agriculture	Hilly
77	76.000	77.000	Hilly	Hilly
78	77.000	78.000	Hilly	Hilly
79	78.000	79.000	Agriculture	Agriculture
80	79.000	80.000	Agriculture	Agriculture
81	80.000	81.000	Agriculture	Agriculture
82	81.000	82.000	Agriculture	Agriculture
83	82.000	83.000	Agriculture	Agriculture
84	83.000	84.000	Agriculture	Agriculture
85	84.000	85.000	Agriculture	Agriculture
86	85.000	86.000	Agriculture	Agriculture
87	86.000	87.000	Agriculture	Agriculture
88	87.000	88.000	Vacant	Vacant
89	88.000	89.000	Agriculture	Agriculture
90	89.000	90.000	Agriculture	Agriculture
91	90.000	91.000	Agriculture	Agriculture
92	91.000	92.000	Agriculture	Agriculture
93	92.000	93.000	Agriculture	Agriculture
94	93.000	94.000	Hilly	Hilly
95	94.000	95.000	Forest	Forest

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
96	95.000	96.000	Agriculture	Agriculture
97	96.000	97.000	Agriculture	Agriculture
98	97.000	98.000	Agriculture	Agriculture
99	98.000	99.000	Vacant	Vacant
100	99.000	100.000	Agriculture	Agriculture
101	100.000	101.000	Agriculture	Agriculture
102	101.000	102.000	Vacant	Vacant
103	102.000	103.000	Vacant	Agriculture
104	103.000	104.000	Agriculture	Agriculture
105	104.000	105.000	Agriculture	Agriculture
106	105.000	106.000	Agriculture	Agriculture
107	106.000	107.000	Agriculture	Agriculture
108	107.000	108.000	Agriculture	Agriculture
109	108.000	109.000	Vacant	Vacant
110	109.000	110.000	Agriculture	Agriculture
111	110.000	111.000	Agriculture	Agriculture
112	111.000	112.000	Agriculture	Agriculture
113	112.000	113.000	Agriculture	Agriculture
114	113.000	114.000	Agriculture	Agriculture
115	114.000	115.000	Forest	Forest
116	115.000	116.000	Forest	Forest
117	116.000	117.000	Forest	Forest
118	117.000	118.000	Forest	Forest
119	118.000	119.000	Forest	Forest
120	119.000	120.000	Forest	Forest
121	120.000	121.000	Forest	Forest
122	121.000	122.000	Forest	Forest
123	122.000	123.000	Forest	Forest
124	123.000	124.000	Forest	Forest
125	124.000	125.000	Agriculture	Agriculture
126	125.000	126.000	Agriculture	Agriculture
127	126.000	127.000	Agriculture	Agriculture
128	127.000	128.000	Agriculture	Agriculture
129	128.000	129.000	Agriculture	Agriculture

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
130	129.000	130.000	Agriculture	Agriculture
131	130.000	131.000	Agriculture	Agriculture
132	131.000	132.000	Agriculture	Agriculture
133	132.000	133.000	Agriculture	Agriculture
134	133.000	134.000	Agriculture	Agriculture
135	134.000	135.000	Agriculture	Agriculture
136	135.000	136.000	Vacant	Vacant
137	136.000	137.000	Agriculture	Agriculture
138	137.000	138.000	Agriculture	Agriculture
139	138.000	139.000	Agriculture	Agriculture
140	139.000	140.000	Agriculture	Agriculture
141	140.000	141.000	Agriculture	Agriculture
142	141.000	142.000	Agriculture	Agriculture
143	142.000	143.000	Agriculture	Agriculture
144	143.000	144.000	Agriculture	Agriculture
145	144.000	145.000	Agriculture	Agriculture
146	145.000	146.000	Agriculture	Agriculture
147	146.000	147.000	Agriculture	Agriculture
148	147.000	148.000	Agriculture	Agriculture
149	148.000	149.000	Agriculture	Agriculture
150	149.000	150.000	Agriculture	Agriculture
151	150.000	151.000	Agriculture	Agriculture
152	151.000	152.000	Vacant	Agriculture
153	152.000	153.000	Agriculture	Agriculture
154	153.000	154.000	Agriculture	Agriculture
155	154.000	155.000	Agriculture	Agriculture
156	155.000	156.000	Agriculture	Agriculture
157	156.000	157.000	Agriculture	Agriculture
158	157.000	158.000	Agriculture	Agriculture
159	158.000	159.000	Agriculture	Agriculture
160	159.000	160.000	Agriculture	Agriculture
161	160.000	161.000	Agriculture	Agriculture
162	161.000	162.000	Vacant	Vacant
163	162.000	163.000	Agriculture	Agriculture

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
164	163.000	164.000	Agriculture	Agriculture
165	164.000	165.000	Agriculture	Agriculture
166	165.000	166.000	Agriculture	Agriculture
167	166.000	167.000	Agriculture	Agriculture
168	167.000	168.000	Agriculture	Agriculture
169	168.000	169.000	Agriculture	Agriculture
170	169.000	170.000	Agriculture	Agriculture
171	170.000	171.000	Agriculture	Agriculture
172	171.000	172.000	Agriculture	Agriculture
173	172.000	173.000	Forest	Agriculture
174	173.000	174.000	Agriculture	Agriculture
175	174.000	175.000	Agriculture	Agriculture
176	175.000	176.000	Agriculture	Agriculture
177	176.000	177.000	Agriculture	Agriculture
178	177.000	178.000	Agriculture	Agriculture
179	178.000	179.000	Agriculture	Agriculture
180	179.000	180.000	Agriculture	Agriculture

Source: *Reconnaissance Survey by Consultant, January 2018*

9.1.5 Habitations

The project Road has the following habitation areas along the proposed alignment. The habitations have mostly Huts and pucca Structures. The habitations/ Settlements along the proposed road given in **Table 9.2**.

Table 9.2: Settlements of Villages/ Habitations along the Existing Road

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
1	1.500	Manne
2	4.100	Tattekere
3	6.700	Nijagal Kempohalli
4	7.100	Maddenahalli
5	8.200	Lakkuru
6	9.800	Agalakuppa
7	15.600	Hosapalya

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
8	23.300	Banawadi
9	28.200	Goruru
10	30.100	Gudemaranahalli Handpost
11	32.000	Gudemaranahalli
12	40.700	Byalakere
13	43.500	Magadi
14	52.400	Hanchikuppe
15	54.200	Atimgere
16	60.200	Gungarahalli
17	61.000	Melahalli
18	73.000	Basavanapura
19	74.300	Rampura Doddi
20	75.500	Ramanagara
21	81.000	Kunagal
22	85.700	Chikkenahalli
22	87.300	Anajawadi
23	89.300	Chikka Madhawadi
24	90.700	Alisab Doddi
25	93.000	Aralalusandra
26	96.300	Varager Halli
27	97.600	Chathra
28	104.000	Dodda Maralawadi
29	108.000	Banavasi
30	110.000	T. Maniyambal
31	125.000	Indalavadi
32	127.000	Thimmasandra
33	132.000	Vanakanahalli
34	135.000	Menasiganahalli

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
35	136.100	Muttur
36	142.600	Kappakollu
37	143.500	Payarakanahalli
38	145.500	S. Mudugandanahally
39	148.500	Golisandram
40	158.500	Thorapalli Agraharam
41	161.200	Kothur
42	161.800	Perandapalli
43	163.000	Kadirapalli
44	164.200	Alur
45	164.800	Dasapalle
46	167.200	Payarkuttalai
47	171.000	Nandimangalam
48	172.600	Attur
49	176.800	B. Mudaganahalli
50	179.600	Kadiriganadinna
51	180.500	Sampangere

