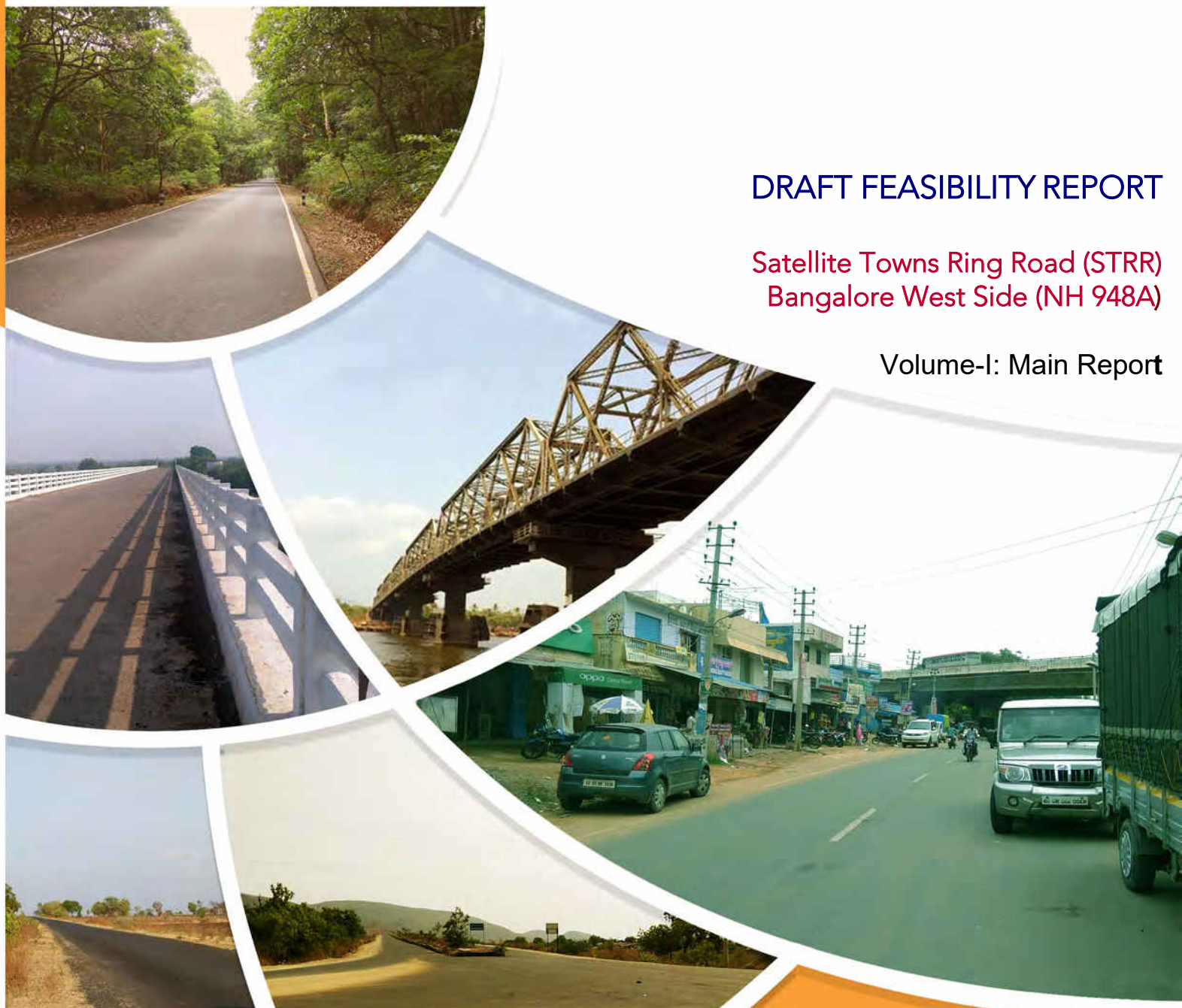
CONSULTANCY SERVICES FOR
PREPARATION OF DPR FOR DEVELOPMENT OF

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



DRAFT FEASIBILITY REPORT

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

Volume-I: Main Report

Louis Berger

May 2018

DRAFT 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*	
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MAIN INDEX

DRAFT FEASIBILITY REPORT

VOLUME I: MAIN REPORT

Chapter-1:
Executive Summary

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER-1: EXECUTIVE SUMMARY

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 – Tachoor 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 present report forms part of Stage 2 - Draft Feasibility Report

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

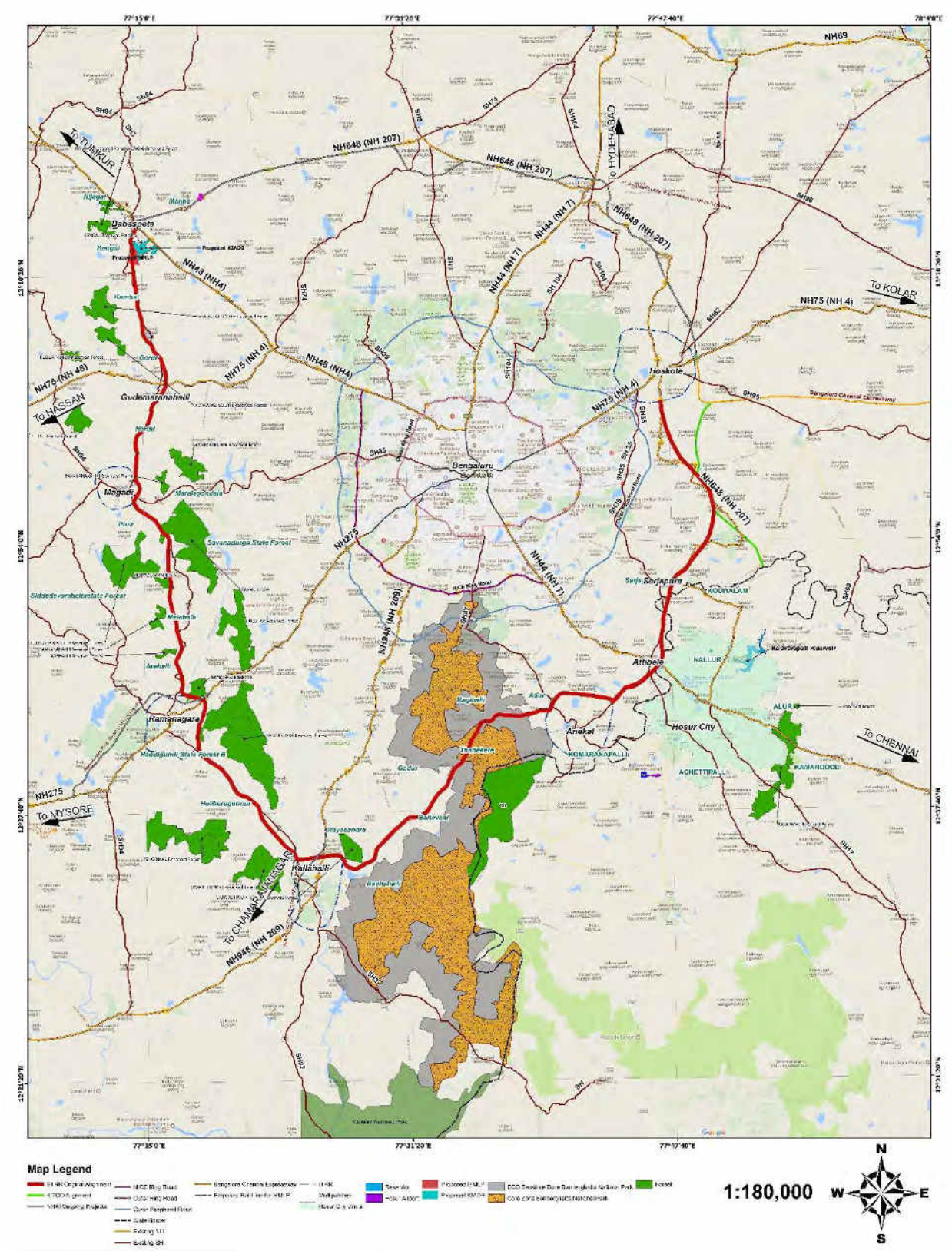


Figure .1.1: Original STRR Alignment as think of by Karnataka State Government

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.**

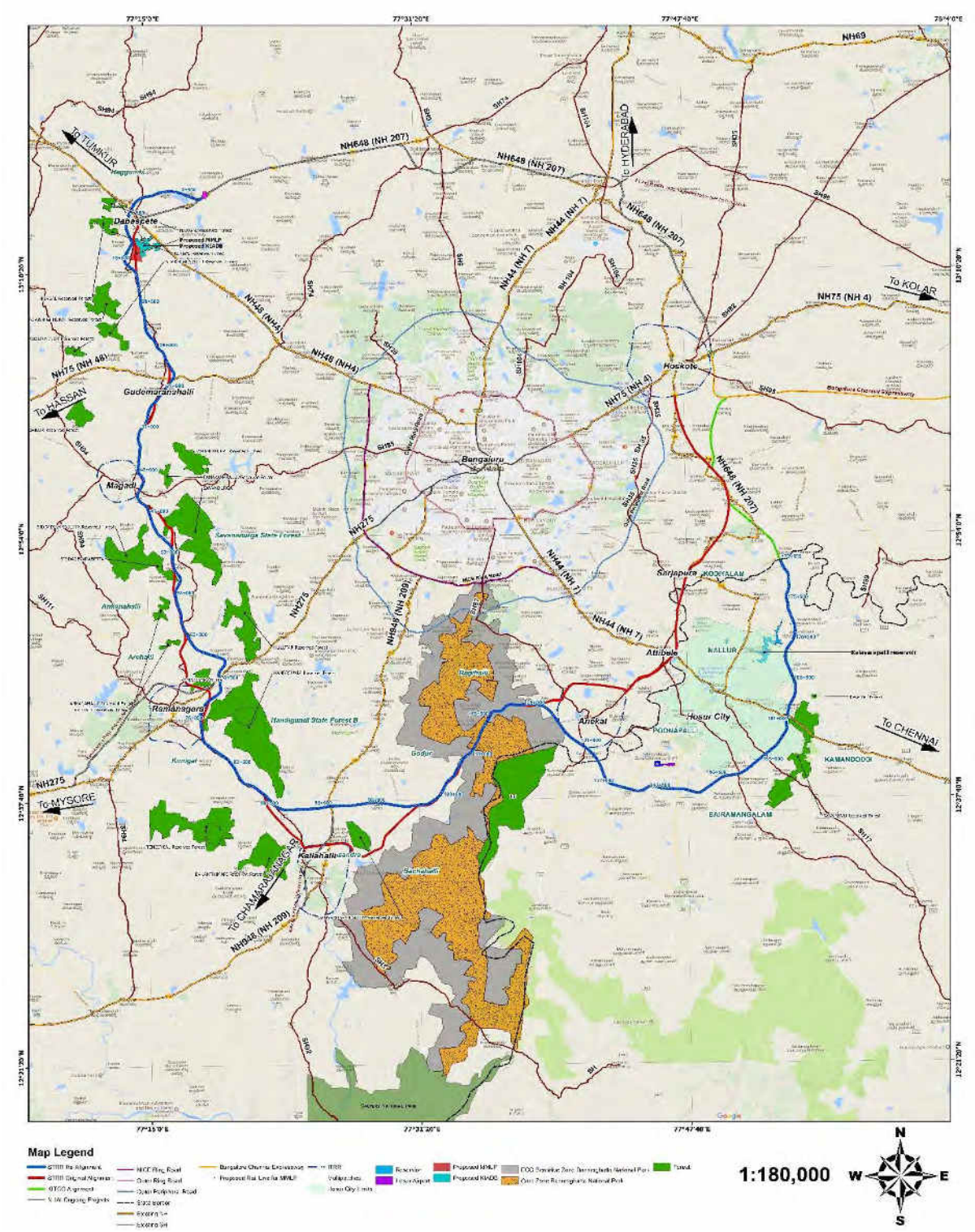


Figure 1.2: Final Alignment

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 75m 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	43746	17142	31159	8524	24061	42718
PCU	70014	12648	31660	7426	28247	66747

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	553	12	22	1732	478	692	12

	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
(4 Wheels)							
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**

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 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

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 as per analysis.

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 six 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	Design Chainage (km)		Cumulative Standard Axle (CSA) - in msa			Design Traffic (20 year Design Period)	Design Traffic (30 year Design Period)
	From	To	15th Year	20th Year	30th Year		
HS 1: Dobbasapete to Gudemaranahalli	0.00	30.00	53.78	87.91	199.92	90	200
HS 2: Gudemaranahalli to Magadi	30.00	44.00	32.02	52.37	119.32	55	120
HS 3: Magadi to Ramanagara	44.00	70.00	24.67	40.39	92.46	45	95

Homogeneous Section	Design Chainage (km)		Cumulative Standard Axle (CSA) - in msa			Design Traffic (20 year Design Period)	Design Traffic (30 year Design Period)
	From	To	15th Year	20th Year	30th Year		
HS 4: Ramanagara to Kallahalli/Kanakapura	70.00	98.00	21.05	34.58	79.82	40	80
HS 5: Kanakapura to Anekal	98.00	137.00	37.52	61.56	141.46	65	145
HS 6: Anekal to KN/TN Border	137.00	185.00	60.60	99.18	226.53	100	230

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.

Pavement Option - Flexible

	HS-1	HS-2	HS-3	HS-4	HS-5	HS-6
Traffic	**90 msa**	**55 msa**	**45 msa**	**40 msa**	**65 msa**	**100 msa**
Bituminous Concrete (BC)	50	50	40	40	50	50
Dense Bituminous Macadam (DBM)	110	90	95	90	95	115
Wet Mix Macadam (WMM)	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200
Subgrade (CBR >= 8%)	500	500	500	500	500	500

Pavement Composition - CT Base

	HS-1	HS-2	HS-3	HS-4	HS-5	HS-6
Traffic	**200 msa**	**120 msa**	**95 msa**	**80 msa**	**145 msa**	**230 msa**
Bituminous Concrete (BC)	50	50	50	50	50	50
Dense Bituminous Macadam (DBM)	50	50	50	50	50	50
Crack Relief Layer /Wet Mix Macadam (WMM)	100	100	100	100	100	100
Cement Treated Base (CTB)	185	175	170	165	180	185
Granular Sub-base (GSB)	250	250	250	250	250	250
Subgrade (CBR >= 8%)	500	500	500	500	500	500

Rigid pavement:

- 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 >= 8%) 500 mm

PAVED SHOULDER

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

1.4.3 Bridges and Structures

Preliminary assessment are made from topo sheet and following cross drainage structures re envisaged. This will be further studied after completion of topo sheet and the proposals will be further modified as per site requirements

No of Cross Drainage Structures Envisaged

No.	Section Name	No. of Structures			
		Pipe Culverts	Box Culverts	Minor Bridges/ Canal crossing	Major Bridges
1	No. of cross drainage	114	201	15	5
	Total				335

In order to ensure uninterrupted free flow traffic all major interchanges are proposed with grade separated structures. The details of locations are as follow.

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

1.5 PRELIMINARY COST ESTIMATES

The consultants have framed the indicative project cost for 4lanes with paved shoulder configuration. Three options are worked out for flexible pavement, Cement treated base type and rigid pavements.

- Flexible Pavement: INR 5690.31crores and the cost per km is INR 31.62crores
- Cement Treated Base: INR 5654 crores and the cost per km is INR 31.41crores
- Rigid Pavement: INR 6171.0crores and the cost per km is INR 34.29crores

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	EIRR (%)	NPV(million)
Scenario 1:Base Costs and Base Benefits	18.3	42,346
Scenario 2:Base Costs Plus 15% and Base Benefits	17.9	37,887
Scenario 3:Base Costs and Base Benefits Minus 15% 12.32% 519.4	16.5	33,373
Scenario 4:Base Costs Plus 15% and Base Benefits Minus 15% 12.00% 434.6	16.1	28,916

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 the project is economically viable at current price.

1.7 FINANCIAL ANALYSIS

It is concluded from financial analysis 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 **10.6%** and **11.4%.** The Analysis has been carried out by providing brand new Satellite town ring road.

Therefore the Project may be implemented on differed payment system, which is Annuity based or else on EPC contract basis with Government fund.

1.8 CONCLUSIONS AND RECOMMENDATIONS

- 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.
- The proposed road facility will able to connect important towns such as Dobaspete, Magadi, Ramanagara, Kanakapura and Anekal in Karnataka (134.331km) and Hosur in Krishnagiri district (.45.331km)
- 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 and this proposed facility will ease traffic in Hosur city.
- A comprehensive set of traffic surveys conducted along the project road. The project road divided in 7 homogeneous sections. Traffic volume count conducted at 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 and other three sections HS1, HS2, and HS 3 require six lanes in later as per analysis. Therefore, a six lane facility to the entire corridor is proposed.
- The economic appraisal of the project carried out comprising costs of developing the project with direct benefits (Vehicle operating cost and time saving) to the road user likely to use the project road. The analysis reveal that the project as a whole is economically viable considering direct benefits. The indirect benefits such as environmental benefit, reduction in accident, reduction in congestion level in the area were however not considered.
- The financial analysis carried out and concluded that the project is economically viable at current price. Therefore is recommended to take up on Annuity or EPC mode for implementation.
- Considering the Banneragatta National Park's wildlife Clearances involved in the project it is proposed to take up in project in three phases. The section from km 0 to km 82.200 and from km 138.000 to km 179.969 are encumbrance free from BNP wildlife Clearances and could get implemented without any delays.

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

TABLE OF CONTENTS

LIST OF FIGURES

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

2.1 ESTABLISHMENT

The National Highways Authority of India was constituted 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 are 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 been taken up.

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

2.3 FUNCTIONS

The function and activities of National Highways authority of India are stipulated 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 mandated 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 north-eastern 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. 2,000 crores per annum. Further, Parliament decreed that the fund so collected were to be 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 be tapped to fund, and the agencies to whom it was available were clearly defined 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 was 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 been 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 offered 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 be transferred back to NHAI by the Concessionaries.

NHAI funds are 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 tried 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 been announced by the Government.

- Government will carry out all preparatory work including land acquisition and utility shifting. Right of way (ROW) to be 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 modern high capacity equipment for highway construction.

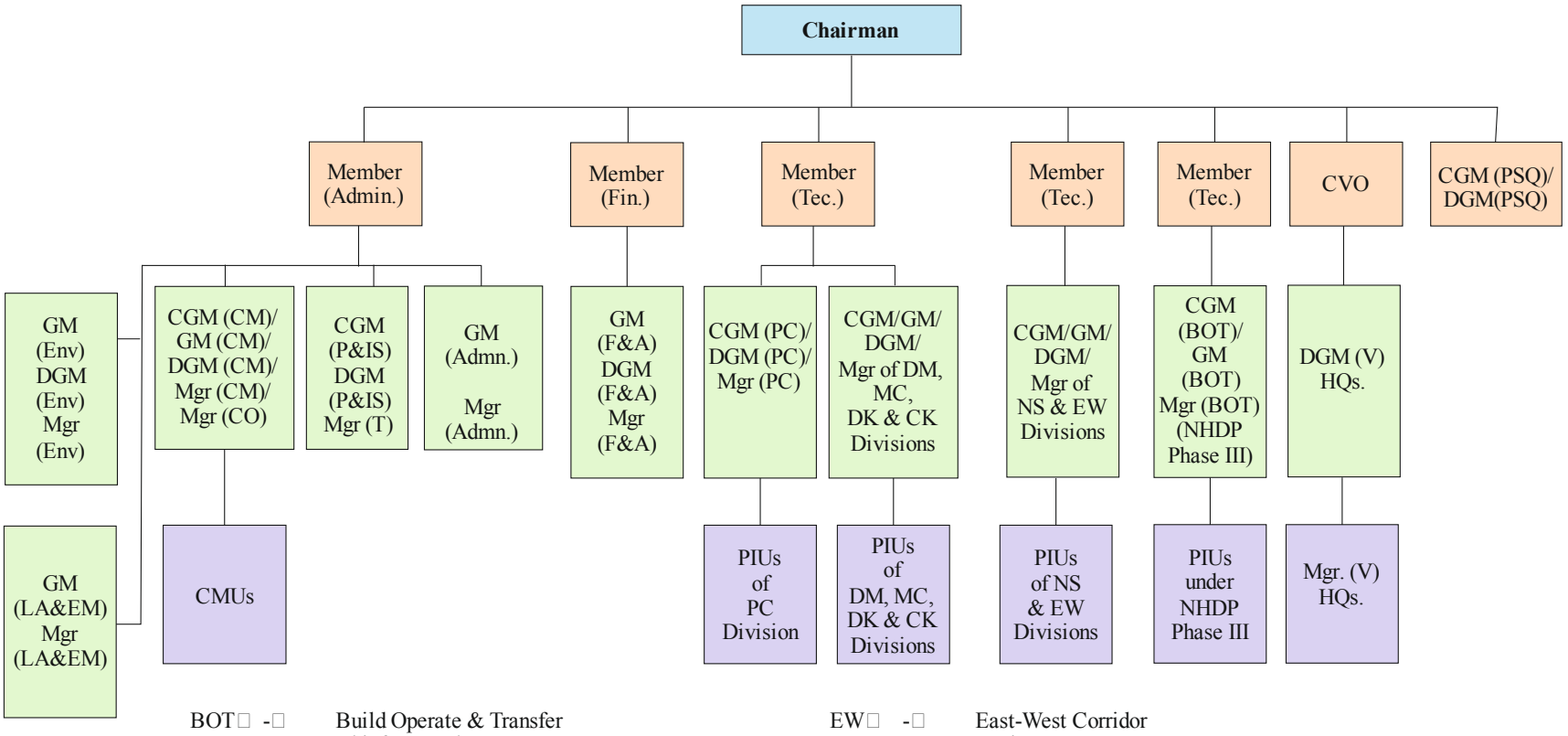
2.6 COST RECOVERY MECHANISM

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 is being 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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER-3: PROJECT DESCRIPTION INCLUDING POSSIBLE ALTERNATIVE ALIGNMENTS / BYPASS AND TECHNICAL/ENGINEERING ALTERNATIVES

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 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, 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**.

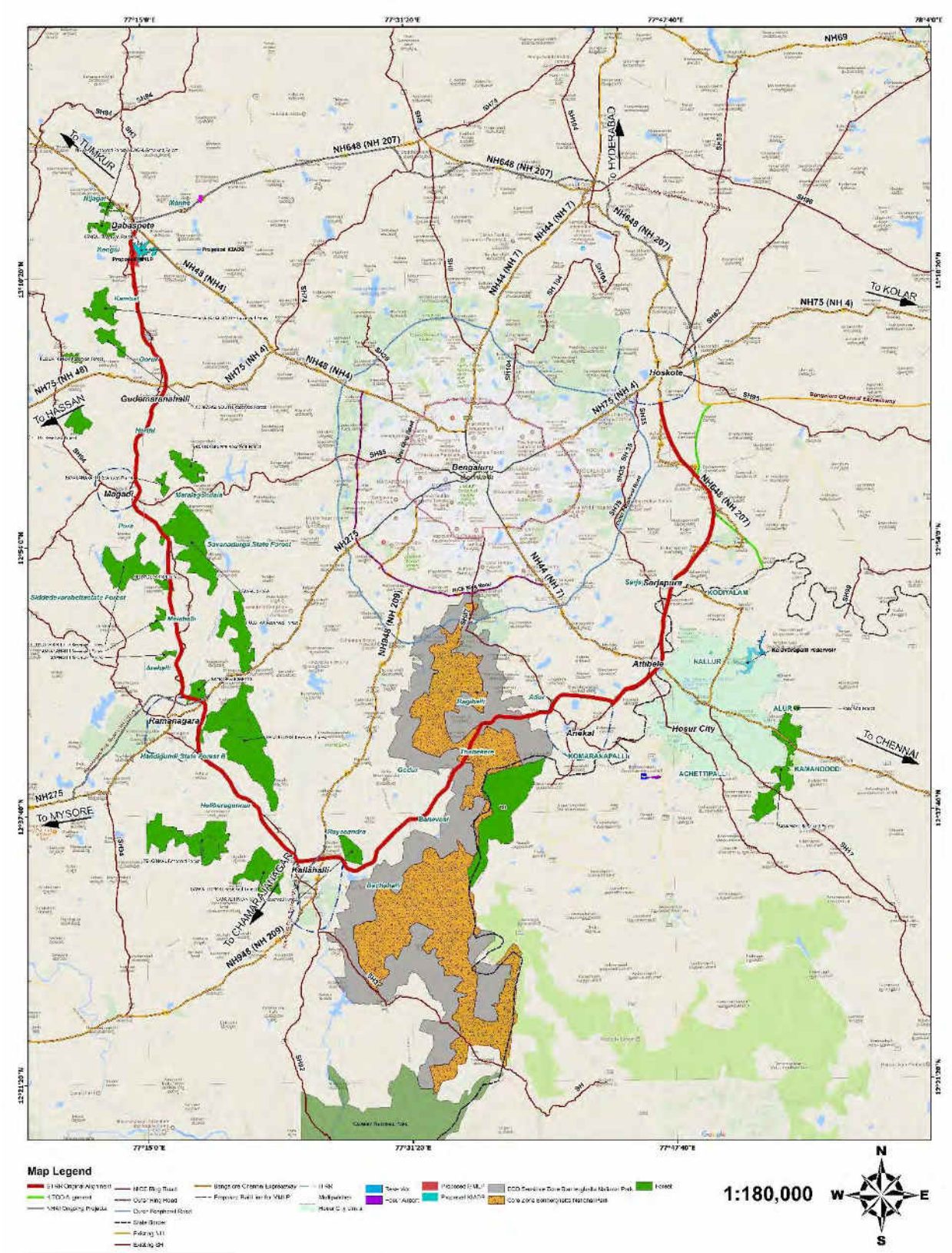


Figure 3.1: Original STRR Alignment as think of by Karnataka State Government

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 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.

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 stake holders, district level officers, and NHAI. Four options proposed and all options discussed with its merits and demerits. The details given in **Figure 3.2.**

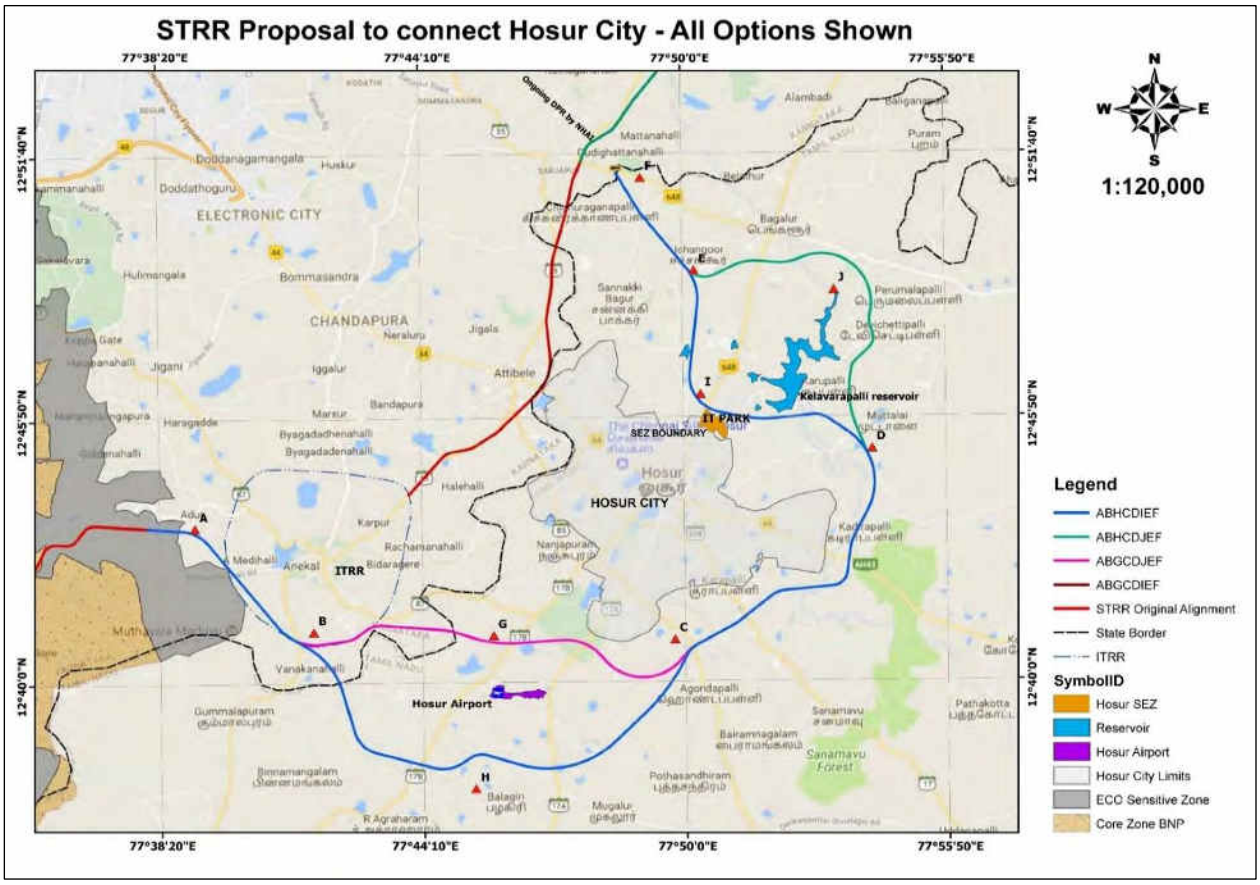


Figure 3.2: STRR proposal connect Hosur city with four options

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 are 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.**

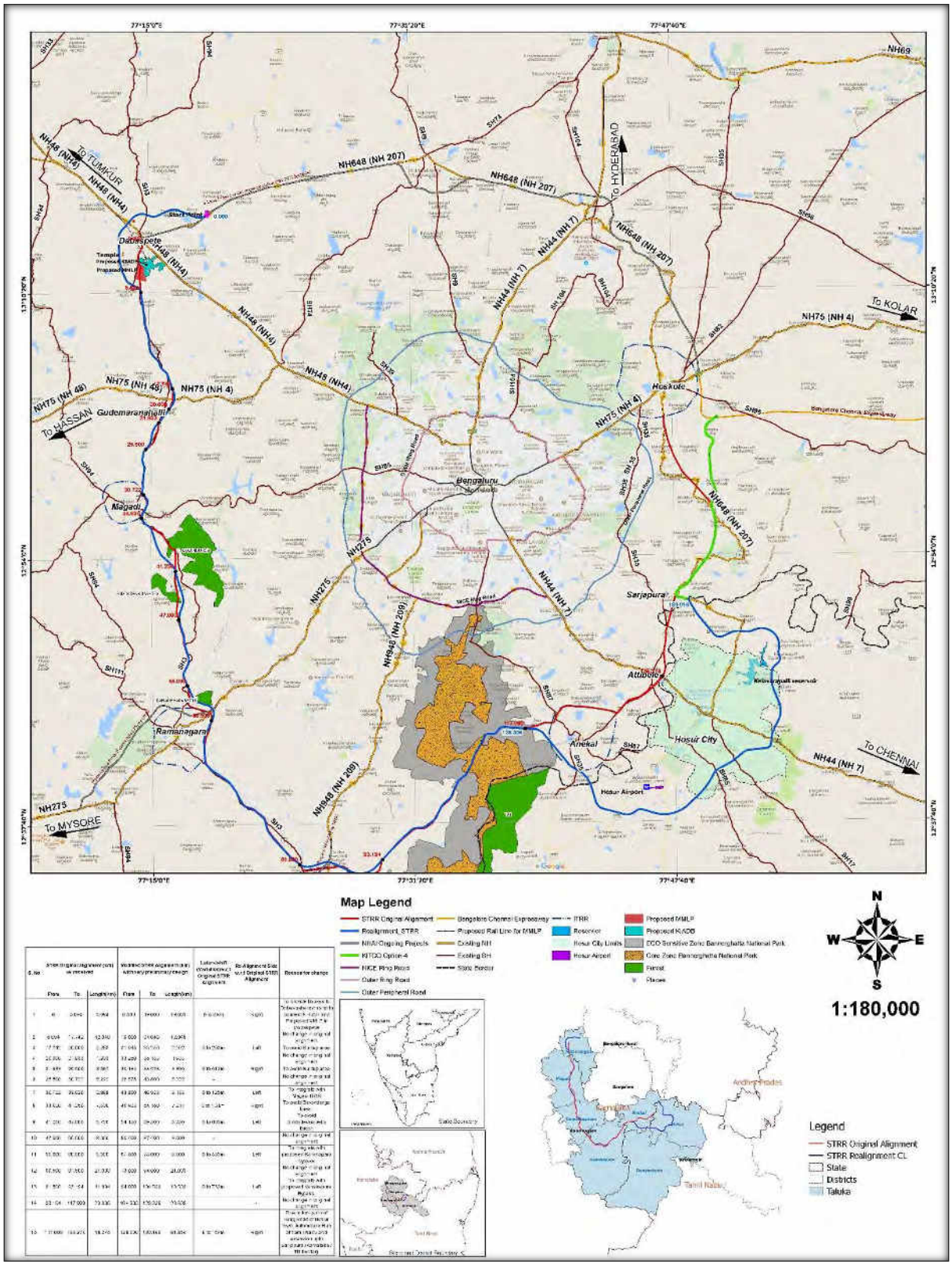


Figure 3.3: Concurrence obtained for alignment from Karnataka state

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-I/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

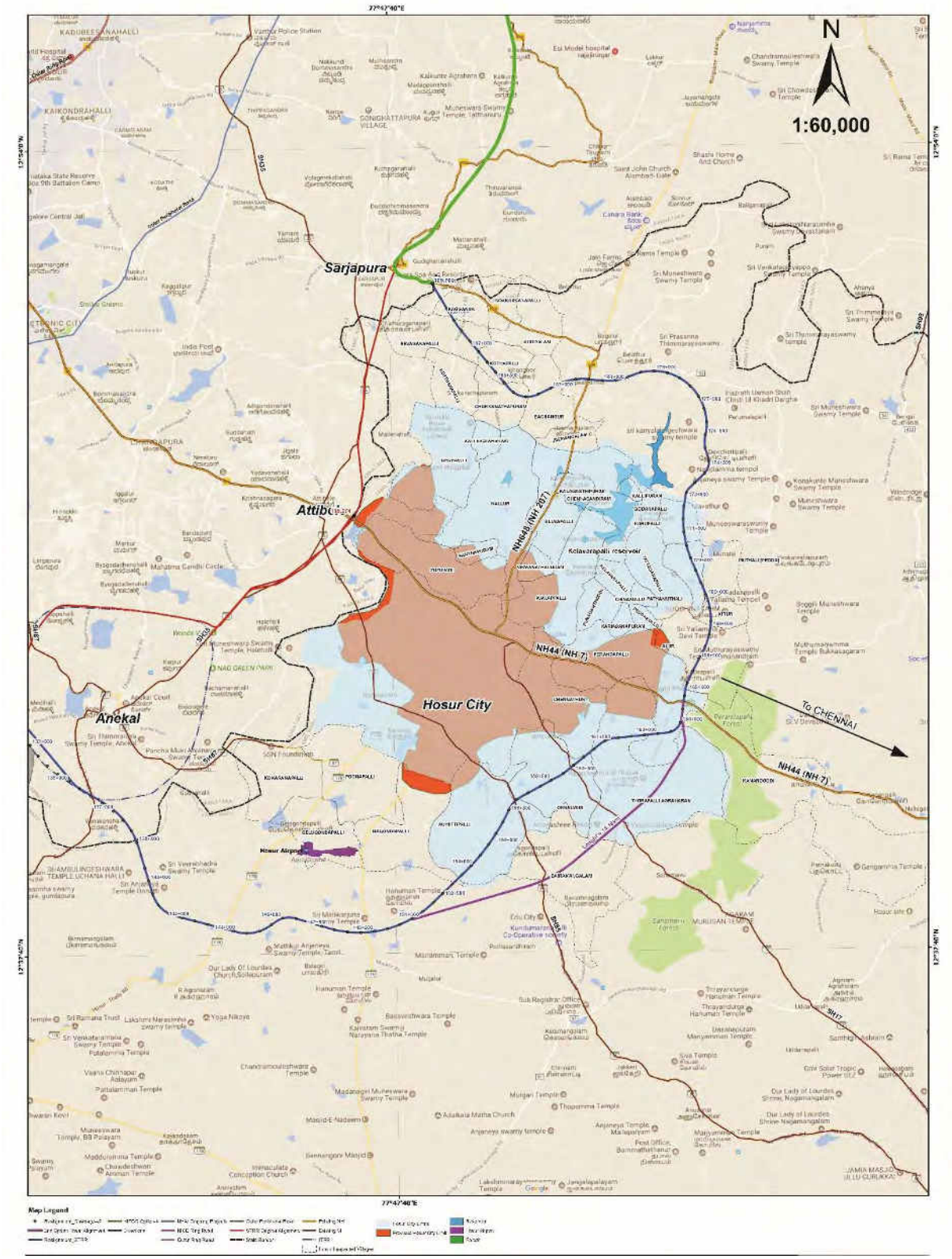
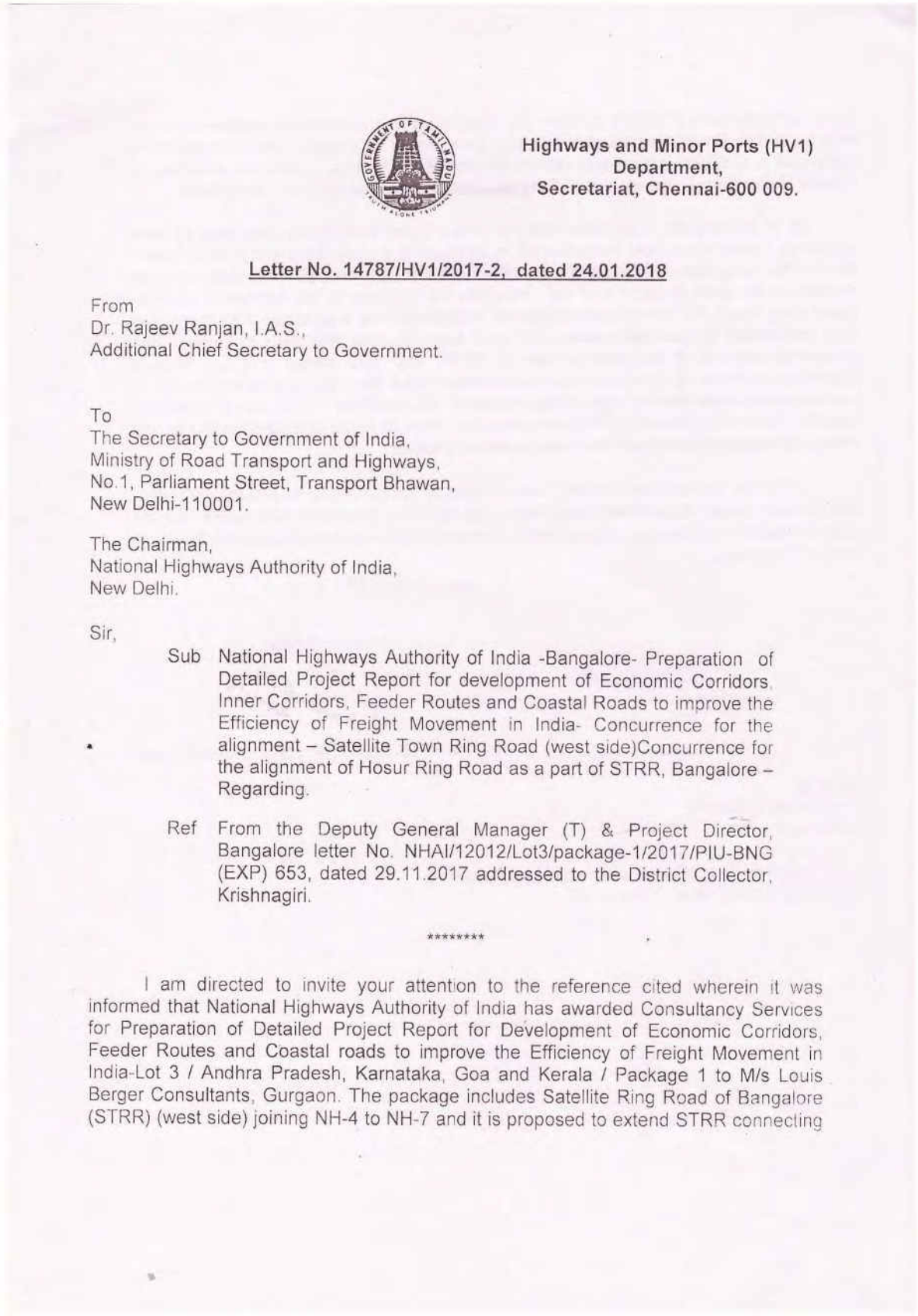


Figure 3.5: Concurrence obtained for alignment of Hosur portion of Tamil Nadu



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

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

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. Sarangath 24.1.18

for Additional Chief Secretary to Government.

Copy to:
The District Collector,
Krishnagiri.

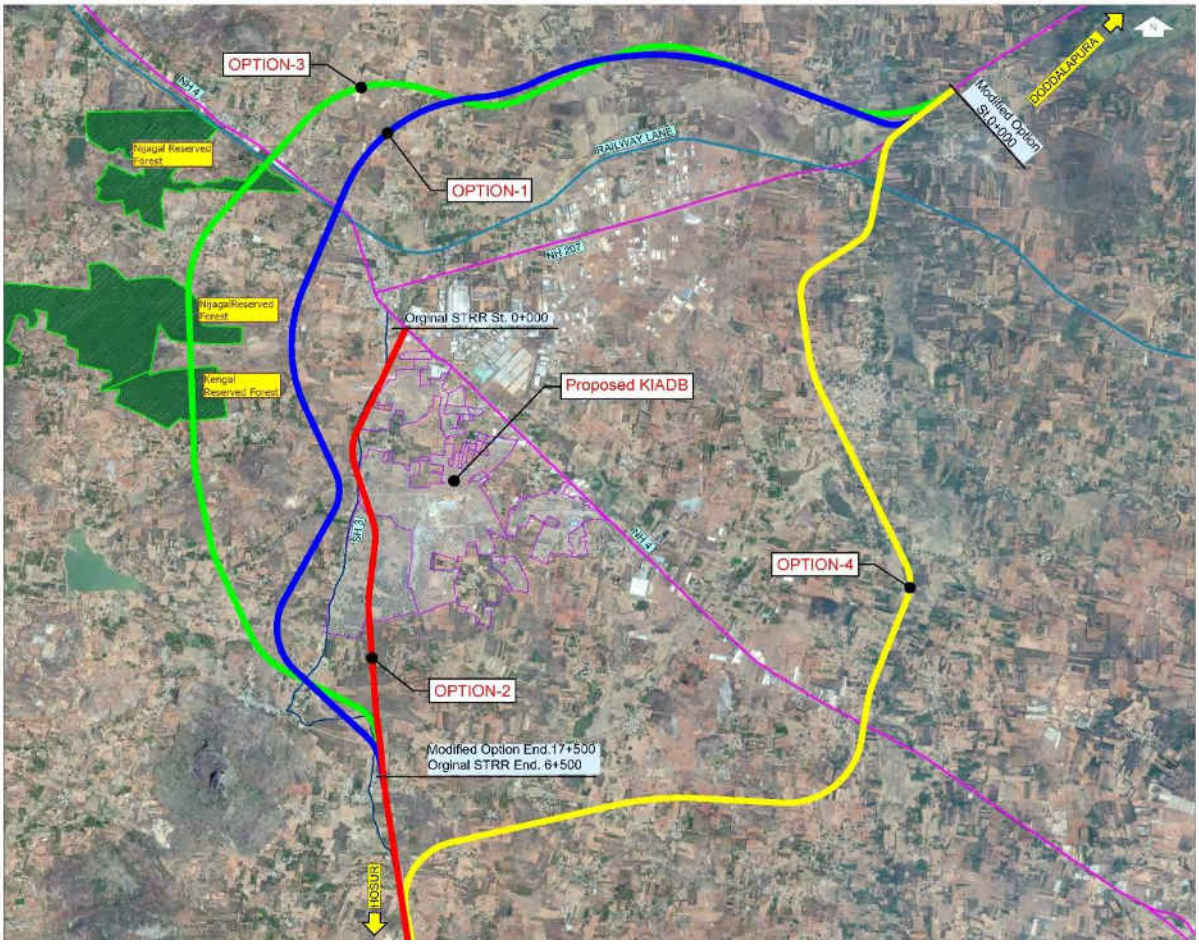
The Chief Engineer (Construction and Maintenance),
Highways Department, Chennai-25.

Figure 3.6b: 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

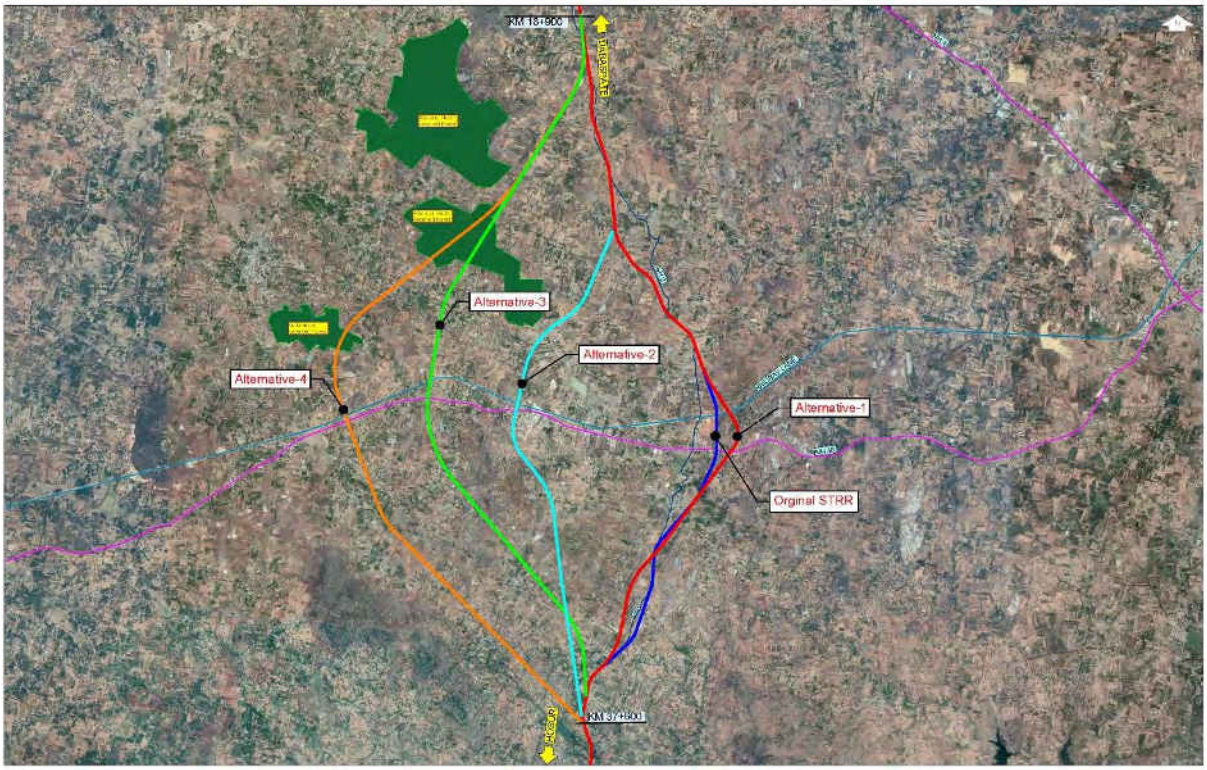
The comparative statements of all four options of proposed modifications in Dobbaspet are given below.