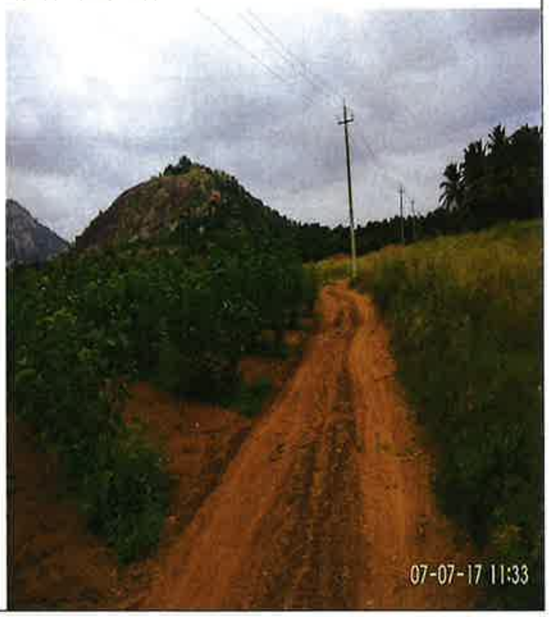
Plate 9.1: Project Road features and Settlements along the Existing/Proposed Road Alignment

strr atedeli
43P 802005 1413800

Alimarahalli Rd xing
43P 758718 1394853

near 76000 bld
43P 757575 1396207

near 75300
43P 757114 1397404



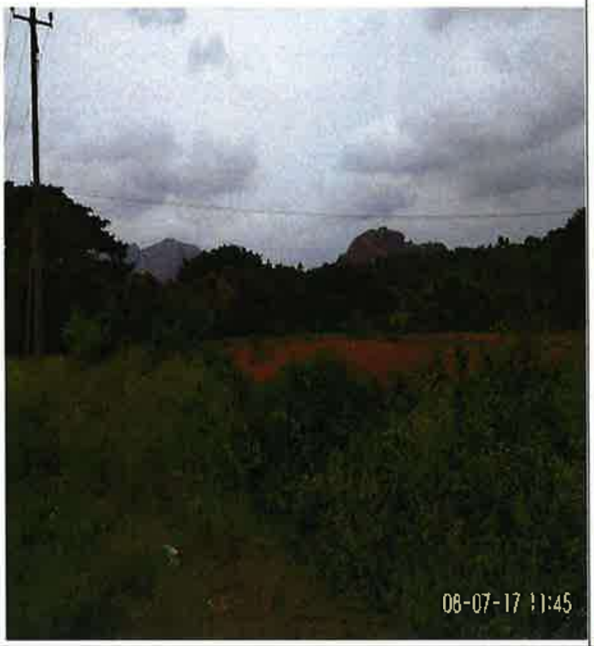
near 74800
43P 756904 1397804

near singasandra vill
43P 755848 1398691

near km 74
43P 747956 1417315

near 41200
43P 746921 1425942

near km 35000
43P 743967 1430853



near 25200
43P 743901 1439912

9.2 PROJECT IMPACTS

The assessment of potential positive externalities and negative impacts of the project is identified preliminarily. The assessment of impacts is being covered under following variables: number of structures likely to be impacted, number of religious structures likely to be impacted, number of community property and resources likely to be impacted, built up sections along the corridor etc. The project may trigger the following categories of loss:

- Loss of Agricultural/ homestead/ Forest Land and other Properties
- Loss of Residential Properties
- Loss of Commercial Properties
- Loss of Residential cum Commercial Structures
- Loss of economic/ livelihoods

The project affected families may be categorized in following three broad categories:

- Title holders: People who are losing land, land & structures, only part of structures, which are under legal ownership of the incumbent
- Non-Title holders: People who are losing structures/ part of structures, which were erected/ extended on the land not under his legal ownership, and
- Livelihoods Losers: Any person from the previous categories, Kiosks operators, tenants of the affected structures and employees of the affected Business are likely to be affected with existing economic/ physical livelihood losses.

The details of land acquisition and quantum of loss under each category will be given in Detailed Project Report stage.

9.2.1 Impacts on Land

The total length of the proposed road is 179.969km. There are seven talukas involve in both states. The land acquisition details are already published for all the taluks. The details of 3A(1) are as below.

Sl. No	State	District	Taluka	Chainage (km)	
				From	To
1	Karnataka	Bangalore Rural	Nelamangala	0.000	19.645
2		Ramanagara	Magadi	19.645	56.034
3			Ramanagara	56.034	86.295
4			Kanakapura	86.295	119.745
5		Bangalore Urban	Anekal	119.745	134.942
6	Tamil Nadu	Krishnagiri	Denkanikottai	134.942	142.086
7				148.956	154.883
8			Hosur	142.086	148.956
9				154.883	179.969

Total land Involvement are as follow:

- Karnataka state: 1040hectares only for mainline and without considering for Interchanges.
- Tamil Nadu state: 440hectares only for mainline and without considering for Interchanges

Total land requirements envisaged only for 70m corridor and without consideration of Interchanges, Toll plazas, truck lay byes etc. The other details are currently under design stage.

Total land requirement phase wise are, Phase I (km 0 to km 79.000): 675ha, Phase II (km 79.000 to km 144.480): 400ha & Phase III (km 144.480 to km 179.969): 405ha.

This report pertinent to Phase 2.The current LA status are

- 3A published: 405 ha (100%)
- 3D published: 43.114 Ha. (two villages of Denkanikottai taluk coming under Phase-2)
- Addl. 3A(1): 4.135 Ha. (To be Published)

It is intent to complete the 3D of Karnataka section by end of June 2019.

9.2.2 Impacts on Structures

The impacts on structures on the both sides of the road have been preliminarily estimated on the basis of visual assessment within 75 m bandwidth, i.e., 37.5 m on either side of centre line. All the structures mentioned in the list may not necessarily be affected. The final list of the impacts and the mitigation measures will be reported in later Draft DPR stage. The list of likely affected structures according to utilization is presented in **Table 9.3**.

Table 9.3: Likely Affected Structures According to Utilisation

S. No.	Type of Structure	No of Likely Affected Structures
1	Residential Structure	194
2	Commercial Structure	93
3	Residential cum Commercial Structure	6
	Total	**293**

Source: *Reconnaissance Survey by Consultant, January 2018*

9.2.3 Impacts on Community Structures

The impacts on community structures on the both sides of the existing road have also been estimated on the basis of visual assessment within 37.5 m on either side of the centre line. The final design will avoid the community structures as much as possible. The list of likely affected community structures is presented in **Table 9.4**.

Table 9.4: Likely Affected Community Structures According Utilisation

Sl.	Type of Structure	No of Likely Affected Structures
1	Religious Structure	2 Temple
2	Bus Shelter	3
3	School	0
4	Other	1 Hospital
	Total	**6**

Source: *Reconnaissance Survey by Consultant, January 2018*

9.2.4 Community Perceptions about the Project

Consultation with Project Affected Persons (PAPs) is the starting point to address involuntary resettlement issues, concerning land acquisition, rehabilitation and resettlement. People affected by resettlement may be apprehensive that they will lose their livelihoods and communities. Information dissemination of the project is the first principle of consultation. Participation in planning and managing resettlement helps to reduce their fears and gives PAPs an opportunity to participate in key decisions that affect their lives.

The initial consultations with the local people and project affected persons reveals that the people are positive on the project and are generally happy as the proposed road will increase the tourist and the transport of their non-forest produce and handicrafts and thus enhance their livelihood.

All the persons consulted are in favour of the development. They agree to sacrifice requisite land and/or property, if they get fair compensation.

9.3 NEED FOR RESETTLEMENT & REHABILITATION

The projects social impacts and resettlement component includes assessment of possible social impacts of the project and development of appropriate mitigation plans as required. This plan will comply with the appropriate national and local laws and guidelines. GOI regulations of "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013 (RFCTLARR) will be the guided material for all social aspects.

9.3.1 Approach &Methodology for Resettlement & Rehabilitation

The detailed Social Impact Assessment and Resettlement Action Plan, as per the engineering design, will be carried out through the primary data collection through Census Survey and Socio-economic survey of the affected families, Public Consultation in the major affected villages and Consultation with the stakeholders of the Community Property Resources (CPR) including the affected religious structures.

Preparation of the Resettlement Action plan (RAP) will be undertaken within the projects Social Impact Assessment component. The RAP will provide detailed guidance on identification of the affected families, their respective impacts, Resettlement budgets of eligible entitlements, institutional arrangement, implementation strategies and Monitoring & Evaluation based on enumeration of likely project-affected people.

a) Review of Secondary Information

Secondary data available from reliable sources like District Statistical Handbook, previous reports, Land availability data etc.

b) **Social Screening**

Social Screening has been conducted through Reconnaissance Survey along the road alignment and also reviewing the secondary data.

c) Detailed SIA & RAP

The detailed SIA & RAP will be prepared after the design of the proposed development is being finalized, through 1) Identification of the Land Acquisition, 2) Procedures and estimation of acquired Land and structures as per the RFCTLARR 2013 Act, 3) identification of the affected structures of the non-titleholders, 4) Census surveys of all affected households, 5) Socio-economic surveys of the 1/4th of the affected households, 6) Village Profile information of the major villages, defined as having more than 500 m stretches along the proposed road alignment, 7) Consultation of the stakeholders of the Community Property Resources (CPR) including the affected religious structures, 8) Preparation of the Photo identity cards of the non-titled households, 7) Estimation of Resettlement & Rehabilitation (R&R) estimates and 9) Preparation of SIA & RAP Report.

d) **Identification of affected structures**

The affected structures considered as the structures falling under the Corridor of Impact, defined the boundary of the proposed ROW line on both sides. The structures will be identified from the 1:1000 scale printout of the proposed development plan superimposed on topographical survey of the existing ground features. The structures will also be marked, on the map, with suitable structure identification number.

e) Database preparation and analysis

The collected data will be digitized in Excel formats after the field surveys, cleaned for human errors. The Land Acquisition details will be updated after the 3G of the LA process is completed. The data will be analyzed for the further reporting. The different categories of impacts that will be identified will have been classified under three categories, viz., loss of land, loss of structures and loss of livelihood. The quantification of the Rehabilitation and Resettlement entitlements for these losses will be done based on the provisions of schedule II of RTFCTLARRA 2013.

f) **Project affected families**

The project affected families may be categorized in three broad categories of 1) Titleholders, People who are losing land, land & structures, only part of structures, which are under legal ownership of the incumbent; 2) Non-titleholders, People who are losing structures/ part of structures or Kiosks, which were erected/ extended on the land not under his legal ownership; and 3) Livelihood Losers, Any person from the previous categories and also the tenants.

g) **Consultations**

The consultation with the identified project affected people and the local stakeholders will be done. Their views and the suggestions are being considered for finalising the alignment, in accordance with the technical feasibility.

The census data will provide the basis for establishing a cut-off date for non-title holders in order to determine who may be entitled to relocation assistance or other benefits from the project. The Socio-economic data, Village Profile information and the Consultation of CPRs will provide a baseline against which mitigation measures and support will be measured and includes comprehensive examination of people's assets, incomes, important cultural or religious networks or sites, and other sources of support of common property resources.

9.4 LEGAL AND ENTITLEMENT POLICY FRAMEWORK

The main objective of the Legal and Entitlement Policy Framework is to appropriately identify, address and mitigate all adverse socio-economic impacts accrued to the communities, families or people due to the implementation of the Project within the purview of the existing law and regulations of the country and state those are applicable to the proposed project.

Road up-gradation/widening projects often result in acquisition of land, particularly in case when the existing ROW is not adequate to accommodate the proposed up-gradation/widening. In order to protect their interests, administrative, policy and legal frameworks are present. National Acts and policies applicable to this project include:

- National Highways Act (NH Act), 1956;
- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, (New LARR 2013 Act)

The following provisions from the above mentioned policies are likely to applicable for the project.

9.4.1 Land Acquisition

Land acquisition in India refers to the process by which the Central or any State government, excepting the Government of Jammu & Kashmir, in India acquires private land for the purpose of industrialization, development of infrastructural facilities or urbanization of the private land, and provides compensation to the affected land owners and their rehabilitation and resettlement.

Land acquisition in India is now governed by the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (RFCTLARR) and which came into force from 1 January 2014. The land acquisition in Jammu and Kashmir is governed by the Jammu and Kashmir Land Acquisition Act 1934.

In case where a State Government through any Act or Gazette Notification or as approved by any authority of State Government (duly authorized for the purpose) as per their approved procedure has fixed a rate for compensation of land and is higher than the provisions under the RCFTLARR

Act 2013, the same may be adopted by the Competent Authority in determining the compensation for land.

Similarly, in case where a State Government through any Act or Gazette Notification or as approved by any authority of State Government (duly authorized for the purpose) as per their approved procedure has fixed a rate for resettlement and rehabilitation assistance and is higher than the provisions under the RCFTLARR 2013, the same may be adopted by the Executing Authority.

9.4.2 National Highways Act 1956

Land for construction of a new highway or upgradation/widening is acquired using the NH Act 1956. Key provisions relating to acquisition are as follows:

3A. Power to acquire land, etc.

(1) Where the Central Government is satisfied that for a public purpose any land is required for the building, maintenance, management or operation of a national highway or part thereof, it may, by notification in the Official Gazette, declare its intention to acquire such land.

(2) Every notification under sub-section (1) shall give a brief description of the land.

(3) The competent authority shall cause the substance of the notification to be published in two local newspapers, one of which will be in a vernacular language.

3D. Declaration of acquisition.

(I) Where no objection under sub-section (1) of section 3C has been made to the competent authority within the period specified therein or where the competent authority has disallowed the objection under sub-section (2) of that section, the competent authority shall, as soon as may be, submit a report accordingly to the Central Government and on receipt of such report, the Central Government shall declare, by notification in the Official Gazette, that the land should be acquired for the purpose or purposes mentioned in sub-section (1) of section 3A.

3E. Power to take possession.

(I) Where any land has vested in the Central Government under sub-section (2) of section 3D, and the amount determined by the competent authority under section 3G with respect to such land has been deposited under sub-section (1) of section 3H, with the competent authority by the Central Government, the competent authority may by notice in writing direct the owner as well as any other person who may be in possession of such land to surrender or deliver possession thereof to the competent authority or any person duly authorized by it in this behalf within sixty days of the service of the notice.

3G. Determination of amount payable as compensation

The competent authority or the arbitrator while determining the amount under sub-section (1) or sub-section (5), as the case may be, shall take into consideration

a) the market value of the land on the date of publication of the notification under section 3A;

b) the damage, if any, sustained by the person interested at the time of taking possession of the land, by reason of the severing of such land from other land;

c) the damage, if any, sustained by the person interested at the time of taking possession of the land, by reason of the acquisition injuriously affecting his other immovable property in any manner, or his earnings;

d) if, in consequences of the acquisition of the land, the person interested is compelled to change his residence or place of business, the reasonable expenses, if any, incidental to such change.

9.4.3 Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act (RFCTLARR), 2013, Govt. of India

The most relevant Indian regulation for facilitating resettlement and rehabilitation is the RFCTLARR, 2013. This Act is the principal document for procedures to be followed for acquisition of private land by the Government for public purposes and for determining compensation. The Act ensures that no person is deprived of land under this Act and entitles PAPs to a hearing before the actual acquisition. The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (RFCTLARR) Act, 2013 has been effective from January 1, 2014 has subsided all other prevailing Acts and Notification, in this regard, from January 1, 2015.

The key features of the new land acquisition act are as follows:

- Schedule I outlines the proposed minimum compensation based on a multiple of market value.
- Schedule II and III outline the resettlement and rehabilitation (R&R) entitlements to land owners and livelihood losers, which shall be in addition to the minimum compensation per Schedule I.
- The Schedules IV lists out other land acquisition acts, which will be repealed with 1 year after LAAR is effective.

The provisions of this Act Under Section 2(1) relating to land acquisition, compensation, rehabilitation and resettlement, shall apply, when the appropriate government acquires land for its own use, hold and control, including for Public Sector Undertakings and for public purpose. Under RTFCTLARRA, 2013 for land acquisition for various types of project, provisions of consent have been inbuilt to secure the interest of the stakeholders.

9.4.4 Resettlement & Rehabilitation Entitlement Framework

The R&R entitlement framework has been formulated based on the guiding principles outlined in the Policy. This R&R framework will be adopted to formulate the Resettlement Action Plan. The basic principles of R&R entitlement and compensation structure is provided in **Table 9.5**.

Table 9.5: Basic Principles Governing Compensation Structure

Sl. No.	Category of Impact	Eligibility for Entitlement	Relevant RTFCTLARRA 2013 Provisions	
			Entitlement	Provisions
1	2	3	4	5
1	Loss of Land	Titleholder	1. Market value of land. This will be determined as per Sections 26 to 29 of LARR Act 2013 by Collector.	▪ Applicable as per RTFCTLARRA 2013. ▪ PAPs that have received the compensation on or before 31st December 2013 will be provided

Sl. No.	Category of Impact	Eligibility for Entitlement	Relevant RTFCTLARRA 2013 Provisions	
			Entitlement	Provisions
1	2	3	4	5
			2. Amount equivalent to current stamp duty and registration charges on compensation amount for replacement of lost assets.	Additional compensation as per RTFCTLARRA 2013. ▪ This is as per Section 24 of RTFCTLARRA 2013 wherein it is mentioned: *... Provided that where an awarded has been made and compensation in respect of majority of land holdings has not been deposited in the account of the beneficiaries,* *Then, all beneficiaries specified in the notification for acquisition under section 4 of the said Land Acquisition Act, shall be entitled to compensation in accordance with the provisions of this Act.*
			Land Value factor	▪ Scale 1 to 2 based on the distance of project from urban area, as may be notified by appropriate government. Illustrative scale (0-10 km=1), (10-20=1.20), (20-30 km=1.40), (30-40 km=1.80), and (40-50 km=2).
		Affected Family/Person	Land for land	▪ Not applicable
2	Loss of other Immovable Assets	Titleholder	Value of Assets attached to land or building	▪ This will be provided to affected families as per the RTFCTLARRA 2013 (provision under First Schedule Sl.No.2 (ref. Section 29 of the said Act). ▪ This will be provided along with the loss of land and/or the structure which will be finalized by the Collector (revenue department).
3	Loss of Land, Structure and other immovable assets (1.2)	Titleholder	Solatium	▪ As per RTFCTLARRA 2013 – Under section 30(1) of the said Act. ▪ The compensation is calculated for land, structures and such assets attached to the building or land as applicable and the total of all considered before considering the solatium.
4	Loss of Land and other assets	Titleholder	Additional 12% on market value of land.	▪ In addition to the market value of land, additional 12% per annum to be paid on such market value commencing on and from the date of publication of notification of SIA u/s (2) of section 4 in

Sl. No.	Category of Impact	Eligibility for Entitlement	Relevant RTFCTLARRA 2013 Provisions	
			Entitlement	Provisions
1	2	3	4	5
				respect of land, till award or date of taking possession of land whichever is earlier.
5	Land/ Structure	Titleholder	Stamp duty and registration fee.	▪ The stamp duty and other fees payable for registration of the land or house allotted to the affected families shall be borne by the Requiring Body.