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 Forest land & thus forest clearance need to be obtained 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 are given below

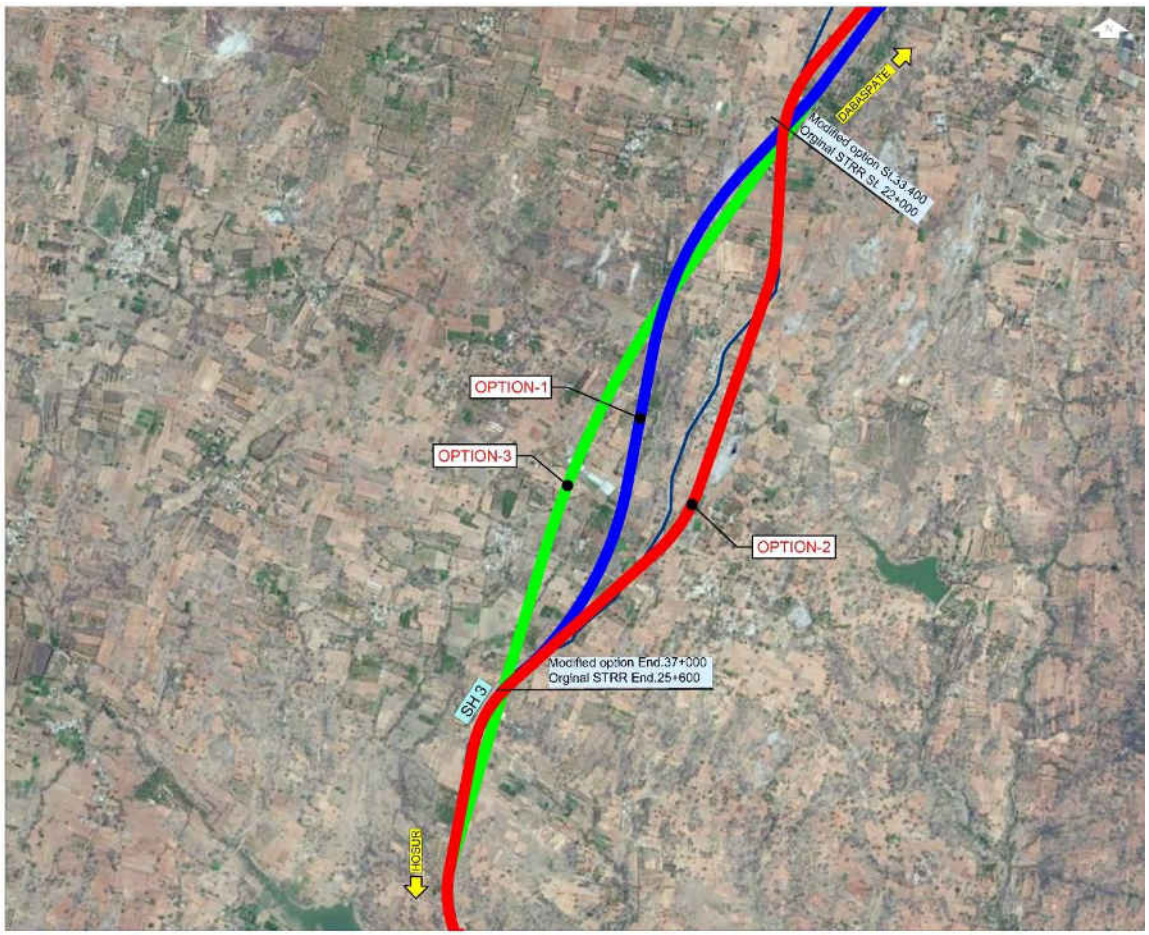
S. No.	Description	Original STRR	Alt 1	Alt 2	Alt 3	Alt 4
1	Length of Alignment (km)	26	27.2	26.1	27.2	29.3
2	Built-up stretch	Nil	Nil	Nil	Nil	Nil
3	Terrain	Plain/rolling	Plain/rolling	Plain/rolling	Plain/rolling	Plain/rolling
4	Speed	100 kmph	100 kmph	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry 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/Agricultural Land	Barren/Agricultural Land	Barren/Agricultural 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 Hec.	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 affected. 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

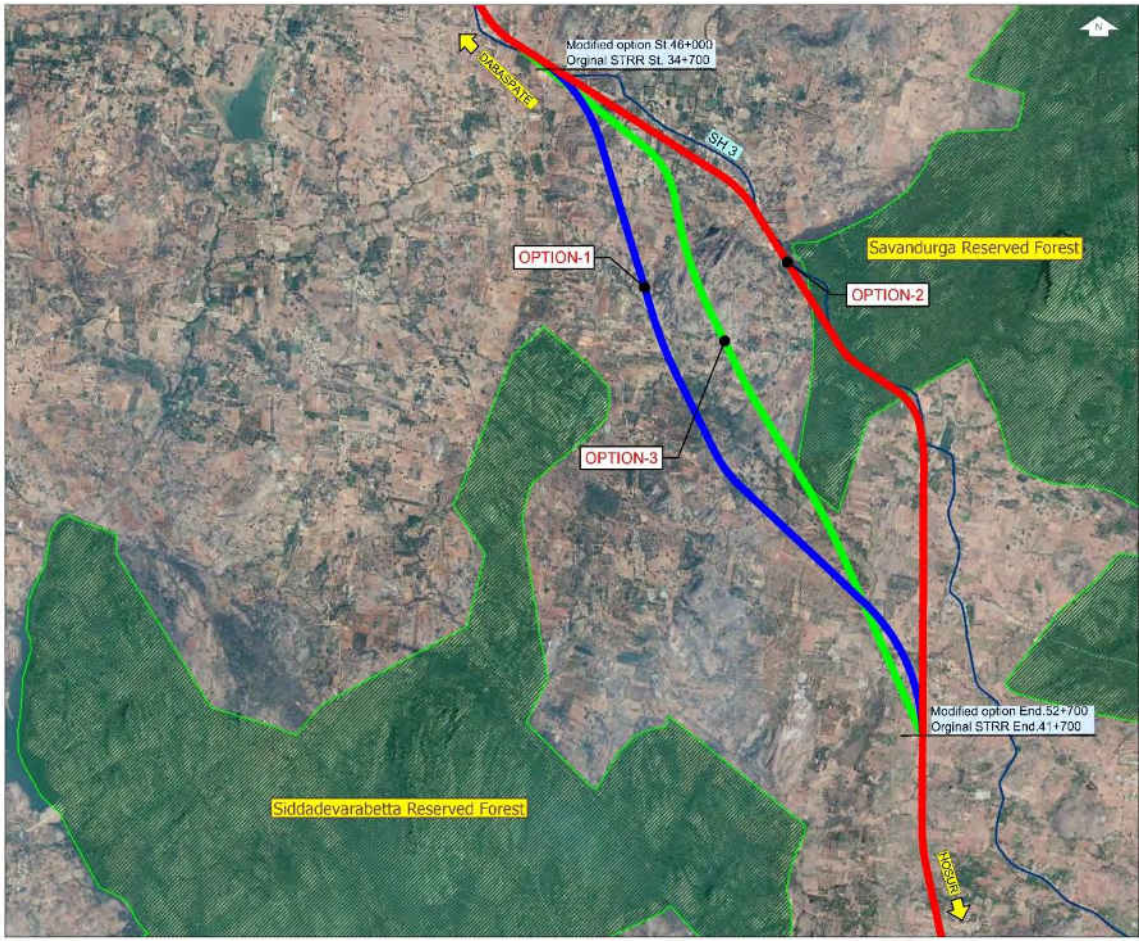
The comparative statements of all four options of proposed modifications are given below:

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 are given below

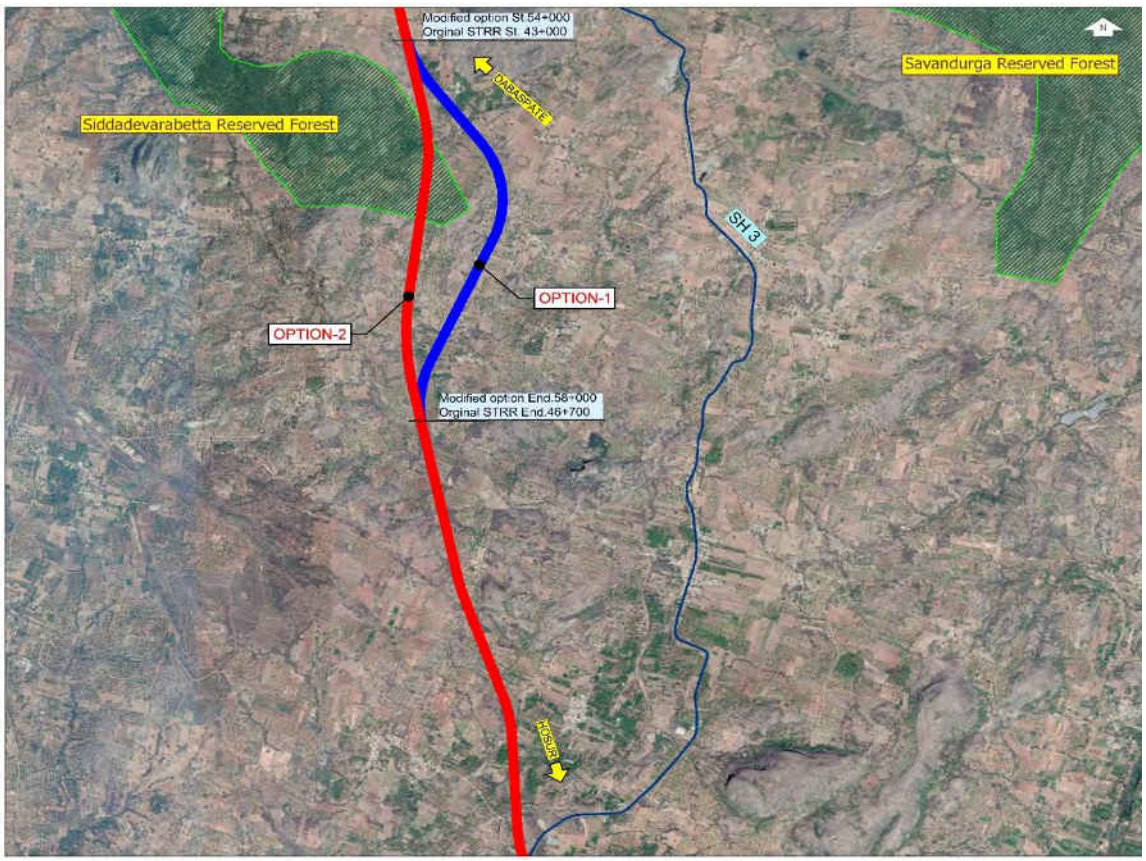
S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
1	Length of Alignment (km)	6.7	7	8.8
2	Built-up stretch	Nil	Nil	Nil
3	Terrain	Plain	Plain	Plain
4	Speed	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry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

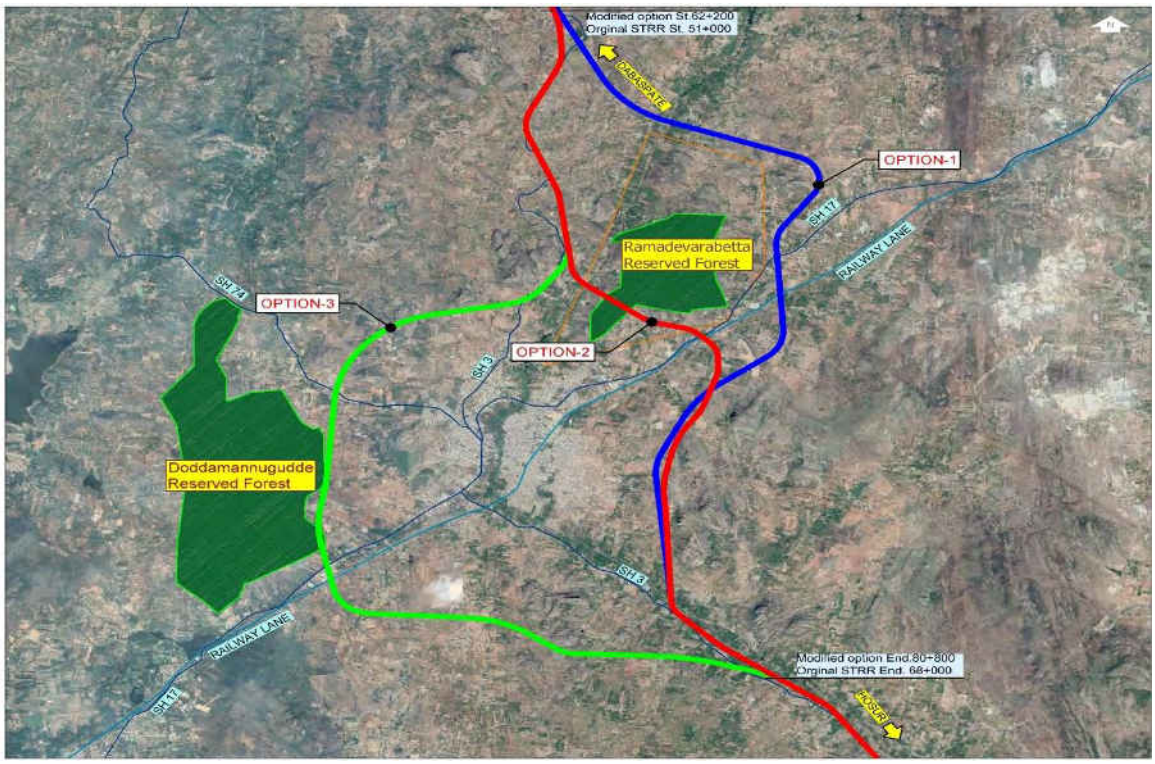
S. No.	Description	Option-1	Option-2 (original STRR)
1	Length of Alignment (km)	4	3.7
2	Built-up stretch	Nil	Nil
3	Terrain	Plain	Plain
4	Speed	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry is good, supports 100 kmph speed. 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 are given below

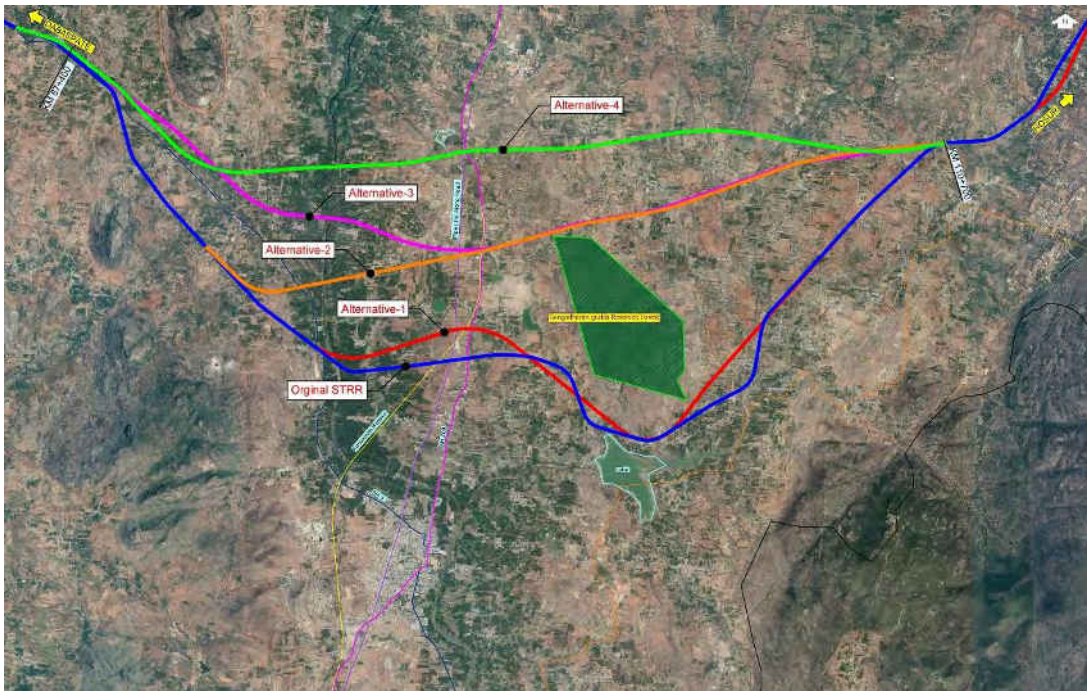
S. No.	Description	Option-1	Option-2 (original STRR)	Option-3
1	Length of Alignment (km)	18.6	17	25.05
2	Built-up stretch	Nil	Nil	Nil
3	Terrain	Plain	Plain	Plain
4	Speed	100 kmph	100 kmph	100 kmph
5	Geometries	Geometry is good, supports 100 kmph speed. Good sight distance with curves widely spaced.	Geometry 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 Hec.	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 are 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 Hec.					
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 forest land 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 less structures will be affected. 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 combined 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 is 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 upon.

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.

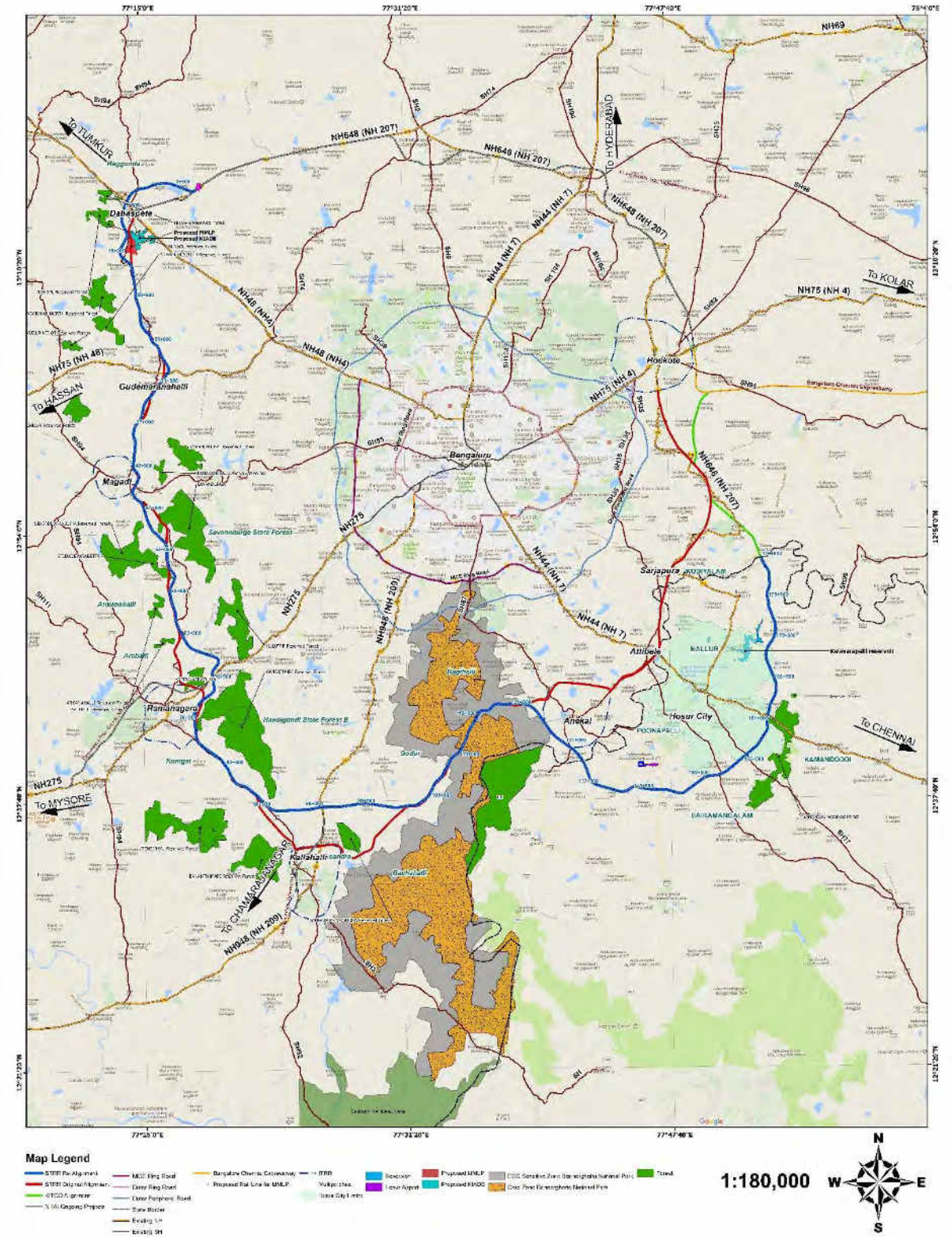


Figure 3.7: Final Alignment

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. Also, 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, Tiruvallur districts of Tamil Nadu (98.33km). The proposed configuration will be 4lanes carriageway with 5 major interchanges with fully access control facilities.

3.7 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 no 6, dated 02/01/2018.

3.8 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. Start point co-ordinate of STRR -750104.8329/1465840.4410 (near Dobbaspet). End point coordinates of STRR merging with KITCO alignment at Tamil Nadu/Karnataka Border – 83614.6946/1424665.8098 (near Sampangere).

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

Project proposals

The proposal envisages a four/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 design speed for the proposed road shall be 100km/h as terrain is plain/rolling.

Proposed ROW

A 75m corridor will propose for the entire alignment.

Road Configuration

Four/Six lanes divided carriageway configuration with raised median will proposed as per 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. As far possible the minor cross roads will elevated and the main carriageway will kept on ground level to ensure safe geometry standards. Service roads will envisage as per requirement for segregation of local traffic needs.

The proposed alignment crisscrosses the existing SH 3 at many locations. All endeavor will made not to disturb any existing network and try restoring the existing SH 3 where it affected due to proposed STRR proposals.

The details of some of major cross roads given below.

Table 3.3: Major Cross road locations

S No	Tentative location (km)	Cross road
1	0.000 (Kar)	NH 648 (old NH 207)
2	6.8	SH 3
3	8.6	NH 48 (old NH 4)
4	30.1	NH 75 (old NH 48)
5	44.2	SH 85

S No	Tentative location (km)	Cross road
6	70.0	NH 275 (Ramanagara)
7	95.4	NH 948 (old NH 209)
8	131.7	SH 35
9	139.5	17B
10	144.550	17A
11	151.800	SH 85
12	155.600	SH 17
13	160.900	NH 44 (old NH 7)

Horizontal Geometry

The tentative horizontal geometry for the proposed road worked out and the details are given in **Annexure 3.1.** It is evident from the table that the entire corridor is cater for 100km per hour design speed.

Proposed Design Standards

The geometry design standard as per 4/6 lanes and Guidelines issued for Bharatmala program.