9.4.5 Other Allowances under RRCTLARR Act 2013

All monetary value (allowances) shall be entitled to be increased by 5% on the 1st January of each year unless the rate of inflation index is less than 5% for that year and presented in **Table 9.6**.

Table 9.6: Allowances as per RFCTLARR Act 2013

Allowance	Amount in INR	Remarks
Transportation Allowance	50,000	One-time grant
Employment Allowance	500,000	One-time grant for each affected family with eligible candidate.
Subsistence Allowance	3,000	Per month till one year after displacement for each affected family
	50,000	additional for SC/ ST affected family
Grant for artisans and small traders	50,000	One-time grant for small traders

9.4.6 Entitlement Matrix

The R&R entitlement framework has been formulated based on the guiding principles outlined in the Policy. This R&R framework will be adopted to formulate the Resettlement Action Plan. The basic principles of R&R entitlement and compensation structure is provided in following table.

PAFs entitled for compensation and rehabilitation are (i) PAFs losing land and other assets with legal title/ traditional land rights will be compensated, and PAFs will be rehabilitated (ii) tenants (iii) owners of buildings, or other objects attached to the land; (iv) PAFs losing business, income, and salaries; (v) assistance to the non-title holders (squatters, etc.). Compensation eligibility is limited by a cut-off date as per the Census survey conducted under the NHAI's assistance for the project.

This entitlement matrix will include various components of R&R benefits and addresses all categories of people being affected and all categories of impacts accrued to the affected families due to the Project.

9.4.7 Social Impacts, Resettlement Rehabilitation and R&R Budget

The Social Impacts and Resettlement will be prepared based on the Census and other survey results and presented after the field survey is completed, digitized and analyzed. It will also be discussed about that how are they affected and what impacts will they experience.

The resettlement budget will comprise itemized estimate of compensation for land, structures, trees, crops, various resettlement assistances, rehabilitation or replacement of CPRs including land, if government land is not available, institutional cost, contingency, additional studies if required, cost towards implementation, engagement of RAP implementation agency, evaluation consultants, etc.

9.5 FURTHER DETAILED SOCIAL & RESETTLEMENT ASSESSMENT

The detailed Social & Resettlement Assessment will be conducted after the road alignment and development schemes are being finalized. The consultant will undertake census (100%) and socio-economic surveys (25%) of the affected persons, as per the proposed development.In addition to the census and socio-economic surveys, public consultations with the stakeholders including the communities and affected persons will be conducted.

The objective is to establish a base line profile of population which includes data on gender, ethnicity, social structure, employment and labour patterns, sources of income (including production and marketing activities), local tenure and property rights arrangements, access to social services and facilities (including health, education, and agricultural extension and credit); use of community and natural resources relevant to formulation of development strategies in order to assist in determining project impacts on the social, economic, cultural, and livelihood activities of affected communities.

All untitled occupants will be recorded at the initial stages and identify cards will be issued to ensure there is no further influx of people into the project area. All consultations with affected persons should be fully documented

The consultant would prepare Resettlement and Rehabilitation Plan; assess feasibility and effectiveness of income restoration strategies and suitability and availability to relocation sites as per guidelines provided in Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (LARR 2013), and/ or guidelines set by Govt. of Karnataka and Tamil Nadu.

Chapter-10:
Cost Estimates

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CHAPTER-10: COST ESTIMATES

10.1 GENERAL

Cost estimate is an important component of the feasibility study and project preparation as it provides vital input to financial evaluation. The cost estimation have been prepared for the project road corridor, for construction of 6 lane with paved shoulder, including cross drainage structures, road furniture, facility etc.

10.2 TYPICAL CROSS SECTIONS

The typical cross sections proposed to be used for construction of project road corridor.

10.3 QUANTIFICATION

The quantification of the road items that are uniformly accruing is calculated as per typical cross sections. The quantification of structures based on general arrangement drawings.

10.4 UNIT RATES

10.4.1 Road Construction Items

The rates have taken from Schedule of Rate, National Highway Circle Bangalore for the year 2018-19.

Table 10.1: Adopted Unit Rates for Road Part

Sl. No.	Items Description	Unit	Rates (Rs.) without GST
1	Clearing and Grubbing of road land	Ha	32600
2	Embankment fill using borrow materials	Cum	295
3	Sub grade & earthen / un paved	Cum	320
4	Median fill	Cum	159
5	Granular Sub-base	Cum	1700
6	Wet mix macadam	Cum	1810
7	Prime Coat	Sqm	60
8	Tack Coat	Sqm	11
9	Dense Bituminous Macadam	Cum	6390
10	Bituminous Concrete	Cum	7720

10.5 PROJECT COSTING

- The cost of road portion and cost of construction of structures have been worked out separately. This cost is based on typical cross-section.

Total project cost

The summary costs for Phase II given as below. The detailed cost estimates given in Volume III – Cost Estimates

Table 10.2: Summary of Project Cost

Flexible Pavement

Description	Total Amount in Rs.	Amount (Rs. in Cr.)
Bill No. 1: Site clearance and Dismantling	44,876,492.00	4.49
Bill No. 2 : Earth Work	1,915,258,144.65	191.53
Bill No. 3 : Grannular Sub Base Courses and Base Courses (Non-Bituminous)	1,501,025,768.77	150.10
Bill No. 4 : Bituminous Courses /Rigid Pavement	1,674,446,870.88	167.44
Bill No. 5 : Culverts	401,156,756.98	40.12
Bill No. 6 : Structures (VUP/ LVUP/ Minor Bridge/ Major Bridge/ Flyover/ ROB)	10,735,127,101.52	1073.51
Bill No. 6E :Interchange (except Toll Plaza & Structure)	678,288,052.27	67.83
Bill No. 7 :Drainage and Protection Works	2,826,731,480.90	282.67
Bill No. 8 : Traffic signs, Road markings and other road appurtunences	98,307,481.32	9.83
Bill No. 9 : Boundary Wall, Crash Barrier & Noise Barrier	1,253,720,288.00	125.37
Bill No. 10 : Miscellaneous Works	388,498,400.00	38.85
Bill No. 11 : Bus Shelter	3,600,000.00	0.36
Bill No. 12: Toll Plaza	481,236,402.55	48.12
Bill No. 13 : Wayside Amenities		
Total Civil Cost excluding GST (In Rs.)	**22,002,273,239.82**	**2200.23**
Add GST 12%	**2,640,272,788.78**	
Total Civil Cost including 12% GST (In Rs.)	**24,642,546,028.60**	
Total Civil Cost (In Cr.)	**2,464.25**	
Project Length in Km.	**65.480**	
Civil Cost per Km (In Cr.)	**37.63**	

Chapter-11:
Economic & Financial Analysis

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CHAPTER-11: ECONOMIC ANALYSIS & FINANCIAL ANALYSIS

11.1 UPDATED ECONOMIC ANALYSIS

Given the importance of infrastructure investment to national development vis-à-vis the scarcity of resources and competing demands from various sectors, it becomes extremely important to allocate available resources in the most beneficial manner amongst various sectors and within a sector, amongst various schemes. In view of the above, it is necessary to ensure that the projects selected for investment are evaluated thoroughly to determine the economic and social benefits offered by the project.

11.1.1 Evaluation Framework

The proposed evaluation framework is based on a cost-benefit analysis, which sets a monetary value where possible on all financial, economic and social costs and benefits over the lifetime of the project.

The underlying principles for this analysis are as follows:

The lifetime of a road project for the present analysis is considered as the period for which reliable traffic forecasts can be made. A discount rate is then applied to future economic costs and benefits to arrive at the Net Present Value (NPV) of the project. The Economic Internal Rate of Return (EIRR) of the project is also computed.

To analyze the cash flow at constant prices, an allowance is made for relative price inflation.

The discount rate is expressed in real terms.

The standard methodology used for the economic evaluation for transport projects has been adopted. The concept of economic feasibility is to maximize the returns on investments. This is accomplished by determining the appropriate improvement proposal that leads to minimum total transport cost, which comprises of two basic components shown below.