3.9 ENVIRONMENT STUDIES

Environmental expert carried out reconnaissance survey of the project road. Important environmental components along the corridor of impact zone of Banneragatta National Park identified. The alignment corridor is passing through this wildlife Sanctuary between km 116 to km 129. The alignment is pass through Buffer as well as core zones in this wildlife park. Though 3 options studied to avoid this location either partly or to maximum extent, no alignment option could found feasible due to its terrain condition as it unable to cater the high speed traffic corridor. So a joint meeting and site visit with PCCF/DFO and PIU/PD/NHAI held on 12/9/2017 & 19/9/2017 and it concluded that the original suggested option found feasible technically for consideration. The portion of alignment passes through Banneragatta National Park given in **Figure 3.8.**

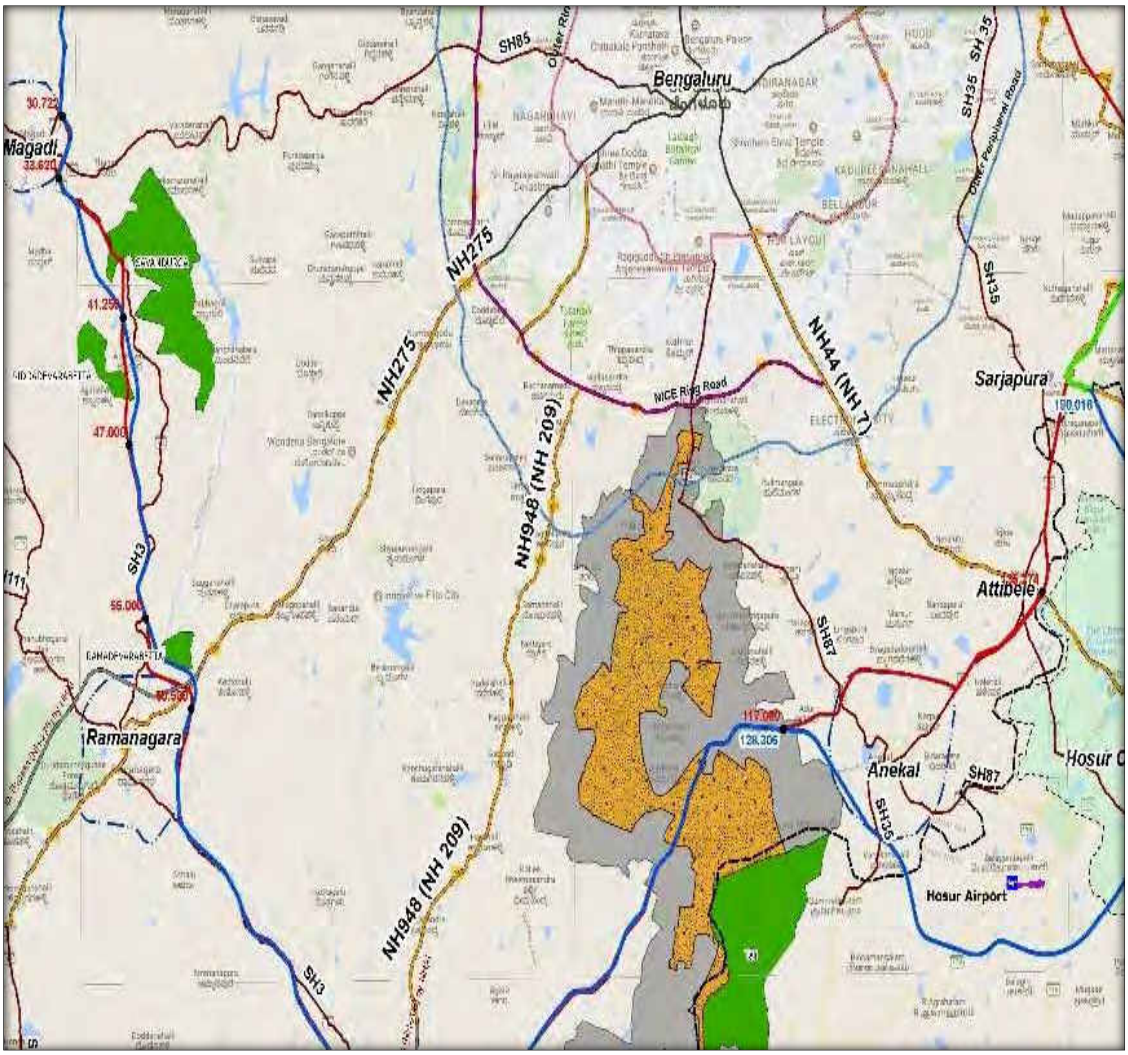


Figure 3.8: Alignment passes through Banneragatta National Park

The environment study will identify trees, forests, National park and its core and buffer zones, public utilities, community resources, cultural sites, high pollution zones, accident prone zones/area etc. On the basis of back ground, information screening exercise will be conduct subsequently. The data collected will be compile to develop environmental scenario and sensitive component within that. Full road length and corridor of impact will put under screening to identify hot spot zones. On the basis of this environment impact assessment and Environmental, management plan will be frame.

The following mitigation measures will be consider in subsequent project stages

- Adequate drainage facilities along the road
- Provision of service roads
- Appropriate noise barriers at sensitive locations
- Development of strip plantation on both sides and median shrubs
- Regular monitoring of ambient air quality, noise level and water quality during construction.
- Grade separation/ interchanges at major intersections.
- Elevated arrangement for through traffic with barricade.

3.10 SOCIAL ASSESSMENT

The social assessment presents to determine the magnitude of actual potential impact due to this new road development. The idea of social study is to minimize the social impact with best possible engineering solutions at the optimal point. The social screening survey will be carry out to assess the negative impact and to suggest the mitigation measures

- To avoid / minimize the adverse impact on nearby communities and natural environment,
- People and properties falling on direct path of road development,
- People indirectly affected by the way of disruption of livelihood, breakage in community linkages
- Impact on land acquisition and resettlement, on indigenous people (SC &ST) and on human safety etc.

In order to minimize or avoid the adverse impact, all necessary modifications will made in design stage. However, in case of unavoidable negative impacts, these will be mitigate through suggested appropriate measures needs to be adopt during construction and operational stages.

To ensure that the project affected persons are duly compensated a Resettlement Action Plan (RAP) would be drawn up as an integral part of project design proposal to ensure that highway improvement are socially sound, sustainable and contribute to the development of social goals. The prime objective of this RAP is to ensure and provide a policy framework to ensure that the affected and displaced persons are aptly resettled and rehabilitated (to improve their livelihood and standard of living or at least to restore them in real terms).

Land use

The terrain along this alignment is predominantly mix of plain and rolling. The land use pattern along this project road comprises of agricultural, built up, barren, industrial, and forest. However, the main land use pattern is agricultural and barren. The tentative land uses along the project are as below.

Table 3.4: Tentative Land Uses along the Project

S. No	Land use pattern	% of land use
1	Agriculture	82
2	Barren	5
3	Built up	3
4	Industrial	3
5	Forest	7

Based on the findings during the initial assessment study some measures have noted for consideration that will reduce the detrimental effects of project appreciably.

- Alternative alignments such as realignment are attempt in the original STRR in order to find a suitable alignment that would have minimum adverse impact on social aspects and minimum land acquisition.

- The alignment avoids schools, places of worships, public utilities and other common resources.

- It will be ensure that the likely affected common properties used by local people will suitably rehabilitated before the start of civil construction work and budgetary provision for the same will be made in the project estimates.

The STRR alignment passes through following districts and talukas in Karnataka and Tamil Nadu states.

No	state	District	Talukas
1	Karnataka	Bangalore Rural	Neelmangala
			Magadi
2		Bangalore Urban	Anekal
3		Ramanagara	Ramanagara
4	Tamil Nadu	Krishnagiri	Hosur
			Denkanikottai

Horizontal Curve Details

Max. restricted Superelevation			5.0%										
Sl. No.	Easting, X	Northing, Y	Radius	Transition Length, L_s	Start Chainage of		End Chainage of		HIP Chainage	Design Speed, V	Δ	L_c	e
					Transition	Curve	Curve	Transition					
1	749817.874	1465637.810	500.000	95.000	25.226	120.226	553.518	648.518	336.872	100	1.056584	433.292	5.00%
2	746423.057	1466930.419	3500.000	0.000		2446.087	5296.78		3871.434	100	0.814484	2850.693	NR
3	744672.988	1466098.371	2000.000	0.000		5397.42	6046.479		5721.95	100	0.32453	649.059	NR
4	742975.635	1465894.953	2000.000	0.000		6261.161	8374.567		7317.864	100	1.056703	2113.406	NR
5	741634.620	1462676.758	2000.000	0.000		9818.959	11467.953		10643.456	100	0.824497	1648.994	NR
6	742493.933	1460756.852	600.000	80.000	12364.875	12444.875	12922.738	13002.738	12683.807	100	0.929772	477.863	5.00%
7	741456.747	1458769.984	800.000	65.000	14279.236	14344.236	15332.154	15397.154	14838.195	100	1.316148	987.918	5.00%
8	742941.853	1457322.813	650.000	80.000	16576.873	16656.873	17010.604	17090.604	16833.739	100	0.667278	353.731	5.00%
9	743381.309	1454458.956	700.000	70.000	19626.287	19696.287	19757.732	19827.732	19727.01	100	0.187779	61.445	5.00%
10	743367.612	1453889.392	750.000	70.000	20125.451	20195.451	20397	20467	20296.226	100	0.362066	201.549	5.00%
11	743805.387	1452553.089	800.000	70.000	21579.996	21649.996	21753.774	21823.774	21701.885	100	0.217223	103.778	5.00%
12	744012.587	1450719.049	1000.000	80.000	23269.515	23349.515	23740.838	23820.838	23545.177	100	0.471323	391.323	4.44%
13	744452.741	1450035.105	1000.000	60.000	24161.074	24221.074	24489.705	24549.705	24355.39	100	0.328631	268.631	4.44%
14	744917.228	1449652.479	650.000	80.000	24743.46	24823.46	25085.991	25165.991	24954.726	100	0.52697	262.531	5.00%
15	745264.454	1448830.041	650.000	80.000	25652.462	25732.462	25957.231	26037.231	25844.847	100	0.468874	224.769	5.00%
16	745923.850	1448223.914	650.000	80.000	26531.922	26611.922	26864.26	26944.26	26738.091	100	0.511288	252.338	5.00%
17	746288.837	1447208.980	3000.000	0.000		27472.434	28155.162		27813.798	100	0.227576	682.728	NR
18	747228.370	1445670.946	600.000	90.000	29179.869	29269.869	29896.891	29986.891	29583.38	100	1.195037	627.022	5.00%
19	745140.889	1442768.417	1200.000	40.000	33033.643	33073.643	33181.288	33221.288	33127.466	100	0.123038	107.645	3.70%
20	744373.440	1441949.703	2000.000	0.000		33669.25	34798.942		34234.096	100	0.564846	1129.692	NR
21	744004.321	1440022.519	1850.000	0.000		35552.388	36763.962		36158.175	100	0.654905	1211.574	NR
22	743332.060	1439408.223	650.000	80.000	36789.949	36869.949	37214.709	37294.709	37042.329	100	0.653476	344.760	5.00%
23	743131.962	1438381.885	650.000	90.000	37872.283	37962.283	38203.956	38293.956	38083.12	100	0.510267	241.673	5.00%
24	743369.906	1437606.168	650.000	80.000	38721.58	38801.58	38984.098	39064.098	38892.839	100	0.403873	182.518	5.00%
25	743140.818	1434618.981	650.000	80.000	41577.119	41657.119	42102.188	42182.188	41879.654	100	0.807798	445.069	5.00%
26	743849.013	1433756.014	650.000	80.000	42533.322	42613.322	43292.137	43372.137	42952.73	100	1.167407	678.815	5.00%
27	743543.081	1433053.656	1000.000	50.000	43623.076	43673.076	43695.965	43745.965	43684.521	100	0.072889	22.889	4.44%
28	743437.882	1432788.035	1500.000	35.000	43857.757	43892.757	44047.549	44082.549	43970.153	100	0.126529	154.792	2.96%
29	742990.634	1431918.113	650.000	80.000	44552.102	44632.102	45221.215	45301.215	44926.659	100	1.029404	589.113	5.00%
30	743378.245	1431231.312	800.000	60.000	45471.027	45531.027	45852.463	45912.463	45691.745	100	0.476795	321.436	5.00%
31	744112.465	1430752.123	1250.000	40.000	46085.375	46125.375	46973.285	47013.285	46549.33	100	0.710328	847.910	3.56%
32	744764.692	1428655.960	3000.000	0.000		48472.603	48981.424		48727.014	100	0.169607	508.821	NR
33	745284.136	1427637.715	1000.000	50.000	49663.752	49713.752	50022.825	50072.825	49868.289	100	0.359073	309.073	4.44%
34	746912.338	1426123.512	1500.000	35.000	51414.087	51449.087	52661.469	52696.469	52055.278	100	0.831589	1212.382	2.96%
35	746915.056	1424589.131	1500.000	40.000	53370.289	53410.289	53697.587	53737.587	53553.938	100	0.218198	287.298	2.96%
36	747168.961	1423449.676	1000.000	80.000	54451.386	54531.386	54906.278	54986.278	54718.832	100	0.454892	374.892	4.44%
37	747885.530	1422486.573	700.000	90.000	55452.906	55542.906	56230.828	56320.828	55886.867	100	1.111318	687.922	5.00%
38	747192.790	1420931.769	800.000	90.000	57245.636	57335.636	57771.427	57861.427	57553.532	100	0.657239	435.791	5.00%
39	747501.723	1419455.025	1500.000	60.000	58924.912	58984.912	59129.055	59189.055	59056.984	100	0.136095	144.143	2.96%
40	747845.956	1418489.152	1000.000	100.000	59884.768	59984.768	60179.491	60279.491	60082.13	100	0.294723	194.723	4.44%
41	747914.224	1417492.450	1000.000	100.000	60894.232	60994.232	61167.454	61267.454	61080.843	100	0.273222	173.222	4.44%
42	748138.459	1416817.159	2000.000	0.000		61626.882	61956.929		61791.906	100	0.165023	330.047	NR
43	749431.291	1414416.902	2000.000	0.000		63726.881	65233.256		64480.069	100	0.753188	1506.375	NR
44	752964.762	1413174.193	500.000	90.000	67519.82	67609.82	68469.284	68559.284	68039.552	100	1.898928	859.464	5.00%
45	752009.286	1411806.338	650.000	80.000	69259.851	69339.851	69762.688	69842.688	69551.27	100	0.773594	422.837	5.00%
46	752241.096	1409585.800	650.000	90.000	71357.865	71447.865	72057.219	72147.219	71752.542	100	1.07593	609.354	5.00%
47	750659.199	1408433.669	2000.000	0.000		73197.18	74155.528		73676.354	100	0.479174	958.348	NR
48	749961.361	1407060.565	1000.000	50.000	74888.433	74938.433	75463.741	75513.741	75201.087	100	0.575308	525.308	4.44%
49	750274.572	1404037.511	650.000	90.000	77949.989	78039.989	78418.346	78508.346	78229.168	100	0.72055	378.357	5.00%
50	751063.186	1403281.933	2000.000	0.000		79166.063	79465.767		79315.915	100	0.149852	299.704	NR
51	752893.204	1402023.896	750.000	70.000	81379.001	81449.001	81623.142	81693.142	81536.072	100	0.325522	174.141	5.00%
52	753784.701	1400840.393	650.000	100.000	82888.314	82988.314	83046.923	83146.923	83017.619	100	0.244014	58.609	5.00%

Annexure -3.1

Max. restricted Superelevation			5.0%										
Sl. No.	Easting, X	Northing, Y	Radius	Transition Length, L_s	Start Chainage of		End Chainage of		HIP Chainage	Design Speed, V	Δ	L_c	e
					Transition	Curve	Curve	Transition					
53	754078.968	1400164.094	1000.000	50.000	83647.126	83697.126	83813.305	83863.305	83755.216	100	0.166179	116.179	4.44%
54	754689.562	1399230.721	650.000	90.000	84593.816	84683.816	85048.206	85138.206	84866.011	100	0.699062	364.390	5.00%
55	755808.565	1398863.651	1000.000	0.000		85859.5	86215.009		86037.255	100	0.355509	355.509	4.44%
56	757077.887	1397879.082	2000.000	0.000		87471.37	87811.346		87641.358	100	0.169988	339.976	NR
57	757488.385	1397430.488	2000.000	0.000		88215.531	88282.492		88249.012	100	0.03348	66.961	NR
58	758786.973	1396103.449	2000.000	0.000		89175.912	90916.621		90046.267	100	0.870355	1740.709	NR
59	760836.145	1396255.613	5000.000	0.000		91963.858	92119.391		92041.625	100	0.031107	155.533	NR
60	762910.332	1396344.888	2000.000	0.000		93959.962	94274.836		94117.399	100	0.157437	314.874	NR
61	764242.282	1396615.513	2000.000	0.000		95293.277	95658.184		95475.731	100	0.182453	364.907	NR
62	766376.879	1396653.934	5000.000	0.000		97275.271	97944.059		97609.665	100	0.133758	668.788	NR
63	769210.790	1397087.326	5000.000	0.000		99686.75	101252.38		100469.565	100	0.313126	1565.630	NR
64	772684.423	1396521.865	5000.000	0.000		103111.9	104835.745		103973.823	100	0.344769	1723.845	NR
65	774056.052	1396776.278	2000.000	0.000		105234.161	105485.918		105360.04	100	0.125879	251.757	NR
66	774965.788	1396837.668	850.000	65.000	105993.299	106058.299	106476.645	106541.645	106267.472	100	0.568642	418.346	5.00%
67	776299.358	1397796.599	1500.000	35.000	107499.164	107534.164	108262.906	108297.906	107898.535	100	0.509162	728.742	2.96%
68	777043.785	1399377.357	1500.000	35.000	109302.365	109337.365	109931.731	109966.731	109634.548	100	0.419578	594.366	2.96%
69	777844.317	1400092.658	800.000	90.000	110451.791	110541.791	110862.552	110952.552	110702.172	100	0.513451	320.761	5.00%
70	778070.518	1400682.551	800.000	90.000	111188.498	111278.498	111385.286	111475.286	111331.892	100	0.245985	106.788	5.00%
71	778507.113	1401346.502	2000.000	0.000		112007.45	112245.364		112126.407	100	0.118957	237.914	NR
72	778924.577	1402153.240	650.000	80.000	112850.035	112930.035	113137.799	113217.799	113033.917	100	0.442713	207.764	5.00%
73	779777.632	1402835.110	650.000	85.000	113943.905	114028.905	114220.611	114305.611	114124.758	100	0.425702	191.706	5.00%
74	780520.723	1404234.387	1500.000	100.000	115517.949	115617.949	115799.239	115899.239	115708.594	100	0.187526	181.290	2.96%
75	780804.115	1405129.011	800.000	80.000	116513.872	116593.872	116700.038	116780.038	116646.955	100	0.232707	106.166	5.00%
76	781524.479	1406364.047	2000.000	0.000		117994.011	118159.347		118076.679	100	0.082668	165.336	NR
77	782060.678	1407404.880	450.000	115.000	118919.24	119034.24	119434.918	119549.918	119234.579	100	1.145952	400.678	5.00%
78	783041.313	1407432.966	650.000	80.000	119845.355	119925.355	120449.15	120529.15	120187.253	100	0.928914	523.795	5.00%
79	783692.233	1408196.526	850.000	90.000	120696.425	120786.425	121516.581	121606.581	121151.503	100	0.964889	730.156	5.00%
80	784862.508	1408149.298	3000.000	0.000		122119.697	122477.582		122298.64	100	0.119295	357.885	NR
81	787800.494	1408325.829	2500.000	0.000		123831.583	126399.419		125115.501	100	1.027134	2567.836	NR
82	790296.287	1404706.357	4000.000	0.000		128684.443	130073.101		129378.772	100	0.347164	1388.658	NR
83	793499.543	1402419.736	5000.000	0.000		131736.628	134780.507		133258.568	100	0.608776	3043.879	NR
84	794624.043	1399311.199	1200.000	67.000	135874.595	135941.595	137012.428	137079.428	136477.012	100	0.948195	1070.833	3.70%
85	798283.200	1398252.764	1500.000	55.000	139517.933	139572.933	140841.454	140896.454	140207.194	100	0.882347	1268.521	2.96%
86	799385.625	1398971.605	800.000	90.000	141087.314	141177.314	141760.961	141850.961	141469.138	100	0.842059	583.647	5.00%
87	800790.478	1398646.865	3000.000	0.000		142558.75	143233.889		142896.32	100	0.225046	675.139	NR
88	803021.053	1398612.954	2000.000	0.000		144851.857	145396.198		145124.028	100	0.272171	544.341	NR
89	804753.174	1398117.089	800.000	65.000	146501.503	146566.503	147239.361	147304.361	146902.932	100	0.922323	672.858	5.00%
90	807476.420	1400104.230	1850.000	0.000		149743.364	150738.023		150240.694	100	0.537654	994.659	NR
91	809345.391	1400286.652	3000.000	0.000		151167.048	152987.383		152077.216	100	0.606778	1820.335	NR
92	813294.280	1403640.360	3000.000	0.000		156762.599	157688.11		157225.355	100	0.308504	925.511	NR
93	814413.110	1405432.010	600.000	0.000		159108.841	159539.547		159324.194	100	0.717843	430.706	5.00%
94	814282.316	1406244.416	2000.000	0.000		159779.117	160487.99		160133.554	100	0.354436	708.873	NR
95	814650.674	1408111.284	2000.000	0.000		161752.195	162309.485		162030.84	100	0.278645	557.290	NR
96	815605.589	1409975.185	2500.000	0.000		162958.952	165138.277		164048.615	100	0.87173	2179.325	NR
97	813929.483	1413958.702	2000.000	0.000		167195.48	169207.198		168201.339	100	1.005859	2011.718	NR
98	815594.587	1416353.397	2500.000	0.000		169695.526	172137.23		170916.378	100	0.976682	2441.704	NR
99	814498.917	1419212.299	400.000	115.000	173728.122	173843.122	173899.312	174014.312	173871.217	100	0.427975	56.190	5.00%
100	814507.756	1419626.858	1000.000	80.000	174081.9	174161.9	174409.177	174489.177	174285.539	100	0.327277	247.277	4.44%
101	814270.960	1420557.255	1000.000	80.000	174882.32	174962.32	175513.558	175593.558	175237.939	100	0.631238	551.238	4.44%
102	814606.225	1421497.444	1000.000	80.000	175978.55	176058.55	176396.401	176476.401	176227.476	100	0.417851	337.851	4.44%
103	814570.370	1422291.998	5000.000	0.000		176950.223	177092.414		177021.319	100	0.028438	142.191	NR
104	814534.451	1423147.511	1000.000	80.000	177494.969	177574.969	178162.952	178242.952	177868.961	100	0.667983	587.983	4.44%
105	814121.069	1423670.800	1000.000	80.000	178370.371	178450.371	178603.651	178683.651	178527.011	100	0.23328	153.280	4.44%
106	813726.706	1424454.928	2000.000	0.000		179326.52	179482.676		179404.598	100	0.078078	156.156	NR

Annexure -3.1

Chapter-4:
Methodology Adopted

TABLE OF CONTENTS

LIST OF TABLES

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 on the basis of 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	1.5	Manne
2	4.1	Tattekere
3	6.7	Nijagal Kempohalli
4	7.1	Maddenahalli
5	8.2	Lakkuru
6	9.8	Agalakuppa
7	15.6	Hosapalya
8	23.3	Banawadi
9	28.2	Goruru
10	30.1	Gudemaranahalli Handpost
11	32	Gudemaranahalli
12	40.7	Byalakere
13	43.5	Magadi
14	52.4	Hanchikuppe
15	54.2	Atimgere
16	60.2	Gungarahalli
17	61	Melahalli
18	73	Basavanapura
19	74.3	Rampura Doddi
20	75.5	Ramanagara
21	81	Kunagal
22	85.7	Chikkenahalli
22	87.3	Anajawadi
23	89.3	Chikka Madhawadi
24	90.7	Alisab Doddi
25	93	Aralalusandra
26	96.3	Varager Halli
27	97.6	Chathra
28	104	Dodda Maralawadi
29	108	Banavasi
30	110	T. Maniyambal
31	125	Indalavadi
32	127	Thimmasandra
33	132	Vanakanahalli
34	135	Menasiganahalli
35	136.1	Muttur
36	142.6	Kappakollu

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
37	143.5	Payarakanahalli
38	145.5	S. Mudugandanahally
39	148.5	Golisandram
40	158.5	Thorapalli Agraharam
41	161.2	Kothur
42	161.8	Perandapalli
43	163	Kadirapalli
44	164.2	Alur
45	164.8	Dasapalle
46	167.2	Payarkuttalai
47	171	Nandimangalam
48	172.6	Attur
49	176.8	B. Mudaganahalli
50	179.6	Kadiriganadinna
51	180.5	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 as given below

Major cross roads

S No.	Road	Road type	Cross road crossing Chainage (km)	Proposed location along STRR (km)
1	NH 207	2L	131.250	0.000
2	MDR	SL	0.350	1.500
3	MDR	SL	4.500	4.350
4	SH 3	2L	129.990	7.100
5	NH 4/48	4L	50.400	8.900
6	MDR	SL	0.550	12.100
7	NH 75/48	4L	42.230	30.360
8	SH 85	2L	47.112	44.485
9	SH 3	2L	93.100	45.360
10	SH 3	2L	72.000	61.540
11	NH 275	4L	318.130	70.258
12	NH 209	4L	431.310	95.678

S No.	Road	Road type	Cross road crossing Chainage (km)	Proposed location along STRR (km)
13	SH 35	2L	51.500	132.185
14	SH 17B	2L	14.790	139.295
15	SH 17A	2L	12.220	144.820
16	SH 85	2L	25.930	152.070
17	SH 17	2L	14.990	155.820
18	NH 44	4L	48.020	161.128
19	SH 17C KM	2L	3.450	174.220

4.2.5 Service Roads

There are no existing service roads on both sides of the state highway

4.2.6 Railway Crossings & ROB

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

Km. 8.946:

The proposed road alignment crosses the railway line at the Ch 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 29.248**

The proposed alignment crosses at CH: 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 71.020:

The proposed STRR alignment crosses the railway line at the CH: 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 45 m.