Table 11.1: Total Transport Cost

Road Agency Cost	Road User Cost
Construction Cost	Vehicle Operating Cost
Maintenance Cost	Other User Cost (like travel time cost)

The reduced costs are treated as benefits calculated over the project life. The results are expressed in Economic Internal Rate of Return (EIRR) and Net Present Value (NPV). The economic analysis is carried out using World Bank developed “Highway Development and Management Model” (HDM-4). The model generates total transport costs (user plus agency cost) in “with” and “without” the project situation. The differences in costs due to road improvement (with the project) are considered as the benefit accruing from road improvement. In HDM-4, economic analysis is carried out using Project Analysis Option, which is concerned mainly with evaluation of investment options. The economic indicators such as the EIRR and NPV at the discount rate of 12 % are calculated.

In order to evaluate the pavement alternatives selected, analysis has been carried out using “present value” method. This helps to compare the costs related to the development using a particular type of pavement on present value terms. For carrying out the same, all costs are estimated at the anticipated years and have been discounted to the present day worth using a pre-determined discount rate.

11.1.2 Basic Approach and Methodology

Economic evaluation has been carried out based on incremental costs & benefits comparing the total net benefits in “Without project” situation with “With Project” situation. The term “Without project” is defined as the base strategy for economic analysis i.e. without project situation. The term “With project” is defined as widening and strengthening of existing facility. Economic analysis has been carried out for with time and accident benefits. Sensitivity analysis has been carried out for the four cases mentioned below, with both the Alternatives.

- Scenario - I Base Costs and Base Benefits
- Scenario - II Base Costs plus 1 5% and Base Benefits
- Scenario - III Base Costs and Base Benefits minus 15%
- Scenario - IV Base Costs plus 15% and Base Benefits minus 15%

11.1.3 Input to the Model

The HDM-4 working methodology requires specifying the traffic, road and environment procedure for the following:

- Characteristics of the road sections using road network manager
- Characteristics of the vehicles that use the road sections
- Traffic growth rates
- The proposed maintenance and road improvement works with their improvement cost

The values of input data that has been used in HDM Model for the present project are as follows: -

11.1.4 General Assumptions

The following assumptions were used for the analysis using the HDM Model.

Table 11.2: General Assumptions for HDM Model

Analysis period	20years
Discount rate	12%
Construction Period	30 Months
Commercial Date of Operation	1-Apr-21
Standard Conversion factor used for converting financial cost to economic cost	0.9
Salvage Value	15%

11.1.5 Road Characteristics

Some basic road characteristic that have been used as inputs to the model are: -

- Road Length, road width, shoulder width, Altitude, Rainfall in m/month, pavement subgrade, FWD deflection value, roughness of existing pavement etc.

Proposed Road

The road length of **65.48 Km** for **Phase 2** of STRR has been considered for the proposed road.

The results obtained from the analysis of Roughness survey and Condition Survey of Pavement has been used as an input to the model. Road deterioration factors that have been used for analysis as inputs to HDM model are given as under: -

- Cracking initiation 1.50
- Cracking Progression 1.50
- Ravelling initiation 1.00
- Pothole progression 1.50
- Rut depth progression 1.50

11.1.6 Traffic Forecast & Growth Rates

The Traffic Forecast figures have been considered from Chapter 7 for the Project.

11.1.7 Project Cost

Capital Cost

The financial capital cost is given at current prices inclusive of Civil and Non Civil works is INR 2039.38 Crores.

The construction cost includes cost of strengthening and upgrading existing 2-lane to 6 lane Facility and partially making Greenfield facility. Economic cost has been worked out by converting the financial cost using standard conversion Factor of 0.9 as suggested by World Bank for highway projects in India.

Routine and Periodic Maintenance

The various maintenance costs has been divided into two parts: routine and periodic maintenance. The salient features and construction policy for both types are mentioned below.

Routine and Periodic maintenance has been taken as given in the table below.

Table 11.3: Cost of Routine and Periodic Maintenance

	Financing Cost			Economic Cost		
	6 Lane	4 Lane	2 Lane	6 Lane	4 Lane	2 Lane
Routine Maintenance	1,407,101	938,067	562,840	1,266,390	844,260	506,556
Periodic Maintenance	9,045,645	6,030,430	3,618,258	8,141,081	5,427,387	3,256,432

11.1.8 Vehicle Characteristics

Basic Characteristics

The data as given in the table below have been obtained from manufacturer's literature and value of the average number of passengers for passenger vehicles are intercepted from origin and destination survey.

Table 11.4: Basic Vehicle Characteristic

Mode	GWT	PCSE	ESAL	Axles	Tyres
Car	1.2	1	0	2	4
2 Wheeler	0.2	0.5	0	0	2
3 Wheeler	0.5	1	0	0	3
Mini Bus	5.3	1.5	0.5	2	4
Bus	14.9	3	0.9	3	6
LMV	4.3	1	0.5	2	4
LCV 4 Wheeler	5.3	1	0.5	2	4
LCV 6 Wheeler	5.83	1.5	0.6	3	6

Mode	GWT	PCSE	ESAL	Axles	Tyres
2 Axle Truck	14.9	3	2.5	2	4
3 Axle Truck	17.8	3	3.2	3	6
MAV (4-6 Axle)	21	4.5	4.7	5	10
MAV (> 6 Axle)	24	4.5	5	6	12
Tractor Without Trailer	8	2	1	3	6
Tractor With Trailer	14.9	4.5	2.5	2	4

Vehicle Utilization

These data have been worked out on the basis of RUC and local enquires made in the area: -

Table 11.5: Vehicle Utilization Data

Mode	Hours Driven Per Year	Km Driven Per Year	New Vehicle Price (Rs)	New Tyre Price (Rs)	Maintenance Labor (Rs)	Crew Wages	Annual overheads cost	Passenger Time (Rs per	Passengers Non Work Time	Cargo Time (Rs veh hr)
Car	600	32,000	337,000	2,500	60		80,000	75	13	
2 Wheeler	600	32,000	60,000	900	40		6,625	40	7	
3 Wheeler	600	32,000	103,000	900	40		24,000	40	7	
Mini Bus	3,000	100,000	765,000	5,000	100	160	83,725	50	9	
Bus	3,000	100,000	1,530,000	7,500	125	80	155,000	50	9	
LMV	2,000	50,000	535,500	3,500	100	80	66,980			21
LCV 4 Wheeler	3,000	100,000	765,000	3,500	100	80	83,725			35
LCV 6 Wheeler	3,000	100,000	841,500	5,000	100	80	92,098			35
2 Axle Truck	3,000	100,000	1,009,800	7,075	100	160	184,195			35
3 Axle Truck	3,000	100,000	1,211,760	7,075	100	160	258,000			60
MAV (4-6 Axle)	3,000	100,000	1,454,112	7,075	100	160	283,800			60
MAV (> 6 Axle)	3,000	100,000	1,744,934	7,076	100	160	283,800			60
Tractor Without Trailer	3,000	100,000	765,000	5,000	100	80	92,098			35
Tractor With Trailer	3,000	100,000	918,000	7,075	100	160	184,195			35

11.1.9 Results of Economic Appraisal

Using the data input to the Model HDM the annual stream of cost savings (VOC + journey Time cost saving) derived from analysis "Without" Project (base case) and "With" project is developed. The Sensitivity analysis has been carried out as per the requirements of TOR.

The relevant EIRR and corresponding NPV are presented below for each option.

Table 11.6: Summary of EIRR and NPV

	Package 1	
Scenario	**EIRR (%)**	**NPV (million)**
Scenario 1:Base Costs and Base Benefits	20.9	17,434
Scenario 2:Base Costs Plus 15% and Base Benefits	19.8	15,028
Scenario 3:Base Costs and Base Benefits Minus 15%	19.0	15,057
Scenario 4:Base Costs Plus 15% and Base Benefits Minus 15%	18.0	12,651

11.1.10 Conclusions

EIRR for current project proposal give a higher value as compared with the cut-off rate (12 %). Also the sensitivity analysis also shows that for current project proposal, considering the worst case, EIRR remains above cut-off rate. It is, therefore concluded that the project is economically viable at current price.