4. Km 158.832

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 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 5 km along the entire road stretch. Pair of twin GPS pillars has the advantage that every 5 km stretch independently use for starting and closing the traverse by Total Station. This 5 km 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 were 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 $\sqrt{k}$ mm 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 Magnasoft Consulting India Pvt. Ltd. having registered office at Bangalore, SEZ Tower-1, Office 2, 201B, 1st floor, Global Village Tech Park, Mylasandara, Patanagere Villages, Mysore Road, Bangalore-560059, Tel: + 91 80 43466000

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 check point 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. Check points once every 4 km 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. We will be using Kaarta's Stencil for Drone (and hand-held) LiDAR survey. Hand-held method will 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 day time 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 data link.

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

Manufacturer	STENCIL powered by Kaarta engine
Model	STENCIL

Stencil Specifications

S No	Specifications
1	For detailed real-time detailed digital 3D model scanning and generation/ Baseline and Detail Modeling modes
2	File format: .ply
3	Multiple Platform Mounting Conversion use Aerial Drone Kaarta Engine
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, 360º Horizontal field of view, 30º 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-decimeter 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

After many trails and in discussions following structures finalized. Though these structure list may not be exhaustive, but are likely structures. Once the alignment survey is completed. An exhaustive structure list will be prepared. Tentative structures numbers listed below. In addition to that, the tentative number of drainage structures required also estimated and the details given below.

No of Cross Drainage Structures Envisaged

No.	Section Name	No. of Structures			
		Pipe Culverts	Box Culverts	Minor Bridges/ Canal crossing	Major Bridges
1	No. of cross drainage	114	201	15	5
	Total				335

4.6 PAVEMENT DESIGN

4.6.1 General

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

4.6.2 Homogeneous Section

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

Table 4.1: Homogeneous Section

	From	To
HS 1	Dobbasapete (Junction NH 4 - SH 3)	Gudemaranahalli (Junction Hassan Road - SH 3)
HS 2	Gudemaranahalli (Junction Hassan Road - SH 3)	Magadi (Junction SH 85 - SH 3)
HS 3	Magadi (Junction SH 85 - SH 3)	Ramanagara (Junction Mysore Road - SH 3)
HS 4	Ramanagara (Junction Mysore Road - SH 3)	Kallahalli/Kanakapura (NH 209 (Chamarajanagar Road) - SH 3)
HS 5	Kanakapura (NH 209 (Chamarajanagar Road) - SH 3)	Anekal (Junction SH 85/SH35)
HS 6	Anekal (Junction SH 85/SH35)	KN/TN Border (Junction NH 7 (Hosur Road) - SH 87)

4.6.3 Design CBR

The subgrade CBR adopted for pavement design is 8%.

4.6.4 Design Life

For Flexible Pavement:

As per Clause 4.3.2 of IRC:37-2012, 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 be provided for full design period.

For Rigid Pavement:

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

4.6.5 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 were conducted side by side. In the traffic census surveys, all types of vehicles traveling in both directions were 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 were 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 defined 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 is arrived at from axle load surveys on typical road sections so as 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 is determined by the relationship:

For Single Axle having single wheel:

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

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 Tonne

The relationship is sometimes 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 are grouped by intervals of one tonne and the frequency of each interval is determined. Equivalency factors are 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 is computed from the following relationship:

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

The VDF calculated for all commercial vehicles on the basis of Axle load survey is given in **Table 4.2**. The detailed analysis sheet are given in **Appendix 4.1**, ***Volume II: Appendix to Main Report.***

Table 4.2: Adopted VDF

Vehicle Type	Bangalore-Mysore Section		Bangalore -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							

4.6.6 Design Lane Traffic

As per IRC: 37-2012 for 6-lane divided carriageway, 60% of the commercial vehicles in one direction has been considered.

4.6.7 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 estimated and projected by adopted growth rates for the entire design period.

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

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

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

Implementation of the project would be taken up in the year 2021 and that the project road would be opened to traffic in the year 2022;

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

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 4.3**.

Table 4.3: Design Traffic Summary

Homogeneous Section	Design Chainage (km)		Cumulative Standard Axle (CSA) - in msa			Design Traffic (20 yr Design Period)	Design Traffic (30 yr Design Period)
	From	To	15th Year	20th Year	30th Year		
HS 1: Dobbasapete to Gudemaranahalli	0.00	30.00	53.78	87.91	199.92	90	200
HS 2: Gudemaranahalli to Magadi	30.00	44.00	32.02	52.37	119.32	55	120
HS 3: Magadi to Ramanagara	44.00	70.00	24.67	40.39	92.46	45	95
HS 4: Ramanagara to Kallahalli/Kanakapura	70.00	98.00	21.05	34.58	79.82	40	80
HS 5: Kanakapura to Anekal	98.00	137.00	37.52	61.56	141.46	65	145
HS 6: Anekal to KN/TN Border	137.00	185.00	60.60	99.18	226.53	100	230

4.6.8 Structural Design of Pavement

The following options has been considered:

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

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

Option 3: Rigid Pavement

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

Design of new pavement is based on the IRC-37: 2012 guidelines using the software IITPAVE. The input required to run the software is given below.

a. Input Data

Subgrade CBR – 8%

$E_{subgrade}$ = 17.6 x $CBR^{0.64}$ = 67.00 MPa

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

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

= 0.2 x 67 x $(450)^{0.45}$

= 208 MPa

$M_{R\_bituminous}$ = 1700 MPa for VG 30 bitumen at 35 ^{0}C

Poisson Ratio - 0.35 for bituminous mix

- 0.35 for granular layer

- 0.45 for subgrade

Tyre Pressure – 0.56 MPa

Centre to centre distance between tyres – 310 mm

Wheel load – 20 kN

b. Performance Criteria

Fatigue Model

$N_f = 2.21 \times 10^{-4} \times [1/e]^{3.89} \times [1/M_R]^{0.854}$ (for 80% reliability and traffic < 30 msa)

Rutting Model

$N = 4.1656 \times 10^{-8} \times [1/e]^{4.5337}$ (for 80% reliability and traffic < 30 msa)

c. Pavement Composition

Based on above parameters, the pavement composition are given below in **Table 4.4** and snapshot of IITPAVE software is given in **Appendix 4.3**, ***Volume II: Appendix to Main Report*** for reference.

Table 4.4: Pavement Composition – Granular Base and Granular Sub-base

	HS-1	HS-2	HS-3	HS-4	HS-5	HS-6
Traffic	**90msa**	**55msa**	**45msa**	**40msa**	**65msa**	**100 msa**
Allowable Horizontal Tensile Strain (x 10^{-6})	174.64	198.21	208.70	215.12	189.88	169.97
Allowable Vertical Compressive Strain (x 10^{-6})	326.50	363.96	380.43	390.45	350.79	319.00
Bituminous Concrete (BC)	50	50	40	40	50	50
Dense Bituminous Macadam (DBM)	110	90	95	90	95	115
Wet Mix Macadam (WMM)	250	250	250	250	250	250
Granular Sub-base (GSB)	200	200	200	200	200	200
Subgrade (CBR >= 8%)	500	500	500	500	500	500
Actual Horizontal Tensile Strain (x 10^{-6})	172.60	194.90	201.70	208.90	189.00	167.60
Actual Vertical Compressive Strain (x 10^{-6})	242.40	267.80	275.40	283.20	260.20	236.60

Note: GSB - Drainage layer (top 100mm) have gradation 4 of table V-1 in Annex V of IRC: 37-2012

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 is given below in **Table 4.5**.

Table 4.5: Maintenance Schedule for Flexible Pavement (Granular Base and Granular Sub-base)

Year	Maintenance Schedule		
	BC	DBM	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

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

Design of new pavement is based on the IRC-37: 2012 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 considered for this option. The input required to run the software is given below.

a. Input Data

Design Life – 30 years

Subgrade CBR – 8%

$E_{subgrade}$ = 17.6 x $CBR^{0.64}$ = 67.00 MPa

Thickness of Granular Layer (GSB), h = 250 mm

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

= 0.2 x 67 x $(250)^{0.45}$

= 160 MPa

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

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

$M_{R\_bituminous}$ = 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

- 0.45 for subgrade

Tyre Pressure – 0.56 MPa

Centre to centre distance between tyres – 310 mm

Wheel load – 20 kN

b. Performance Criteria

Fatigue Model

$N_f = 2.02 \times 10^{-4} \times [1/e]^{3.89} \times [1/M_R]^{0.854}$ (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

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

c. Pavement Composition

Based on above parameters, the pavement composition are given below in **Table 4.6** and snapshot of IITPAVE software is given in **Appendix 4.3**, ***Volume II: Appendix to Main Report*** for reference.

Table 4.6: Pavement Composition for 30 years Design Life
(CT Base and Granular Sub-base)

	HS-1	HS-2	HS-3	HS-4	HS-5	HS-6
Traffic	**200 msa**	**120 msa**	**95msa**	**80msa**	**145 msa**	**230 msa**
Allowable Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	142.23	162.19	172.23	180.01	154.49	137.21
Allowable Vertical Compressive Strain (x 10^{-6}) on Subgrade	273.77	306.42	322.63	335.09	293.9	265.46
Allowable Tensile Strain (x 10^{-6}) in Cementitious Layer	63.24	65.99	67.29	68.26	64.96	62.51
Bituminous Concrete (BC)	50	50	50	50	50	50
Dense Bituminous Macadam (DBM)	50	50	50	50	50	50
Crack Relief Layer /Wet Mix Macadam (WMM)	100	100	100	100	100	100
Cement Treated Base (CTB)	185	175	170	165	180	185
Granular Sub-base (GSB)	250	250	250	250	250	250
Subgrade (CBR >= 8%)	500	500	500	500	500	500
Actual Horizontal Tensile Strain (x 10^{-6}) in Bituminous Layer	126.8	127.2	127.4	127.6	127	126.8
Actual Vertical Compressive Strain (x 10^{-6}) on Subgrade	139.6	147	150.6	154.4	143	139.6
Actual Tensile Strain (x 10^{-6}) in Cementitious Layer	62.11	65.03	66.55	68.12	63.55	62.11

*Note: * DBM for traffic > 30 msa - Air void of 3% after rolling with volume of bitumen close to 13% (Bitumen content may be 0.5% to 0.6% higher than the optimum)*
GSB - Drainage layer (top 100mm) have gradation 4 of table V-1 in Annex V of IRC: 37-2012

4.6.8.3 Option 3 –Rigid Pavement

IRC: 58- 2015 guidelines have been 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 was carried out along the project road.

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

- **Wheel Base Characteristics**

The spacing between successive axles of any vehicle needs to be considered 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 4.5 m, the axles with spacing of more than 4.5 m are not expected to contribute to top-down fatigue cracking.

- **Design Period**

The rigid pavement has been basically 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 considered 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 considered 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 are 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 500 mm 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 is 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 is considered for design. The thickness of DLC is kept 150 mm as recommended in the guidelines.

As per Clause 5.7.3.9 of IRC: 58-2015, commercially available synthetic geo-composite layer can also be used 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 is 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 is generally ignored.

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

➢ **Concrete Strength and Properties**

Flexural strength of concrete is required for the purpose of design of concrete slab. Usually, concrete design is based on 28 days strength. In the case of concrete pavement, 90 days strength can be 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 is 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 >= 8%) 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's job or preferably should meet at the contraction joints.

Load Transfer Devices

i. Dowels for Transverse contraction and construction Joints

  - Diameter 34 mm
  - Length 500 mm
  - Spacing 235 mm

ii. Tie Bars for Longitudinal Joints

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

4.6.9 Paved Shoulder

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

4.6.10 Truck and Bus Lay-Bye – Concrete Block

Interlocking concrete blocks are proposed for truck and bus 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 is given below in **Table 4.7**.

Table 4.7: Composition of Concrete Block Pavement

	Thickness (mm)
Paver Block Thickness	100 mm (M 40 grade)
Sand Bed	40
Dry Lean Concrete (DLC)	75
WMM	150
GSB	250

4.7 PRELIMINARY COST ESTIMATES

The rate of materials adopted in the preliminary cost estimate based on the basic rates of SOR 2016-2017 North East zone, Kalaburagi with escalations as applicable. The format for working out rates for different items of bill of quantities finalized 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

4.8 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 maintained, 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.

4.9 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 with respect to:

- 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.

4.10 ENVIRONMENTAL SCREENING

Environmental Screening has been conducted during feasibility stage as pre-requisite of the impact assessment study with objective 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 be 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 be 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 been studied. The applicability of various acts and laws is 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 were 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 been collected on meteorology, demography, forests and related aspects, land use pattern, topography etc. from reliable sources. Also, additional relevant environment data has been collected from individual research works; either published or unpublished. The source of the data has been documented in the report as reference. The data collected will be broadly subjected to the ground truth verification during detailed field investigations and modifications that may be necessary to the database will be carried out.

c) Reconnaissance survey of the project impact zone

A drive over inspection of the project corridor has been 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 been 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 been 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 been 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 been considered to define the indirect area of Influence.

d) Analysis of data and Screening exercise

The data collected through the above steps has been compiled to develop the environmental scenario of the project area and the sensitive components within that. The full road length and CoI was 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 were identified through a scientific procedure.

Identified Valued Environment Components (VECs) in the Project

Following is a list of important environment components that were 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 be 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 were identified based on the screening data and Impact identification matrix was developed highlighting the general mitigation measures.

g) Scope of detailed EIA study

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

Chapter-5:
Socio Economic Profile

TABLE OF CONTENTS

LIST OF TABLE

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 has been 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	179.696 km	Karnataka	Bangalore Rural	Nelamangala	Newly declared NH 948A
		Km 134.365 to 179.696 km	45.331			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 185km. 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 is 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 south western region of India. The capital and largest city is Bangalore (Bengaluru). Karnataka is bordered 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 and 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 6th 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 south eastern part of Karnataka state. Bangalore is the district headquarters and also capital of the state. Bangalore Rural district is located in the south-eastern 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 is bounded 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 served 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 connected by metalled roads. Bangalore district is also well served 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 South-Eastern 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. By and large this rural district is Agricultural and Ragi is the main crop through mulberry is raised over considerable tracts. The climate of the district is salubrious and very agreeable. It is devoid of extremes. But rainfall is meagre, and as no major river flows in the district Irrigation facilities are also 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. Bangalore Rural District is bounded on the North by Tumkur and Kolar Districts: 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 seems to 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 be 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 are found more in the urban than rural areas.

This situation is echoed 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 4 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 south-eastern 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 connected 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 situated 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. And 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 are also seen in many places. Animal Husbandry is being practiced 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 remembered for prosperous silk weaving Industry. The District lies in the southern maiden region of the State and is by and large.

- 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 are spread over the entire district Granite quarrying and crushing is 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 is bounded on the north by Bangalore Rural and Tumkur districts, on the north-east by Bangalore Urban district and on the west by Mandya district. On the South and south-east, the district is covered by Chamarajanagar district and districts of Tamil Nadu State. 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 been 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 covered 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 covered by Clay skeletal soil rocky land in combination. Towards south the soil is more coarse loamy and coarse loamy silt. Pokey land is found in the south, south east and east. Towards east, hilly ranges are present. More of clayey and clayey loamy soil is found here. Clayey soil is 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 which is 31km away from Ramanagara, Ramadevarabetta located within the city, SRS betta which 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 south western portion of Nandi hills. Taking a south – westerly route, the river passes through Dod Ballapur 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 been formed by building a dam across the river near Abur and its waters are being effectively utilized for irrigation. Number of coconut gardens is 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 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 are 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 classed 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 south west monsoon season (June to September).
- The north east 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 south west 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 north east monsoon from October is also a moist rainy period but with slightly less clouds. Wind are weaker and blow from east-north east to north east. 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 moderated by occasional thunderstorms and squalls. April is seen 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 north east

rainfall brings about 241 mm in about 14 rainy days. Usually this follows the south west 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, Sun flower 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 connected 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 called as Cosmopolitan Cocoon Market because of the people from different states participates in cocoon transaction here. On an average, 35 Metric tons of cocoons are being 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 money lenders, who exploited the helpless debtors. The intervention of the government by enacting acts to control and regularise these money lender were implemented. 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 is also known as 70 Silk town. The Bidadi industrial area has been 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 is 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 were made in the rock to resemble caves. It was also in this region that the famous Hindi movie, Sholay, was shot.

JanapadaLoka

JanapadaLoka is situated 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 was built in 1946 across the River Kanva (a tributary of the River Cauvery). The river here is named after the sage Kanva, who was supposed to have lived in this region during the time of Ramayana. Kanva Reservoir has 5 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 birth place 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 pointed out to the south-west of this temple, where only broken brick and ruined walls are noticed.

Savandurga

Savandurga is a hill located at a distance of 60 km west of Bangalore. It is also known as Magadi Hills. The hill is famous for a temple and is also believed to be among the largest monolith hills in the world. The Savandurga hills are frequently visited by pilgrims who come to visit the Basaveshwara Savandi veerabhareeshwra swamy temple situated at the foothills. At the foothill there is a village by the same name and the forest around has been 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 is also known as DakshinaKasi or the Varanasi of the South. Temples dedicated to Gangadhareswara, Hanna Devi and a cave spring called 'Pattala' are found at the top of the hill.

Channapattana

Channapattana is located 60 km south-west of Bangalore on Mysore-Bangalore highway. The City was 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. The temple was built by "Hoysala kings". 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 situated 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 can 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 south-eastern 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 is bounded by Bangalore rural district in the East, West and North except in southeast, where the district is 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 is 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 be divided into rocky upland, plateau & flat topped hills at a general elevation of about 950amsl.The major part is sloping towards south and south east 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 dissected 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 is 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 together 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-north-easterly to south-south-westerly. 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 are 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 dissected 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. The hilly terrain in the southern part is covered by small shrubs and bushes.

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 drained 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 drainage pattern of the Bangalore North taluk is governed by the granitic ridge running north-north-easterly to south-south-westerly almost in the middle of the taluk. The drainage towards east is 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 is 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 considered 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 classified 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 followed 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, south west monsoon contributes 52 to 56 per cent and north east 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: Salient 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

S. No.	Particular	Units	Figure
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
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 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 were 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 headquartered in Yelahanka, Bangalore.

Bangalore is served by Kempegowda International Airport, located at Devanahalli, about 40 kilometres (25 miles) from the city centre. It was formerly called 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, and is a factor in leading the "IT revolution" in Bangalore.

Bangalore is the second fastest-growing major metropolis in India, and is also 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 is fairly well spread across sectors, for example, we have engineering industries, aeronautical industries, textile industries, information technology industries, and bio-technology 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 bio technology 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 bio technology 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 been 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 was 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. BMTC offers special buses for sightseeing in Bengaluru, including double-decker open roof bus.

- **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 was 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 is 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** was 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 is built to look like a smaller replica of the Windsor in England.
- **Mayo Hall** was designed in memory of the Lord Mayo and is 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 30th district of Tamil Nadu.

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

Krishnagiri district is 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 11º 12'N to 12º 49'N Latitude, 77º 27'E to 78º 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 north-western 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 north-western part of the district. Ponnaiyar is the major river draining the district and is ephemeral in nature. It originates 2 from Nandhi hills in Karnataka, enters Tamil Nadu west of Bagalur and flows almost in a south easterly 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 divided 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 is 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 spoken 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

S. No.	Particular	Units	Figure
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
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 connected by Prime Minister's Golden Rectangle 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 called a Cosmopolitan society. Ancient Art & Culture is preserved and maintained by inhabitants. The major entertainment for rural folk form the 'Street Play' (theru koothu) and 'Sevai Attam'.