Annexure 11.1

HDM-4

HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Analysis Summary

Study Name: **STRR-PHASE 2**
Run Date: **03-05-2019**
Currency: **Indian Rupee (millions)**
Discount: **12.00%**
Analysis Mode: **Analysis-by-Project**

Alternative: STRR 6L vs Alternative: DO Nothing
Sensitivity Scenario: Base Sensitivity Scenario

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Costs	Savings in NMT Trav & Operating Costs	Reduction in Acciden Costs	Net Social / Exogenous Benefit	Net Economic Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	15,522.80	-24.95	0.00	97,447.67	41,014.72	0.00	0.00	0.00	122,964.54
Discounted	15,853.00	-9.07	0.00	23,644.77	9,833.55	0.00	0.00	0.00	17,434.38

Economic Internal Rate of Return (EIRR) = 20.9% (No. of solutions = 1)

Alternative: STRR_6L vs Alternative: DO_Nothing
Sensitivity Scenario: 15% Less Traffic

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Costs	Savings in NMT Trav & Operating Costs	Reduction in Acciden Costs	Net Social / Exogenous Benefit	Net Economic Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	15,522.80	-24.95	0.00	88,750.76	40,296.19	0.00	0.00	0.00	113,549.12
Discounted	15,853.00	-9.07	0.00	21,425.54	9,446.45	0.00	0.00	0.00	15,026.06

Economic Internal Rate of Return (EIRR) = 19.8% (No. of solutions = 1)

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H D M - 4 **Economic Analysis Summary**

Alternative: STRR 6L vs Alternative: DO Nothing
Sensitivity Scenario: 15% More Cost

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Costs	Savings i NMT Trav & Operating Costs	Reductio in Acciden Costs	Net Social / Exogenous Benefit	Net Economic Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	17,851.21	-28.69	0.00	97,447.67	41,014.72	0.00	0.00	0.00	120,639.86
Discounted	18,230.95	-10.43	0.00	23,644.77	9,833.55	0.00	0.00	0.00	15,057.80

Economic Internal Rate of Return (EIRR) = 19.0% (No. of solutions = 1)

Alternative: STRR 6L vs Alternative: DO Nothing
Sensitivity Scenario: 15% Less Traffic+15% More Cost

	Increase in Road Agency Costs			Savings in M VOC	Savings in M Travel Tim Costs	Savings i NMT Trav & Operating Costs	Reductio in Acciden Costs	Net Social / Exogenous Benefit	Net Economic Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	17,851.21	-28.69	0.00	88,750.78	40,296.19	0.00	0.00	0.00	111,224.43
Discounted	18,230.95	-10.43	0.00	21,425.54	9,446.45	0.00	0.00	0.00	12,651.47

Economic Internal Rate of Return (EIRR) = 18.0% (No. of solutions = 1)

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11.2 FINANCIAL ANALYSIS

11.2.1 Introduction

The financial feasibility of the proposed project options is based on the Project Cost and uses toll revenues as the key parameter to assess the Internal Rate of Return (IRR), which is a preferred Discounted Cash Flow technique for financial analysis.

11.2.2 Cost of the Project

The basic project cost for financial analysis is given below.

Phase	Length	Cost
II	65.48 KM	INR 2200.23 Crores

11.2.3 Means of Finance

A simple mix of bank loan and promoters' equity is assumed for analysis in 70%: 30% proportion of debt equity. In realistic situation it may be a mix of equity/ IPO, preference capital, debt, debentures, etc. However, it will not alter our analysis and hence simple capital structure is assumed.

11.2.4 Inflation and Rate of Interest

Observing current trend, GDP growth, domestic and forex markets, it may be reasonable to assume that average inflation may remain in the range of 5% on year to year basis. All the direct costs are inflated at this rate. Rate of interest on term loan is taken at 11% per annum. This is realistic to conservative estimate. Tenure of loan is 12 to 14 years and interest is on reducing balance.

11.2.5 Toll Revenue

The yearly toll revenue has been calculated in Rs. and tabulated below.

Table 11.7: Yearly Toll Revenue

Year	Daily Rs Lacs)	Yearly Rs (Cr)	Year	Daily Rs Lacs)	Yearly Rs (Cr)
2019	8.51	26.41	2036	163.08	507.36
2020	9.79	30.46	2037	186.34	578.13
2021	14.68	45.55	2038	212.73	659.99
2022	21.42	66.45	2039	242.99	753.88
2023	28.33	87.88	2040	278.35	865.93
2024	32.40	100.79	2041	317.79	985.94
2025	37.03	114.87	2042	362.92	1125.96
2026	42.26	131.11	2043	414.01	1284.46
2027	48.23	149.63	2044	473.73	1473.76
2028	55.41	172.38	2045	541.61	1680.36
2029	63.53	197.11	2046	617.05	1914.40
2030	72.80	225.87	2047	703.16	2181.55
2031	83.27	258.33	2048	802.41	2496.30

Year	Daily Rs Lacs)	Yearly Rs (Cr)	Year	Daily Rs Lacs)	Yearly Rs (Cr)
2032	95.21	296.21	2049	915.63	2840.75
2033	108.77	337.45	2050	1043.54	3237.59
2034	124.19	385.29	2051	1189.20	3689.50
2035	142.47	442.01	2052	1354.20	4212.93

11.2.6 Other Factors

Income statement nets out expenses towards collection of toll and also, administration at the suggested rates by engineers. Routine maintenance and Periodic maintenance are envisaged as per standard norms of maintenance.

11.2.7 Corporate Tax Rate:

30% Tax + 10% surcharge + 3% educational cess = (30% x (1.10)) x 1.03 = 33.99%

11.2.8 Applicable Sections Considered in Tax Calculations:

Section 80 I A

Deduction of an amount equal to 100% of the profits and gains for ten consecutive assessment years.

It may at the option of the assesses, claim the deduction for any 10 consecutive assessment years out of 15 years beginning from the year in which the undertaking or the enterprise develops and begins to operate the infrastructure facility.

Section 115 j B

Minimum Alternative Tax

Deductions under 80 HHB and 80 HHC are explicitly admissible under MAT provisions. However, 80 I A benefit is apparently not admissible for deduction under MAT.

11.2.9 Mat Rate:

10% MAT + 10% surcharge + 3% Educational Cess = (10% x (1.10)) x 1.03 = 11.33%

11.2.10 Logic Design of Tax Calculation:

For Corporate Tax:

- 80 I A benefit is to be availed of, within first 15 years of operation. Hence latest years in which we start availing of tax benefit is 6th year of operation.
- Project is likely to make losses in first few years of operation. Hence tax payable may be NIL. In such year(s), till we start making book profit, tax benefit of 80 I A is not availed of. This is subject to (a) above.
- Loss is carried forward for the purpose of tax calculation as permissible.

For MAT:

- 80 I A benefits not admissible under provisions of MAT.
- Unabsorbed depreciation is not carried forward for tax deduction.
- Loss other than unabsorbed depreciation is carried forward.
- The undertaking / Enterprise would pay corporate tax / MAT whichever is higher.

11.2.11 Results

It is concluded that the project is not viable on commercial format. The traffic on the project stretch is considerably low. At 40% grant component, the Project IRR and Equity IRR are coming at **12.0%** and **13.1%** for **Phase 2.** The Analysis has been carried out by providing brand new Satellite town ring road. The Project may be implemented on differed payment system, which is Annuity based or else on EPC contract basis with Government fund.