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 conducted 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 produced in this district, are processed into pulp. In addition to mango pulp processing, tonnes of mangoes are processed into juice every year in this district. A large-scale mango export zone has been 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 this district process mangoes. Much of the population in this district is employed 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 produced and distributed under different schemes. Apart from production and export, Krishnagiri also hosts Mango exhibition every year which 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 constructed in 1958 during the rule of the then Chief Minister Kamaraj is 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 farm houses are located in the outskirts. The boat house is situated 8 km from the central bus stand which also houses a children's park. There are a variety of ancient temples in the vicinity of 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 is 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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

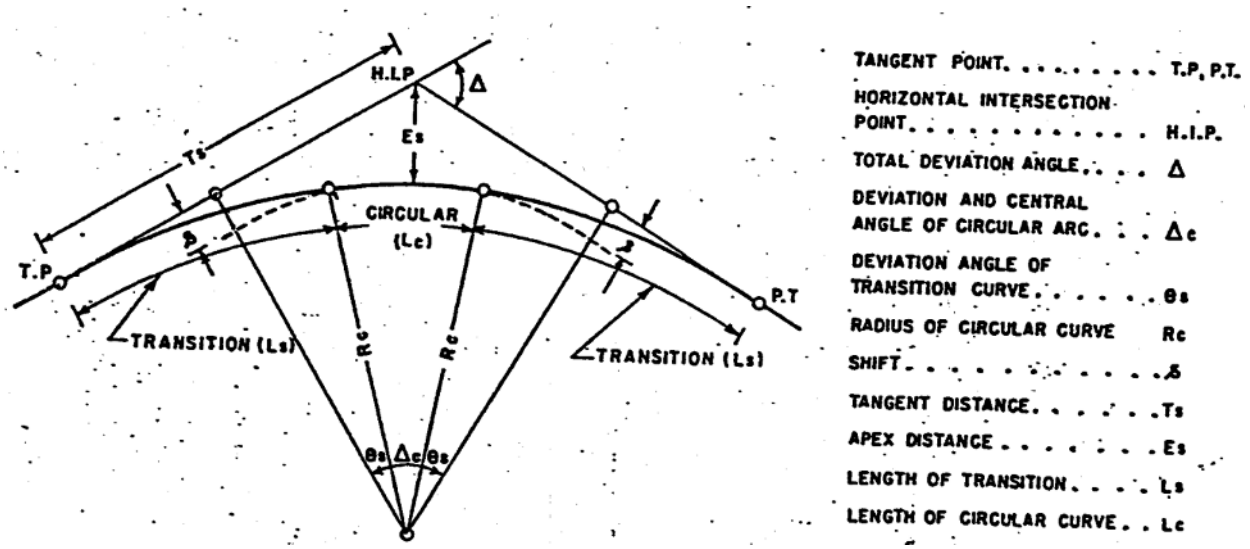


Figure 6.1: Elements of a Combined Circular and Transition Curve

- **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										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

SPEED NOT APPLICABLE

SPEED NOT APPLICABLE

SPEED NOT APPLICABLE

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 **Fig. 6.2.**

Table 6.10: Cross Sectional Elements

S. No.	Description	Standards for 6-lane NH (as per IRC:SP:87-2017)
		Plain / Rolling Terrain
1	**ROW standard as per IRC**	
	• Minimum ROW	60m
	Proposed ROW Based on the Various types of typical cross sections developed and as per site requirements:	
2	**Main Carriageway**	
	Roadway Width	35m
	• Median	5.0m*
	• Kerb Shyness	0.5m
	• Lane Width (Carriageway)	3.5m
	• Paved Shoulder	1.5m*
	• Earthen Shoulder on outer side	2.0m
	Extra width of Pavement and Roadway	
	• Curve Radius 75m to 100m	0.9m
	• Curve Radius 101m to 300m	0.6m
	Service Road	
	Roadway width	10m
	• Separator (Raised Footpath) between Main Road and Service Road	1.5m**
	• Carriageway	7.0m
	• Earthen Shoulder	1.5m*
	• Lined Drain at the end of Service Road	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: 37-2012. 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 15 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 a minimum design period of 15 years 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

S No.	Road	Road type	Cross road Crossing (km)	Proposed STRR (km)
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

No.	Code of Practice / Title of Publication
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
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

No.	Code of Practice / Title of Publication
	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	:	$1.95x10^5$MPa
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 (2/3ϕ), 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.

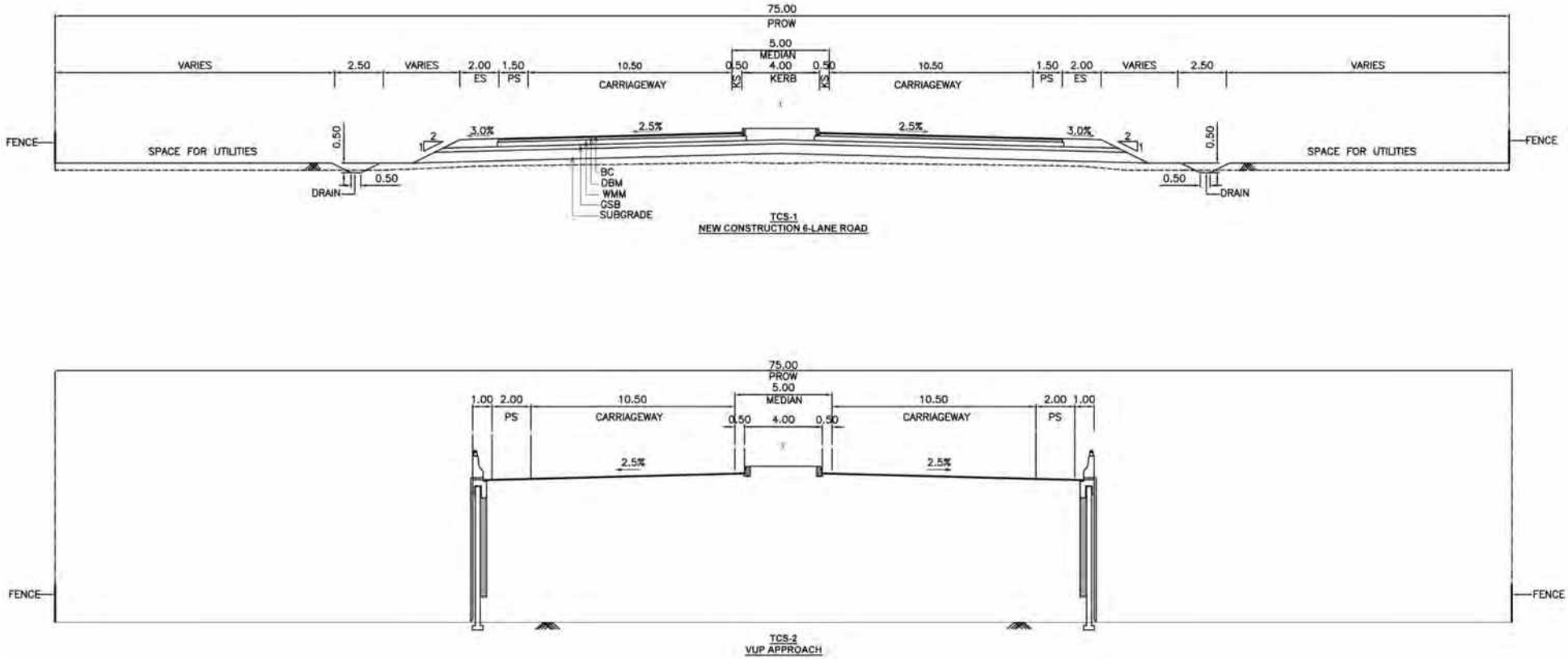


Figure 6.2: Typical Cross Sections

Chapter-7:
Traffic Survey and Analysis

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

(Provided in Volume II: Appendix to Main Report)

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 been carried out to assess the traffic characteristics on existing routes being 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 is 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 is divided into different homogeneous sections.

The homogeneous sections are presented in Table 1.1 below and Figure 1.1 below.

Figure 7.1: Homogeneous sections for traffic study

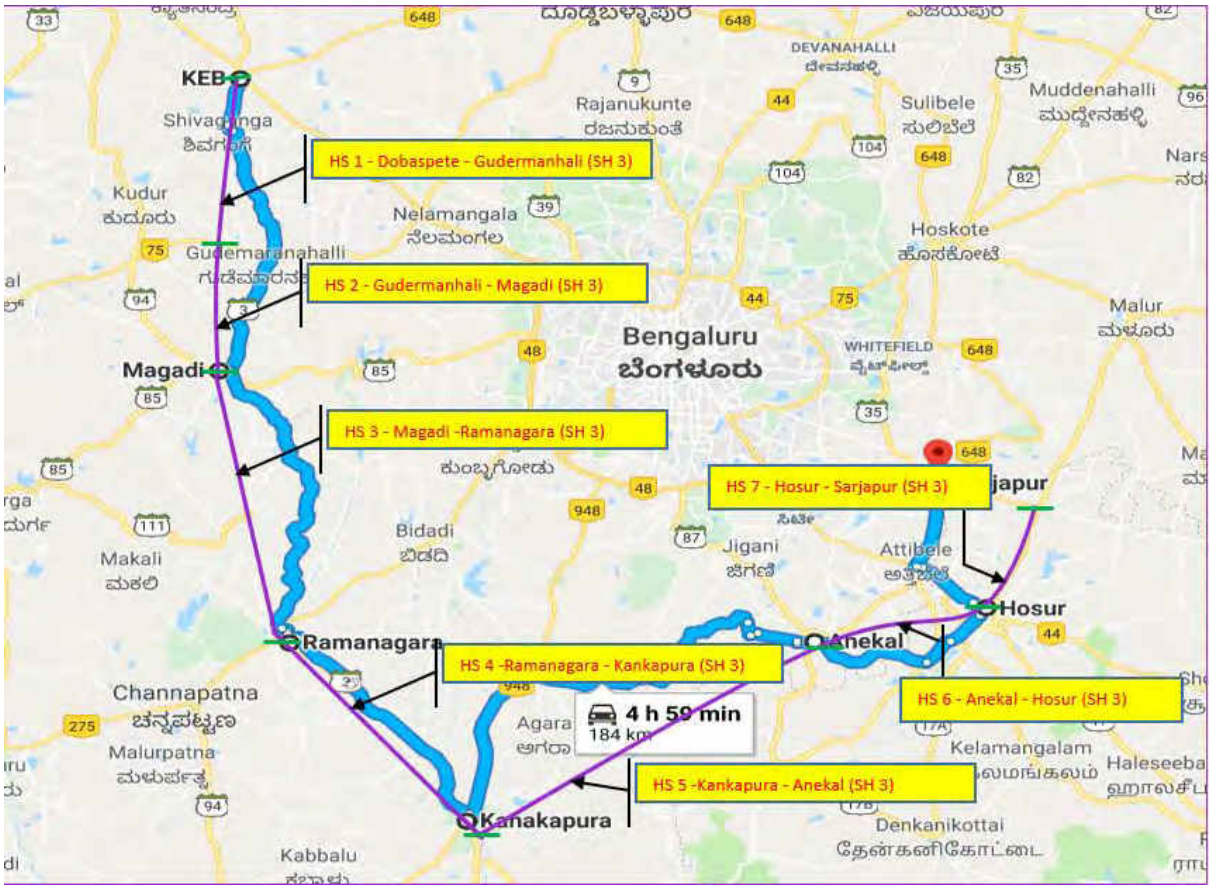


Table 7.1: Homogeneous sections for traffic study

	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 conducted.

1. Classified traffic volume count (CTVC)

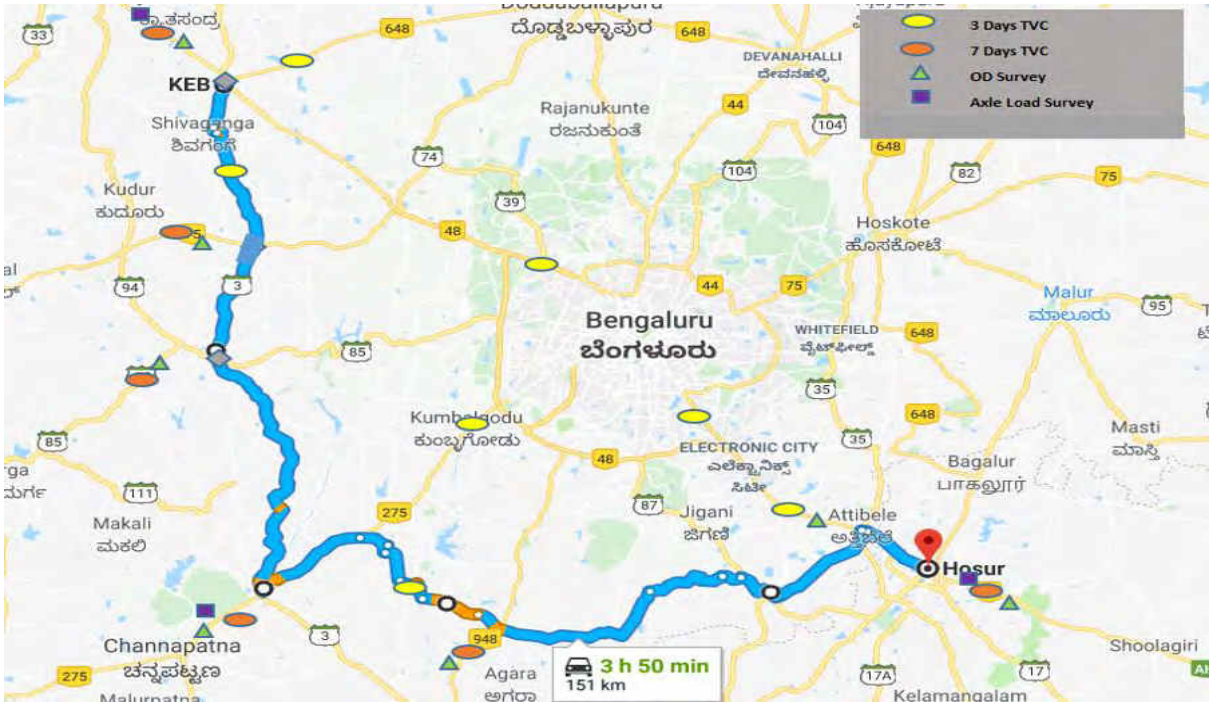
2. Origin – destination survey (OD)
3. Axle load survey

Traffic survey stations for carrying out CTVC, OD and axle load surveys were selected 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 location 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 were 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, a day was divided into two shifts of 12 hours each and different groups of enumerators with a supervisor were assigned for each shift. The count data was recorded at 15-minute intervals for each vehicle group for each direction of travel separately. Trained enumerators were deployed for counting and recording by making tally marks in the five-dash system. This traffic data is used for working out traffic characteristics analysis and forecast, capacity augmentation and toll analysis. The schedule of survey is given in **Table 7.3.**

Table 7.3: Schedule of traffic volume count survey

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		
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 was conducted at seven locations for a day (24 hours) as stated in **Table 7.3**. Roadside interview method was 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 were 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.

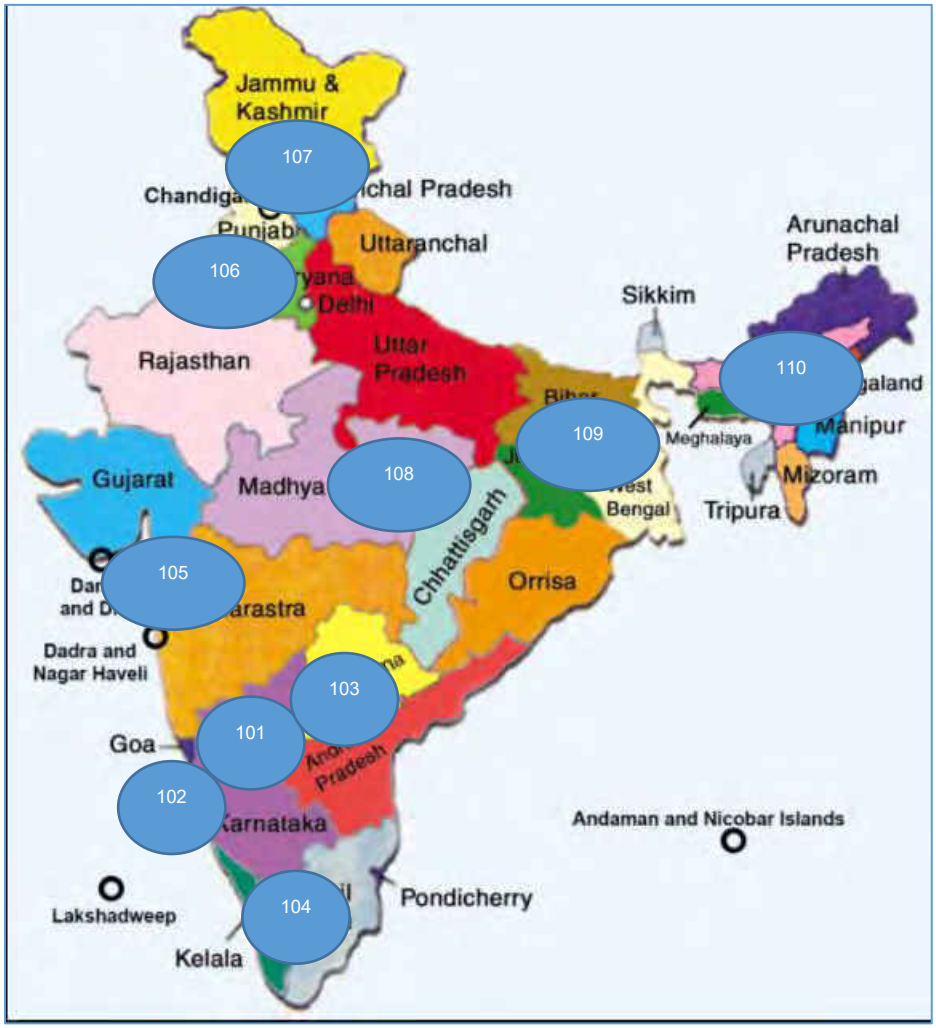
Three types of zones were used for the OD Survey and Analysis as follows:

- 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 is 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 been carried out at three locations in order to estimate vehicle damage factor (VDF) for using in pavement design of proposed Greenfield expressway.

The survey is carried out at two locations, using portable weigh pads. Axle loads of LCVs, and two, three and multi axle trucks are 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 are recorded.

7.5 DATA ANALYSIS – TRAFFIC VOLUME COUNT

The classified traffic volume survey data for twelve count locations is analyzed 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 recorded by conducting traffic counts at twelve strategically selected traffic count stations. Recorded traffic data has been converted into Passenger Car Units using PCU factors as shown in **Table7.4**. These equivalency factors are 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 data for 7 days at six 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 7.5 a: Average Daily Traffic

	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	43746	17142	31159	8524	24061	42718
PCU	70014	12648	31660	7426	28247	66747

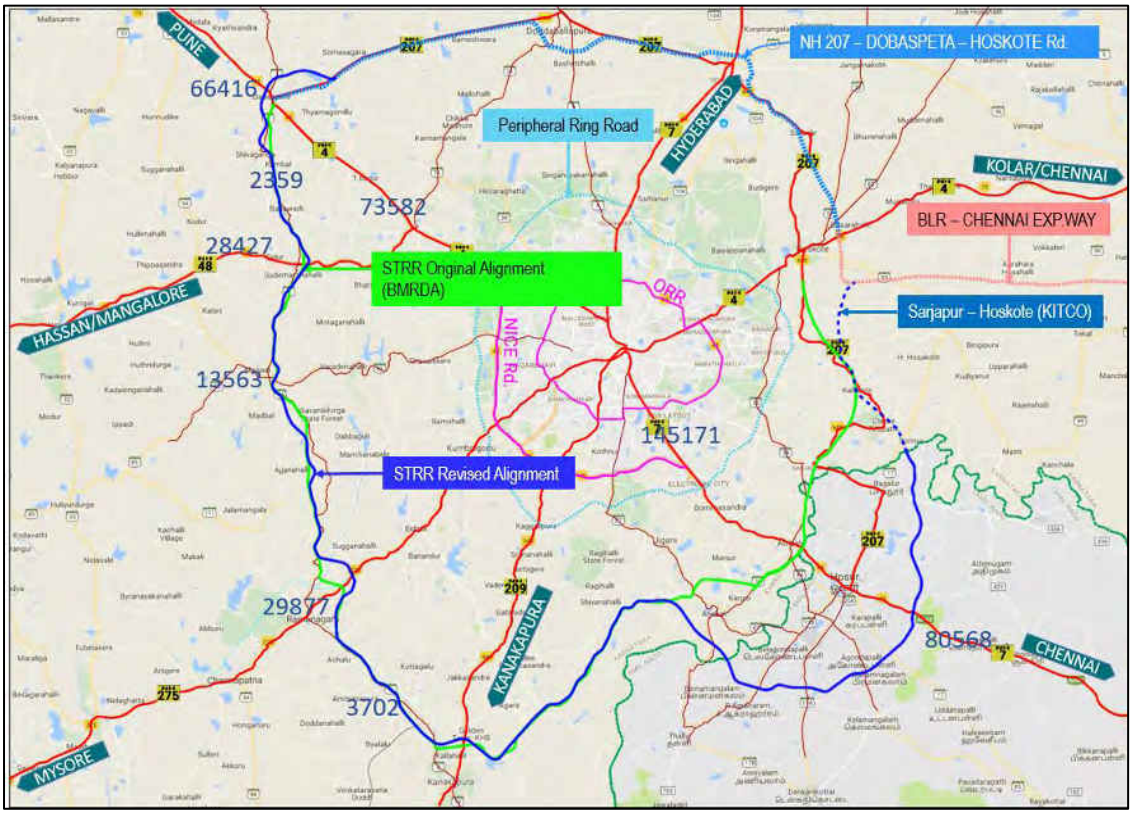
Table 7.5 b: Average Daily Traffic

	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	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



7.5.1.1 Annual Average Daily Traffic (AADT)

The AADT is obtained by adjusting the traffic counts conducted for seasonal variation of traffic in the region. Seasonal variation factor has been derived 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 carried out in the months of December 2017. The seasonal factors are 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 is 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

7.5.2 Hourly Variation of Traffic

Average hourly variation of traffic for the 13 count locations is shown in **Figure 7.6** through **Figure 7.18**. It is observed 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

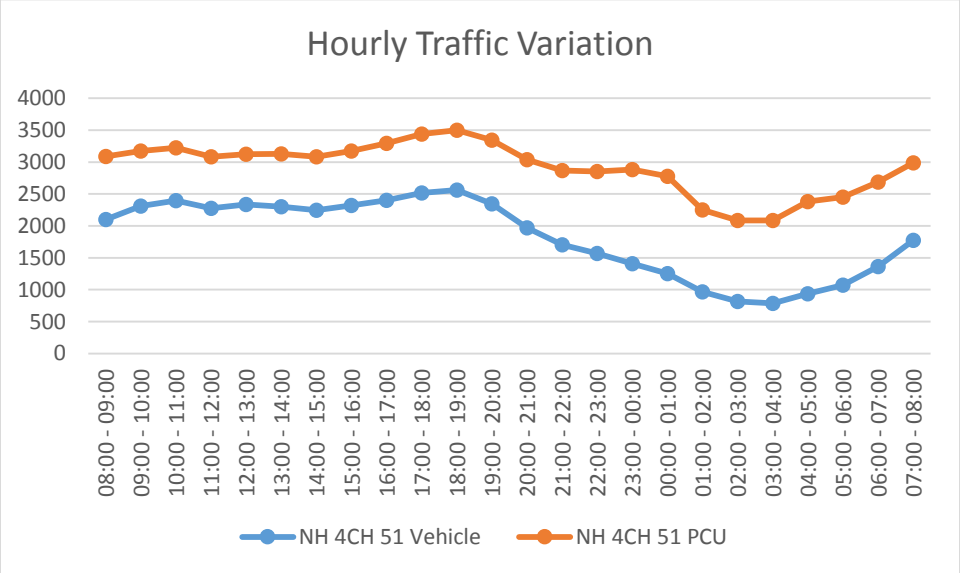


Figure 7.8: Hourly Traffic Variation at SH 85

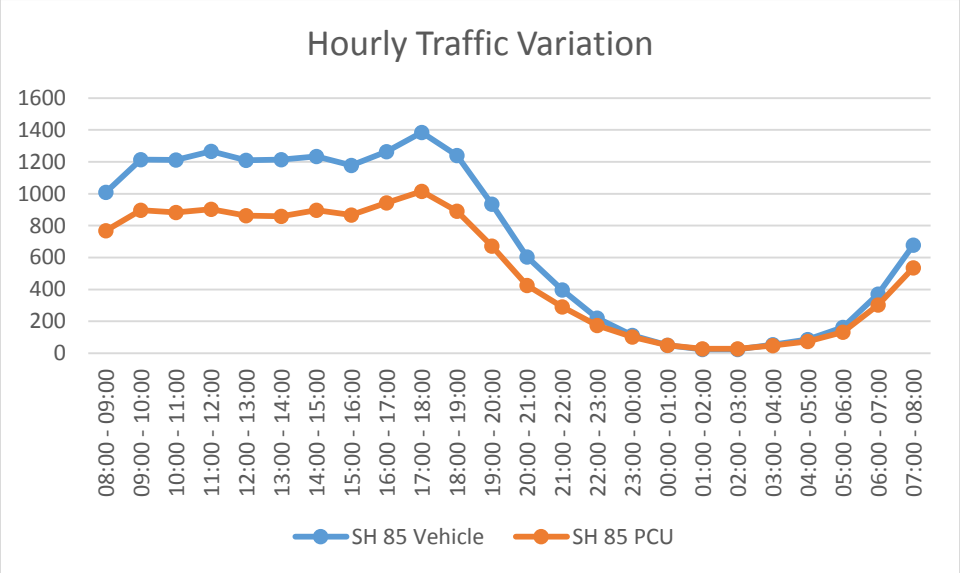


Figure 7.9: Hourly Traffic Variation at NH 275

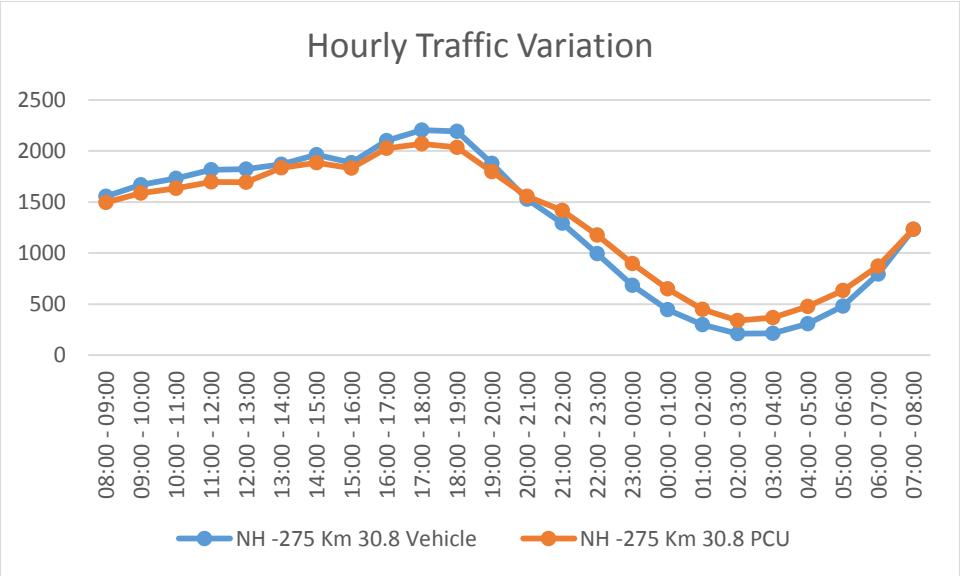


Figure 7.10: Hourly Traffic Variation at NH 209

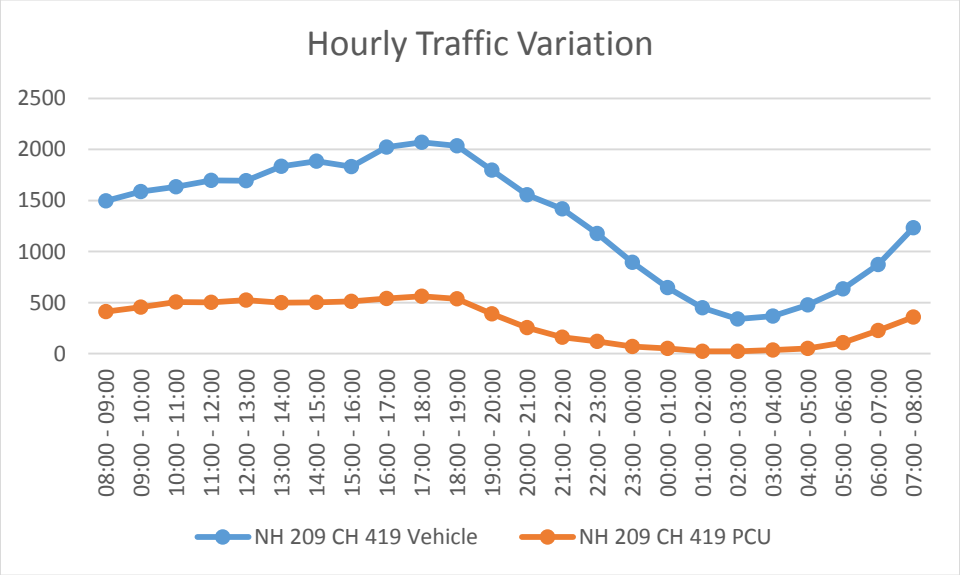


Figure 7.11: Hourly Traffic Variation at NH 48

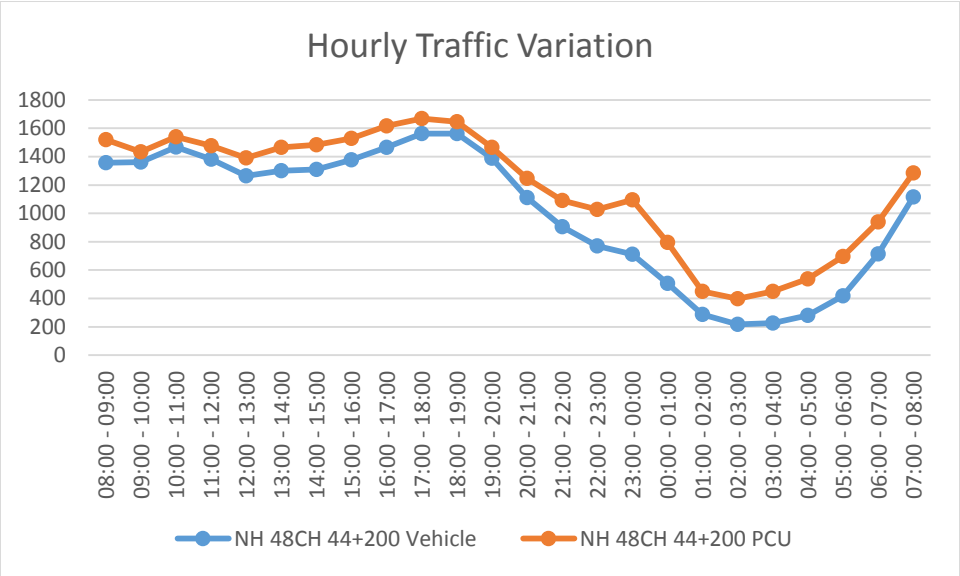


Figure 7.12: Hourly Traffic Variation at NH 7 Ch 49+000

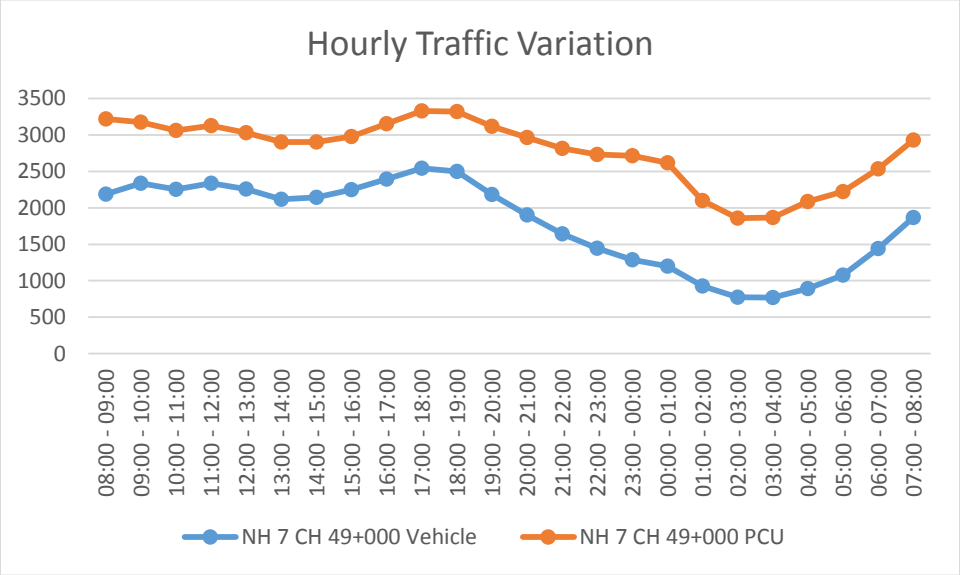


Figure 7.13: Hourly Traffic Variation at NH 7 Ch 31+000

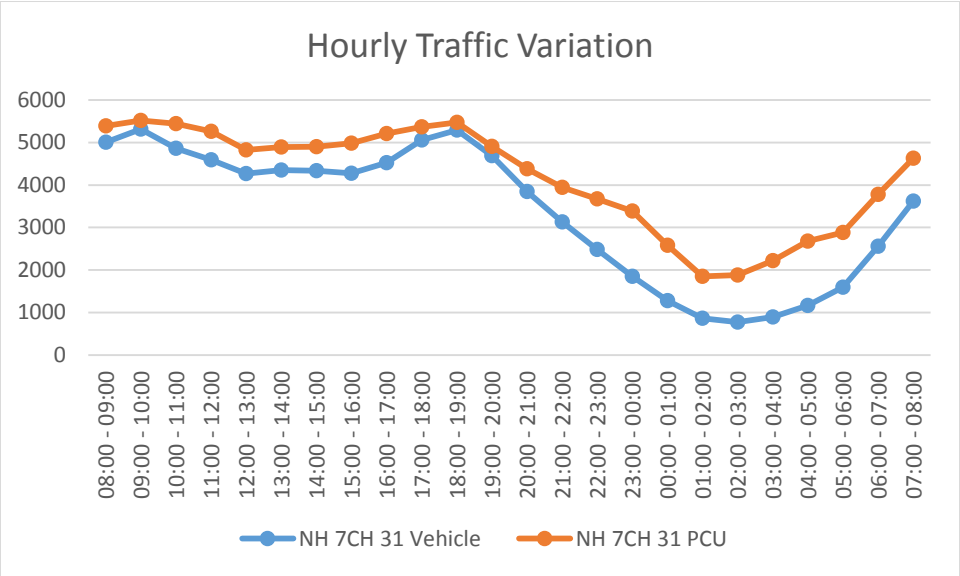


Figure 7.14: Hourly Traffic Variation at SH 3 Ch 118

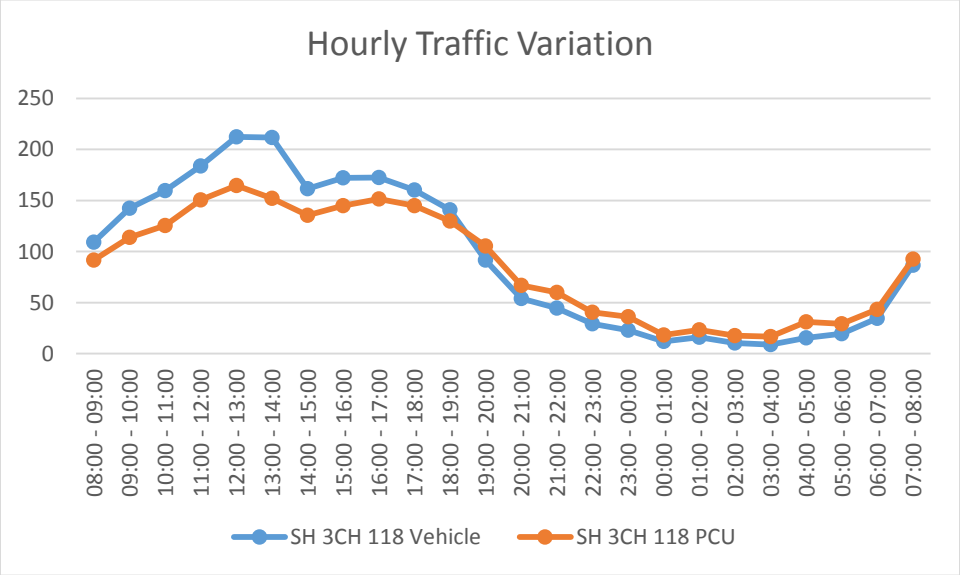


Figure 7.15: Hourly Traffic Variation at NH 207 Ch 138

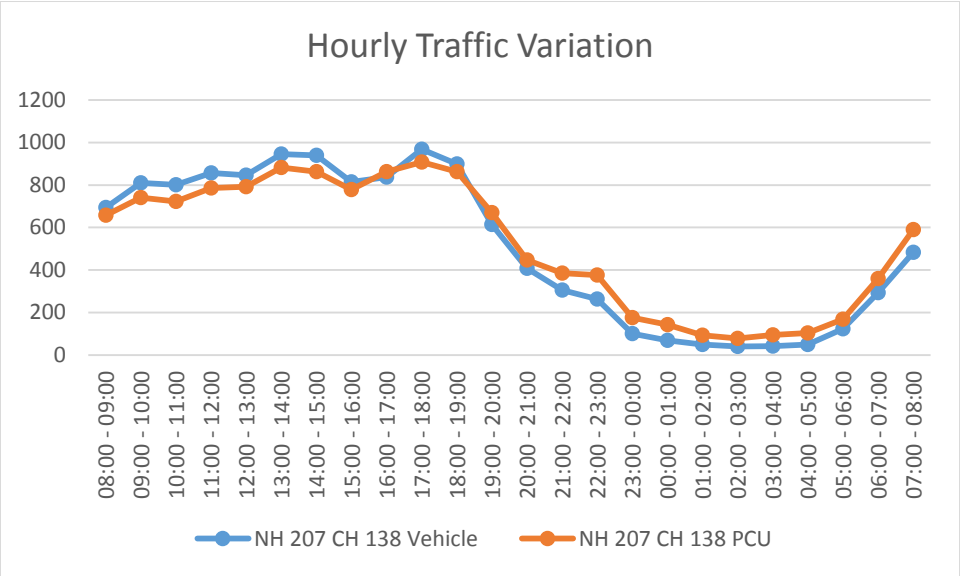


Figure 7.16: Hourly Traffic Variation at NH 4 Nice Road

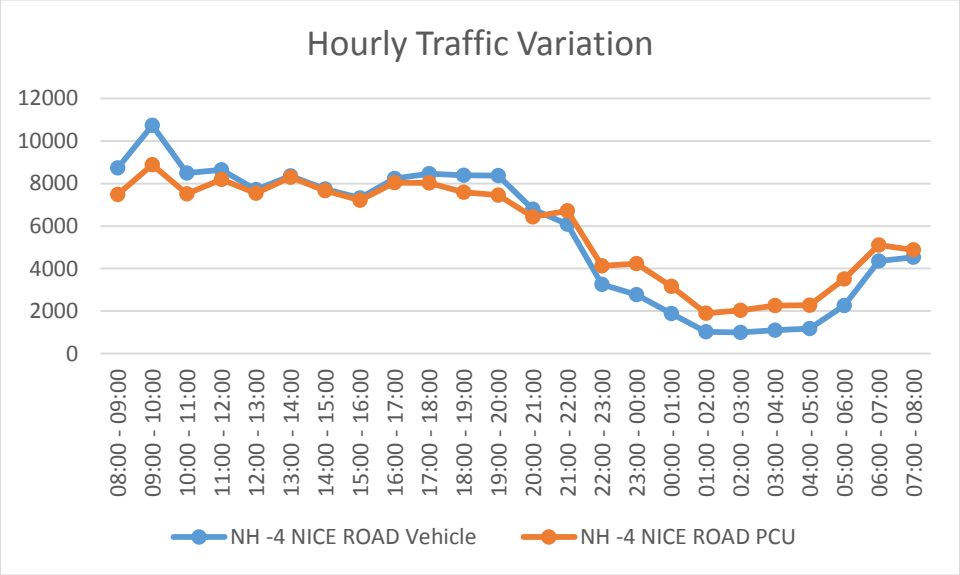


Figure 7.17: Hourly Traffic Variation at NH 7 Before Nice Road

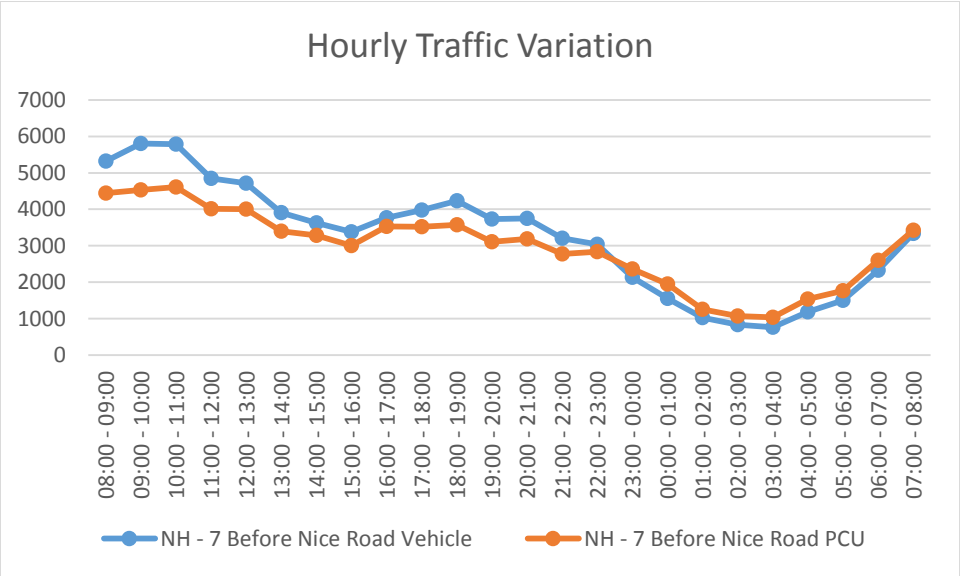


Figure 7.18: Hourly Traffic Variation at NH 275 Nice Road

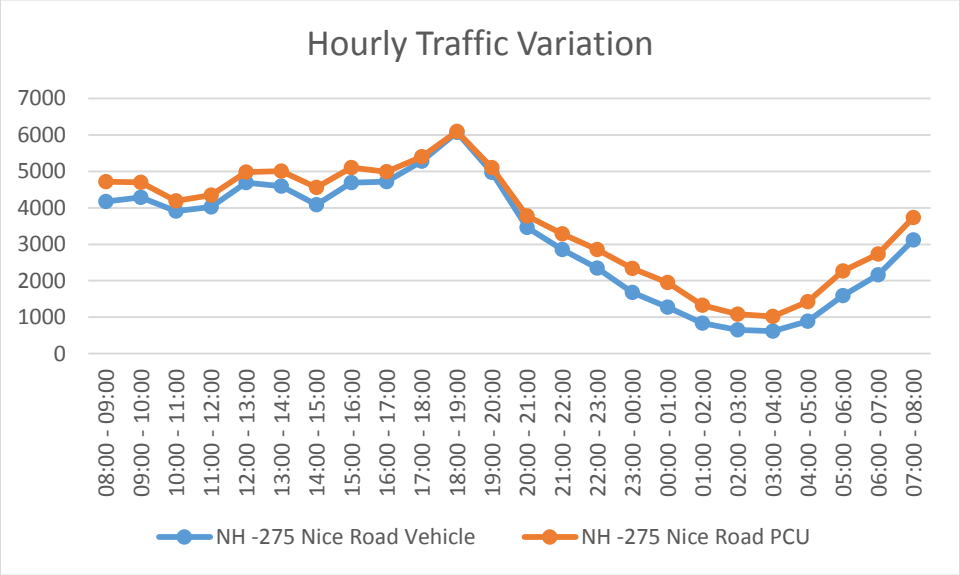
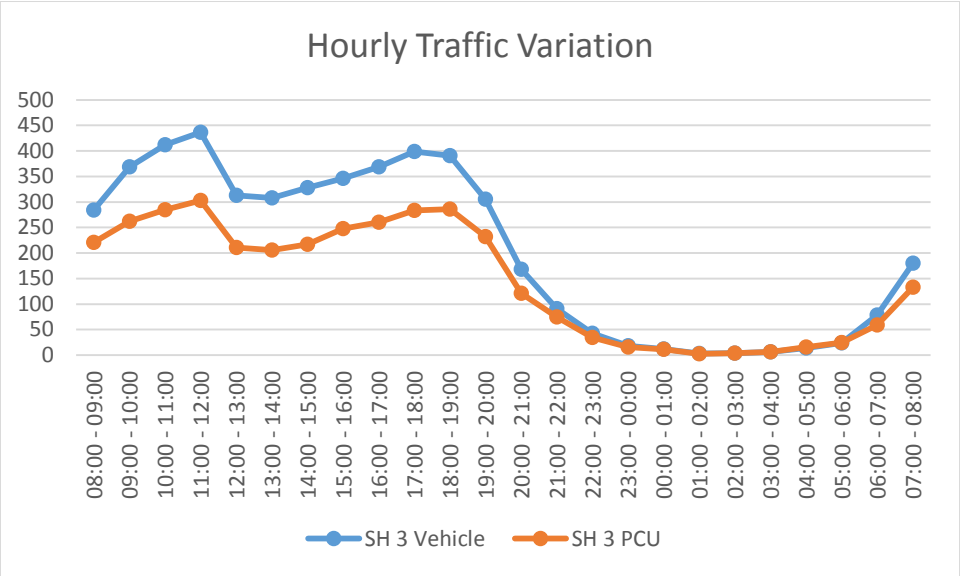