Annexure 11.2

Phase 2

Rs in Million

Financial Year (Ending)	COST						Total Revenue	Net Cash Flow before Tax	Opening balance for Interest	Interest	Depriciation		Profit before Tax (PBT)	Liability	Profit after Tax (PAT)	Net Cash Flow after Tax	Principal Repay-ment	Total Expense	Equity Cash Flow	Cum. Cash Flow	DSCR
	Constru ction	Insaura nce	Maintenance		Toll Admn.	Total					WDV	SLM		MAT Tax							
			Routine	Periodic																	
2019	4202					4202		-4202	2801							-4202			-1401	-1401	
2020	5603					5603		-5603	3735							-5603			-1868	-3268	
2021	4202	17.5	48.1		189.3	4457		-4457	2801		1167	424	-5624		-5624	-4457			-1401	-4669	
2022		33.3	101.1		397.5	532	370	-162	8404	987	2218	849	-3367		-3367	-162	934	2453	-2084	-6752	-0.1
2023		29.9	106.2		417.4	553	977	424	7470	878	1996	849	-2450		-2450	424	934	2365	-1388	-8140	0.2
2024		26.9	111.5		438.3	577	1121	544	6536	768	1796	849	-2020		-2020	544	934	2278	-1157	-9297	0.3
2025		24.3	117.0		460.2	601	1278	676	5603	658	1617	849	-1599		-1599	676	934	2194	-916	-10213	0.4
2026		21.8		790	483.2	1295	1458	163	4669	549	1455	849	-1840		-1840	163	934	2777	-1319	-11532	0.1
2027		19.6	129.0		507.4	656	1664	1008	3735	439	1310	849	-740		-740	1008	934	2029	-364	-11897	0.7
2028		17.7	135.5		532.7	686	1917	1231	2801	329	1179	849	-276		-276	1231	934	1949	-32	-11928	1.0
2029		15.9	142.3		559.4	718	2192	1475	1868	219	1061	849	195	63	131	1412	934	1934	258	-11670	1.2
2030		14.3	149.4		587.3	751	2512	1761	934	110	955	849	697	226	471	1535	934	2021	492	-11178	1.5
2031		12.9	156.8		616.7	786	2873	2087			859	849	1228	398	829	1688	934	2118	755	-10424	1.8
2032		11.6		1059	647.5	1718	3294	1577			773	849	803	146	658	1431		1863	1431	-8993	
2033		10.4	172.9		679.9	863	3753	2890			696	849	2194	408	1786	2482		1272	2482	-6511	
2034		9.4	181.6		713.9	905	4285	3380			626	849	2754	506	2248	2874		1411	2874	-3637	
2035		8.5	190.6		749.6	949	4916	3967			564	849	3404	624	2780	3343		1573	3343	-294	
2036		7.6	200.2		787.1	995	5643	4648			507	849	4141	760	3381	3888		1755	3888	3594	
2037		6.8	210.2		826.4	1043	6430	5387			457	849	4930	908	4022	4479		1951	4479	8073	
2038		6.2		1419	867.8	2293	7340	5048			411	849	4637	840	3797	4208		3133	4208	12281	
2039		5.5	231.7		911.1	1148	8385	7236			370	849	6867	1278	5589	5958		2426	5958	18239	
2040		5.0	243.3		956.7	1205	9631	8426			333	849	8093	1516	6577	6910		2721	6910	25149	
2041		4.5	255.5		1004.5	1265	10966	9701			300	849	9402	1771	7630	7930		3036	7930	33079	
2042		4.0	268.2		1054.8	1327	12523	11196			270	849	10926	3545	7381	7651		4872	7651	40730	
2043		3.6	281.7		1107.5	1393	14286	12893			243	849	12650	4104	8546	8789		5497	8789	49519	
2044		3.3		1901	1162.9	3067	16391	13324			218	849	13106	4252	8853	9072		7319	9072	58590	
2045		2.9	310.5		1221.0	1534	18689	17155			197	849	16958	5502	11456	11653		7037	11653	70243	
2046		2.7	326.1		1282.1	1611	21292	19681			177	849	19504	6328	13176	13353		7939	13353	83596	
2047		2.4	342.4		1346.2	1691	24263	22572			159	849	22413	7272	15141	15300		8963	15300	98897	
2048		2.1	359.5		1413.5	1775	27764	25989			143	849	25846	8386	17460	17603		10161	17603	116500	
							Pre Tax FIRR ==>	**13.4%**	**30-Years**						Post Tax FIRR ==>	**12.0%**	Equity FIRR ===>		**13.1%**		**0.7**

Chapter-12:
Proposed Phasing

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CHAPTER-12: PROPOSED PHASING

The proposed alignment of 179.969km passes through three districts of Karnataka state and one district of Tamil Nadu state as follow.

Karnataka state

- Bangalore Rural District: km 0.00 to km 19.500
- Ramanagara district: km 19.500 to km 119.630
- Bangalore Urban district: km 119.630 to 134.630

Tamil Nadu State

- Krishnagiri district: km 134.630 to km 179.969

The STRR project road pass through Banneragatta National Park (BNP) from km 115.000 to km 121.500 and the Eco sensitive Zone boundary of Bannerghatta National Park from km 95.525 to km 138.000 (include BNP core area). Considering the time requirements of BNP Wildlife Clearances from Wildlife Board, the overall project proposed to consider in 3 phases as below.

Phase-1:

The portion start from km 0 (NH 207 - km 131.255) to km 79.000 (before cross point of existing SH 3 - km 52.700) (total length 79.000Km). In order to consider each phases in standalone manner, existing road connectivity to the nearest NH/SH, cross point junction also taken into account. Even though, the nearest existing junction accordingly is on NH-209 at km 95.700, the proposed alignment at that location is passing within the Eco-Sensitive Zone around BNP. Therefore, the end point of Phase-1 is aptly considered at km 79.000 (before proposed junction at existing Km 52.700 of SH-3) as the entire proposed portion falls out of preview of Bannerghatta National Park (BNP). The Phase 1 further divided in two contract packages.

1. **Package 1: from km 0.000 to km 46.300 (after Magadi Interchange)**

   Total length 46.300km

   This section consists

   - Interchanges @ km 0.500, km 8.900, km 12.900 & km 30.400
   - ROBs @ km 8.900 & km 29.280

The end Chainage kept as km 46.300 considering incase, if Package 2 is getting delayed in implementation, the end of Package 1 will merged with existing SH 3 without provision of VUP at km 46.300 so to function as individual package and to ensure individual connectivity to existing road network.

2. **Package 2: from km 46.300 to km 79.000**

   Total length 32.700km

   This section consists

   - Interchanges @ km 44.600 & km 70.350
   - ROB @ km 71.030

The start Chainage kept as km 46.300 considering, in case if Package 1 is not taking off or getting delayed in implementation, this Package start point will merged with existing SH 3 without provision of VUP at km 46.300 so to function as individual package and to ensure individual connectivity to existing road network. The end portion also considered keeping in view the existing SH3

Phase-2

The portion from km 79.000 (before junction with cross point of existing SH 3 - km 52.700) to km 144.480 (total length 65.480km) is considered as Phase 2. It will attract Wildlife Clearances from National Board for Wildlife (NBWL).

1 **Package 1: from km 79.000 to km 112.600 (Before Banneragatta National Park (BNP) proposed elevated structure start)**
Total length 33.600km
This section consists
   - Interchange @ km 95.700

2 **Package 2: from km 112.600 to km 120.700**
Total length 8.100km
   - This section consist of proposed elevated structure in the entire core area of BNP and in the adjoining ESZ area @1km each on both sides including approaches totaling the package length to 8.100km.

3 **Package 3: from km 120.700 to km 144.480**
Total length 23.780km
This section consists
   - Interchange @ km 132.300 & km 139.600

The Phase II considered in 3 packages due to involvement of elevated structure in the BNP core area including in the adjoining ECZ of one km each on both sides. Considering the nature of structure works and combined civil cost, it is propose to consider in three smaller packages

Phase-3

The portion from km 144.480 to km 179.969 (total length 35.489km) consider as Phase 3 as this portion falls out of preview of BNP

The proposals submitted and approved rom NHAI.

1 **Package 1: from km 144.480 to km 179.969**
Total length 35.489km
   - Interchange @ km 145.100 & km 153.350, km 155.500 &km 161.450
   - RUB at km 154.840

The start Chainage kept as km 144.70 considering in case if Phase II delayed in implementation, the Phase III start will merge with existing SH 17A. The provision of grade separator in SH 17A will ensure seamless connectivity. The approach towards BNP side of this grade separator will blocked for public use until Phase II implemented.

The proposed packages already discussed with NHAI and intimated through our letter dated 25/02/2019 and forwarded to RO/NHAI from NHAI through letter dated 26/02/2019

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Chapter-13:
Road Safety Audits

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CHAPTER-13: ROAD SAFETY AUDITS

13.1 GENERAL

In order to focus the attention of central and local road authorities on road safety, many industrialized countries have made the improvement of road safety a statutory duty. Under such legislation, each level of local authority which acts as a road authority is required to undertake road safety activities on its road network. This often includes the collection of accident data, accident analysis, and the definition of Black spots and the design of remedial measures. In recent years, mandatory "Road Safety Audits" have also been added to the list of responsibilities.

Road safety audit is a formal procedure for assessing accident potential and safety performance in the provision of new road schemes, the improvement and the rehabilitation of existing roads and in the maintenance of existing roads. They should be an integral part of highway planning, design, construction and maintenance.

The road safety audit process requires an objective approach to the assessment of accident risk. A team, which is independent of the design team, should undertake the safety audit. The principal method of ensuring this objectivity is through the independent assessment of schemes by persons unconnected with the original design. Accordingly the team should have specialist expertise in the fields of road safety engineering, accident investigation and prevention. Road safety audit has investigation and prevention. Road safety audit has been undertaken in the UK since 1990 and the practice has been adopted elsewhere in the world, notably New Zealand, Australia and Denmark. There exists, therefore, a wealth of experience in its operation and in the benefits that it can bring. Whilst the potential benefits from safety audits are difficult to quantify, both due to the uncertainty of estimating the number of accidents that would have occurred had there been no audit, and the lack of control data to make comparison with unaudited schemes, evidence from overseas countries is accumulating which suggests that the benefits can be high. Nevertheless, safety audit should form part of a broader road safety strategy, with priorities set within an overall programme of highway schemes.

To be fully effective, the process requires commitment amongst politicians, both in central and state government, top management and line managers in any road commissioning, design or construction organization together with awareness of the role and benefits of safety audit.

Whatever the defined legal responsibilities, in India and elsewhere road authorities are implicitly responsible for the safe operation of the roads they design or rehabilitate and for improving safety on existing roads. They should thus apply safety principles in the provision, improvement and maintenance of roads as a means of accident prevention through road safety audits.

There is often insufficient money to cover routine and periodic maintenance. Road safety and related matters are usually low on the list of priorities. This is despite road safety improvements being cost effective with very high savings (in reduced accidents) being achieved which are many times the cost of countermeasures implemented. Hence the improvement of known hazards should form part of every road authority's annual programme.

For example, the use of road signs and markings to channelise traffic through complex junctions, or to provide safe waiting areas for turning vehicles, can often result in substantial reductions in accidents. Yet, because of lack of funds and poor maintenance capability, known hazardous locations are often left untreated and remain the cause of accidents.

Drivers are often presented with misleading information or no advance warning, sight lines may be inadequate, pedestrians may not be catered for, and accidents may occur because of a driver's inability to cope with the particular combination of circumstances and environment. By identifying and eliminating the features which make sites hazardous, engineers can improve road safety. This often means reducing the complexity of a junction or enabling maneuvers to be made in stages. Reducing the number of decisions drivers must make at any one time simplifies the driving task and helps drivers to progress in safety and comfort with a minimum of conflict with other road users. Despite increasing car ownership, public transport is and will continue to be a key component of people's mobility in fulfilling their needs for work, social and recreational travel. Public transport provides an efficient use of road space and, by the correct planning of transport and people's activities, the number of road accidents can be reduced and the overall safety and efficiency of the road network increased. However, when accidents with buses do occur they often incur much casuality, and the common perception is probably that there have been too many bus accidents in recent years, as they tend to make media headlines.

Bus driver behavior is not exemplary with much speeding and frequent lane changing. In congested conditions, public transport accessibility could be greatly improved through the use of segregated bus lanes, which would improve safety by reducing the need for speeding and reduce the frequent lane changing seen. Bus stops are also the source of many accident problems and the careful design of waiting areas for both passengers and buses can greatly improve safety in both urban and rural areas.

Currently there is insufficient consideration given to the needs of the more 'Vulnerable Road Users' (VRUs) by drivers, planners or designers of the road network. These VRUs include pedestrians, cyclists, motorcyclists and moped riders, auto-rickshaws, those riding or driving animals or with animal driven carts. Driver behavior towards those in smaller vehicles or on foot can generally be described as aggressive. Although some segregated crossings are provided, facilities for pedestrians are still far from adequate, with few channelizing devices or traffic islands to break up the traffic flows and provide a safe refuge for pedestrians to cross several streams of traffic. VRUs make up a substantial proportion of road accidents in urban areas and probably a high proportion in rural areas where under reporting of accidents is considered to be most prevalent.

Planning has a profound effect upon the level of road safety and can have a major impact upon pedestrian accidents in particular. Sensitive planning of residential areas and highway networks can ensure that through traffic is rerouted to more suitable roads and that the right sort of environment is created for the road users likely to use each type of road. Geometric design normally seeks to ensure uniformity of alignment and maximum levels of safety and comfort for drivers using the road, within given economic constraints. Compromises are inevitable to achieve an acceptable solution and not all objectives can be fully met. Often, however, it is possible markedly to improve road safety characteristics at little or no extra cost provided the road safety implications of design features are considered at the design stage. Safety should be assessed by consideration of appropriate checklists or audits of the design stages. Keeping in view all the factors the road safety audit have been done during the feasibility stage by ICT's team comprising road safety specialist, road design engineer and traffic engineer with safety audit experience.

13.2 PROCEDURE OF SAFETY AUDITS

Road safety audit is a formal examination of an existing or future road or traffic project, or any project which interacts with road users, in which an independent, qualified examiner looks at the projects accident potential and safety performance. The basis for road safety audits is the systematic application of safety principles. Specific aims are:

- To minimize the risk of accidents occurring on the scheme, and to minimize the severity of accident that do occur;
- To minimize the risk of accidents occurring on adjacent roads as a result of a scheme, i. e. to avoid creating accidents elsewhere on the network:
- To recognize the importance of safety in highway design to meet the needs and perceptions of all types of road user: and to achieve a balance between needs where they may be in conflict;
- To reduce the long term costs of a scheme, bearing in mind that unsafe designs may be expensive or even impossible to correct at a later stage; and
- To improve the awareness of safe design practices by all involved in the planning, design, construction and maintenance of roads.

The objective was to undertake a road safety audit at different stages for the project road to identify locations of potential safety hazard and to suggest appropriate measures to enhance safety along the road. In this study safety audits have been proposed to be done in the following three stages

- Feasibility Stage
- Preliminary Design Stage
- Detailed Design Stage

The following background information will be taken into account for carrying out the safety audit at different stages.

- A set of drawings showing the horizontal and vertical alignment.
- Typical cross section drawings.
- A set of detail cross section drawings.
- A set of drawings showing typical intersection layouts and design layouts at particular junctions.
- Traffic flow and composition (including non motorized vehicles)
- The design reports

13.3 CHECKLISTS

Checklists will be used to ensure a through coverage of the design issues over the full length of the road in each stage of the design.

13.4 FEASIBILITY STAGE

By providing a specific safety input at the feasibility stage of a scheme, road safety audit can influence fundamental issues such as route choice, standards, impact on and continuity with the existing adjacent network, and intersection provision. For traffic management schemes/ small improvements, this stage may be less significant.

13.4.1 Safety Audits

In the feasibility stage the road safety audits for STRR project (km 79.000 to km 144.170) have been done to review the proposed design from a road safety perspective. The following points were checked.

Contents	Items	Remarks
Aspects to be checked	(a) Safety and operational implications of proposed alignment and junction strategy with particular references to expected road users and vehicle types likely to use the road	Yes
	(b) Width options considered for various sections	Yes
	(c) Departures from standards and action taken.	Yes
	(d) Provision for pedestrians, cyclists and intermediate transport.	Yes
	(e) Safety implications of the scheme beyond its physical limits i.e. how the scheme fits into its environs and road hierarchy.	Yes
(i) General	• Departures from standards	Yes
	• Cross-sectional variation	Yes
	• Drainage	Yes
	• Climatic conditions	Yes
	• Landscaping	Yes
	• Services apparatus	Yes
	• Lay-byes	Yes
	• Footpaths	Yes
	• Pedestrian crossings	Yes
	• Access (minimize number of private accesses)	Yes
	• Public Transport	Yes
	• Future widening	Yes
	• Staging of contracts	Yes
	• Adjacent development	Yes
(ii) Local Alignment	• Visibility	Yes
	• New / Existing road interface	Yes
	• Safety Aids on steep hills	Yes
(iii) Junctions	• Minimize potential conflicts	Yes
	• Layout	Yes
	• Visibility	Yes
(iv) Non-motorized road users Provision	• Adjacent land	Yes
	• Pedestrians	Yes
	• Cyclists	Yes
	• Non-motorized vehicles	Yes

Contents	Items	Remarks
(v) Signs and Lighting	• Lighting • Signs / Markings	Yes Yes

13.5 RECOMMENDATIONS

The project team has responded to the audit report. In Stage 1 (Feasibility Stage) auditors, recommendations were taken into consideration. All the audit recommendations for this stage are incorporated and accordingly feasibility report has been prepared.

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Chapter-14:
Conclusions & Recommendations

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CHAPTER-14: CONCLUSIONS & RECOMMENDATIONS

14.1 GENERAL

The proposed STRR phase 2 starts from km 79.000 and terminates at km 144.1480 constituting a length of 65.480km of fully Greenfield highway. The proposed road passes through Ramanagara and Bangalore urban districts of Karnataka state and Krishnagiri district of Tamil Nadu state.

The proposed Greenfield highway will be of 6 lanes facilities as per IRC SP 87-2013. All proposed major intersection points will provisioned with uninterrupted free flow traffic arrangement.

This phase consists one major bridge and eight minor bridges. In addition, 16 Vehicular Underpasses, 10 Vehicular Overpasses, 18 Light Vehicular Underpasses and three interchanges are propose for uninterrupted free flow traffic

14.2 CONCLUSIONS & RECOMMENDATIONS

- To ensure safe, smooth and efficient transport corridor to Bangalore city, it is impetus that infrastructure of city and adjoining towns anticipated the development.
- National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of this traffic are not intend to pass through the Bangalore city.
- The proposed road facility connect important satellite towns such as Dobbasapete, Magadi, Ramanagara, Kanakapura and Anekal in Karnataka & Hosur in Krishnagiri district
- Hosur is an automobile industry town located near to Karnataka state border and generates huge amount of through traffic this proposed facility will ease traffic in Hosur city.
- Considering the Banneragatta National Park's wildlife Clearances involved in the project it is proposed to take up in project in three phases so that the section which is encumbrance free from BNP wildlife Clearances and could get implemented without any delays
- A comprehensive set of traffic surveys and analysis reveal a six-lane facility to the entire corridor.
- The economic appraisal of the project reveal that the project as a whole is economically viable considering direct benefits.

The project is not viable on commercial format. Therefore recommended to take up on Annuity or EPC mode for implementation