Figure 7.19: Hourly Traffic Variation at NH SH 3



7.5.3 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

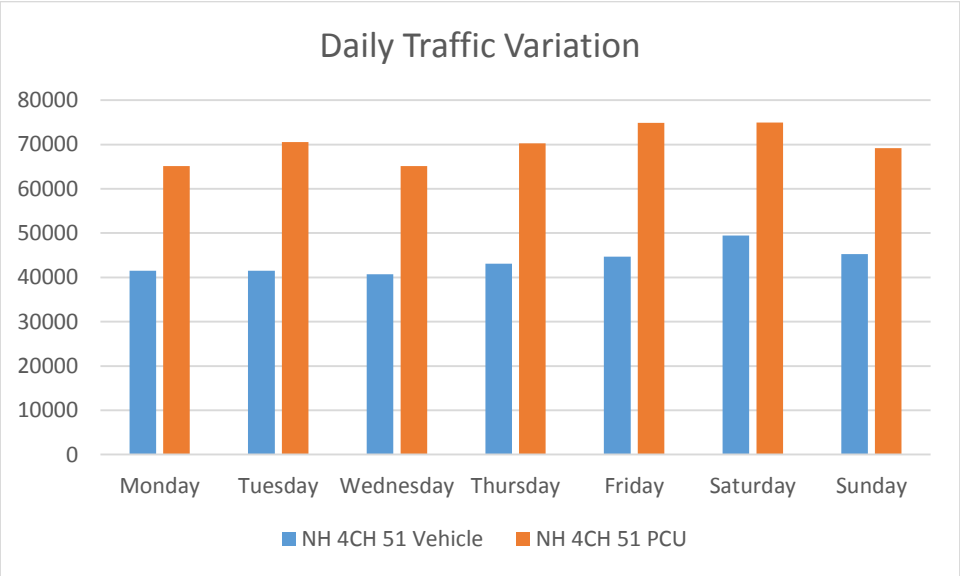


Figure 7.21: Daily Traffic Variation at SH 85

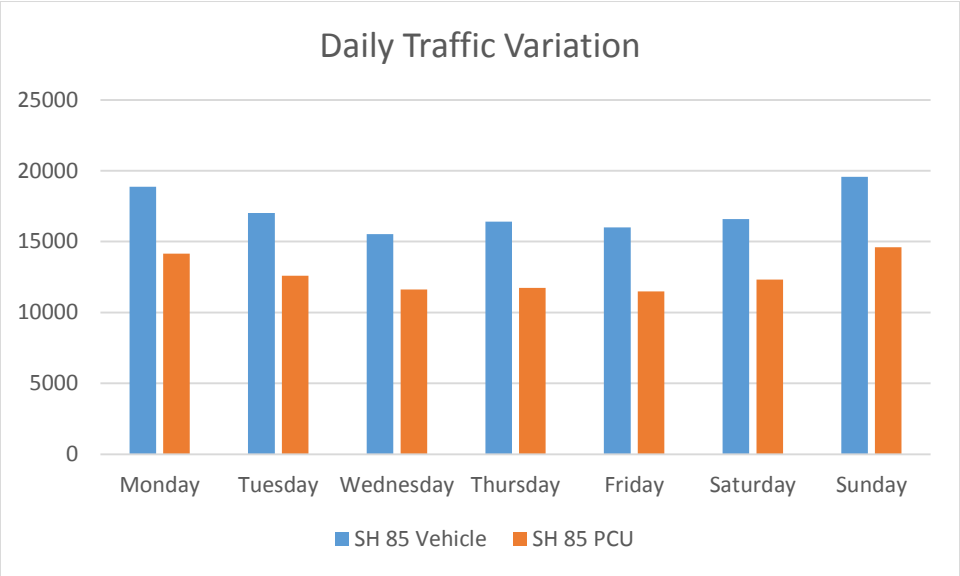


Figure 7.22: Daily Traffic Variation at NH 275 Ch 30+800

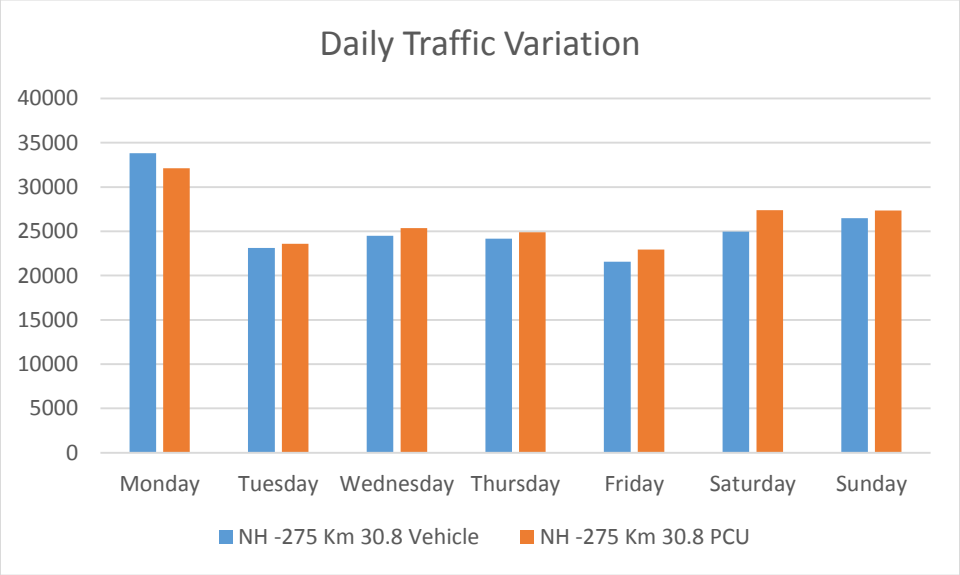


Figure 7.23: Daily Traffic Variation at NH 209

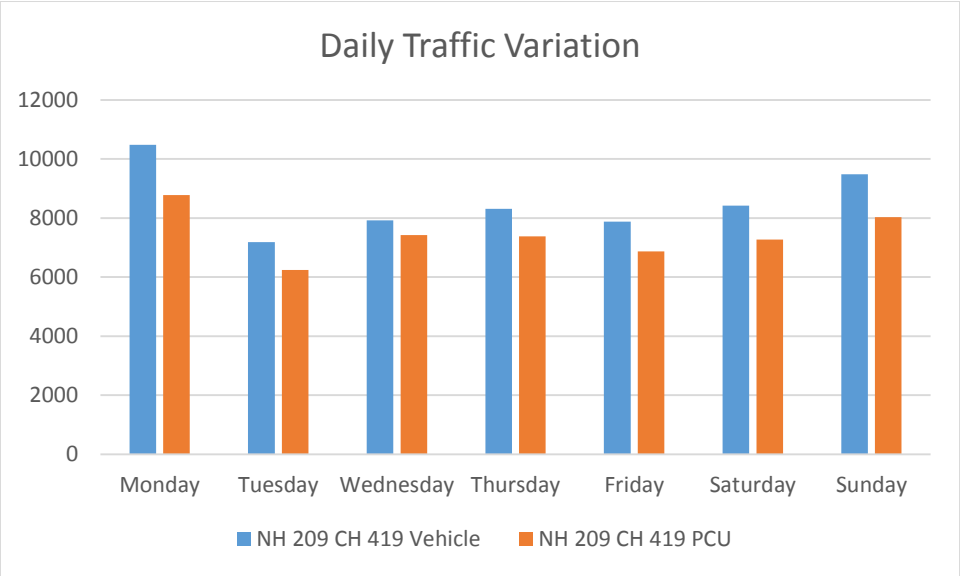


Figure 7.24: Daily Traffic Variation at NH 48

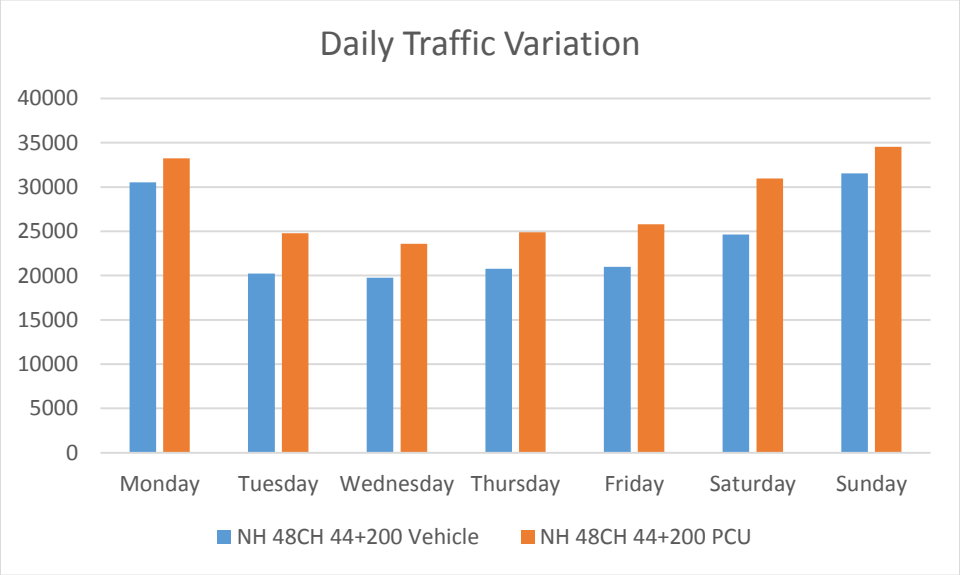


Figure 7.25: Daily Traffic Variation at NH 7 Ch 49+000

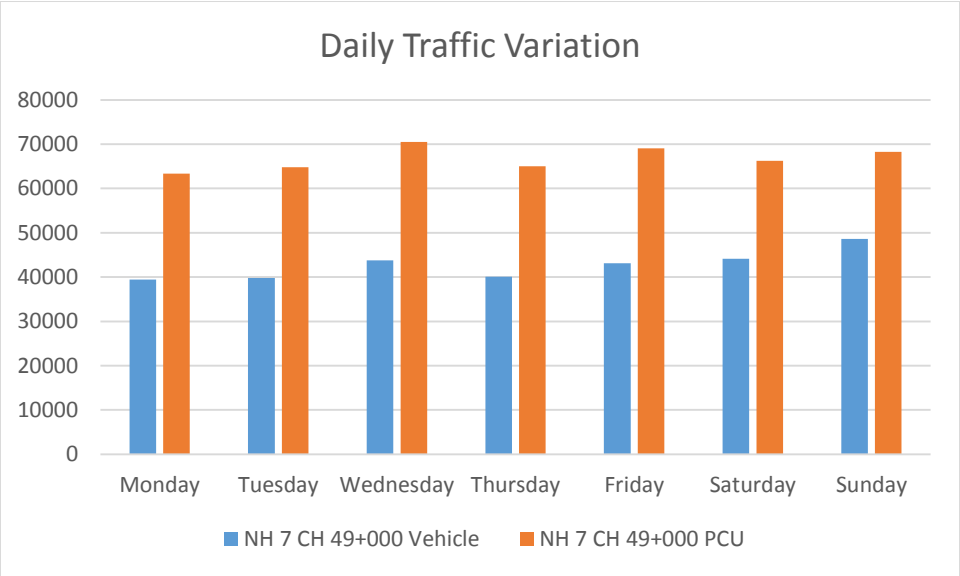


Figure 7.26: Daily Traffic Variation at NH 7 Ch 31+000

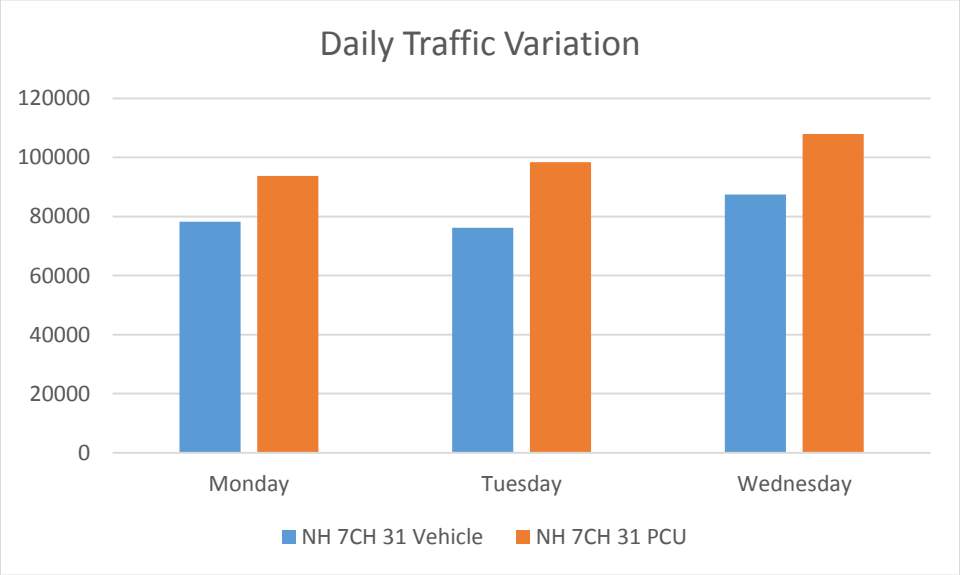


Figure 7.27: Daily Traffic Variation at SH 3 Ch 118+000

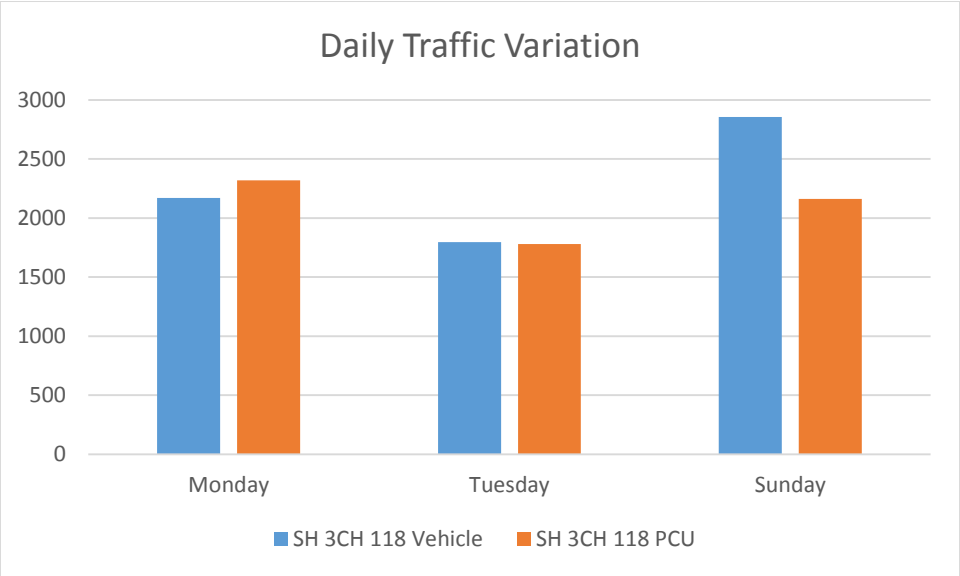


Figure 7.28: Daily Traffic Variation at NH 207 Ch 138+000

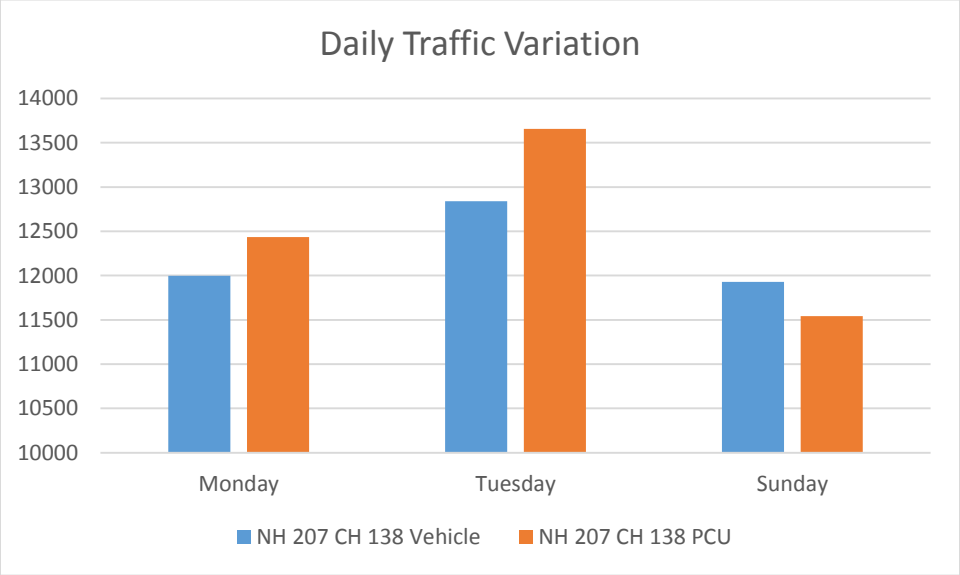


Figure 7.29: Daily Traffic Variation at NH 4 NICE ROAD

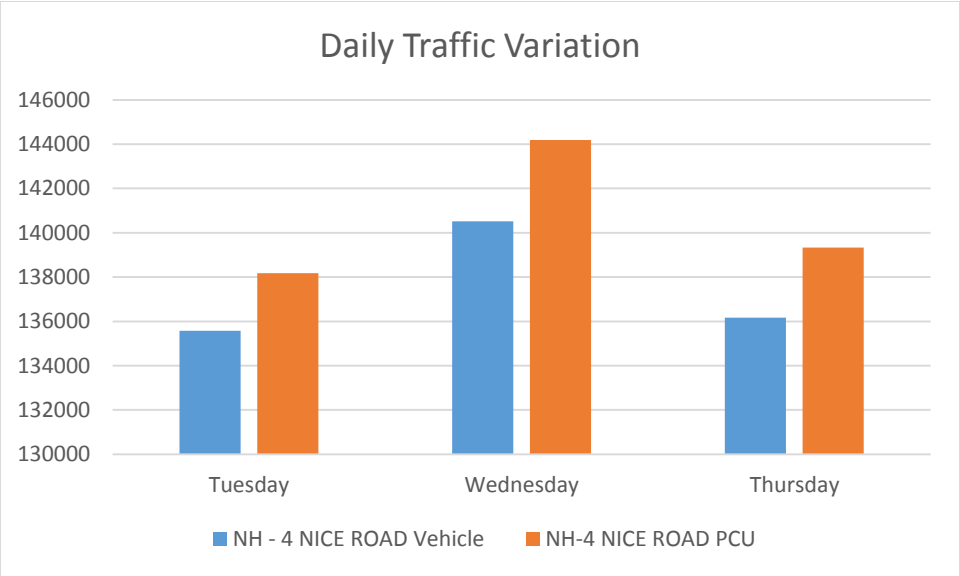


Figure 7.30: Daily Traffic Variation at NH 7 Before NICE ROAD

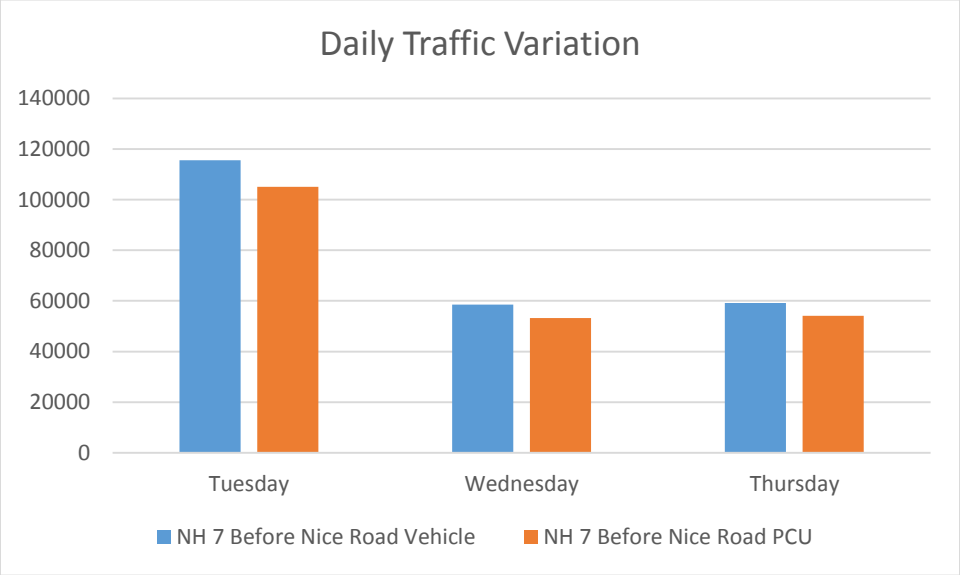


Figure 7.31: Daily Traffic Variation at NH 275 NICE ROAD

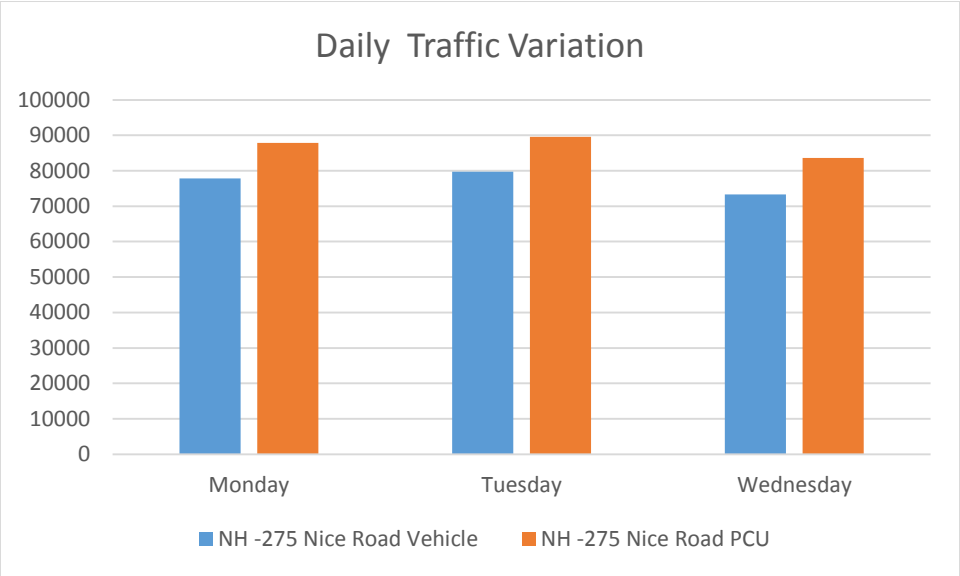
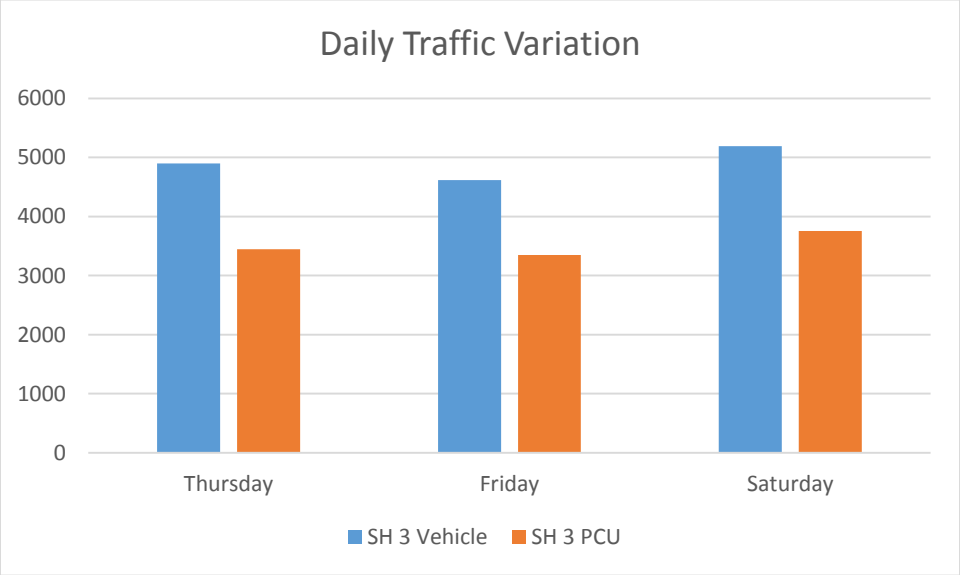


Figure 7.32: Daily Traffic Variation at SH 3



7.5.4 Composition of Traffic

Average composition of traffic at each count location is presented 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.

7.5.5 Directional Distribution of Traffic

Directional split at each of the location is 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 to be made on a more rational basis. The origin - destination surveys have been carried out by means of the roadside interview method at locations selected to capture major trip desires in each section. The surveys have been 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 was 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

Sl 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 been divided 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 are 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 are already being made between various origin and destinations impacted by the STRR route. In this case, the diversion of such traffic to the STRR would be estimated.
3. Induced Traffic: This traffic is based on trips that were not taken 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
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 been presented in the previous chapter. The share of trip pattern at OD locations thus obtained is given 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 is 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 were based on the IRC: SP: 30 - 2012. These values were 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 is 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 ≤ 0.634	Diversion Rate = 98.750 - (CR/0.634) * 8.125
0.634 ≤ CR ≤ 1.465	Diversion Rate = 90.625 - ((CR-0.634)/0.831) * 84.375
1.465 ≤ CR ≤ 2.0	Diversion Rate = 6.25 - ((CR-1.465)/0.535) * 5.25

Truck & Bus

CR ≤ 0.750	Diversion Rate = 100 - ((CR/0.75) * 5)
0.750 ≤ CR ≤ 1.250	Diversion Rate = 95 - ((CR-0.75)/0.5) * 90
1.250 ≤ CR ≤ 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 is 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 considered 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 being developed. 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 considered 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 induced 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 was 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 is carried out in order to assess the Level of Service (LOS) offered by road sections under prevailing roadway and traffic conditions.

Capacity and Design Service Volumes (DSV) specified in IRC-64-1990, Capacity of Roads in Rural Areas have been adopted for determining the Level of Service offered by road sections during the design period. The capacity and design service volumes for various lane configurations in case of plain terrain are 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 these 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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 Dobaspete and terminates near Bagalur in Tamil Nadu/Karnataka border. The STRR alignment is totally a Greenfield alignment totalling the length of 19.696km. 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. Dabaspete. 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 is being undertaken as a parallel exercise with the Engineering Analysis, so as 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 are 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 avoided. Deemed Forests patches shall be 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 to assess for future years and necessary protection measure need to be considered 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. 60m

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 Dobaspete (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:

Karnataka:

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 north-western 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.

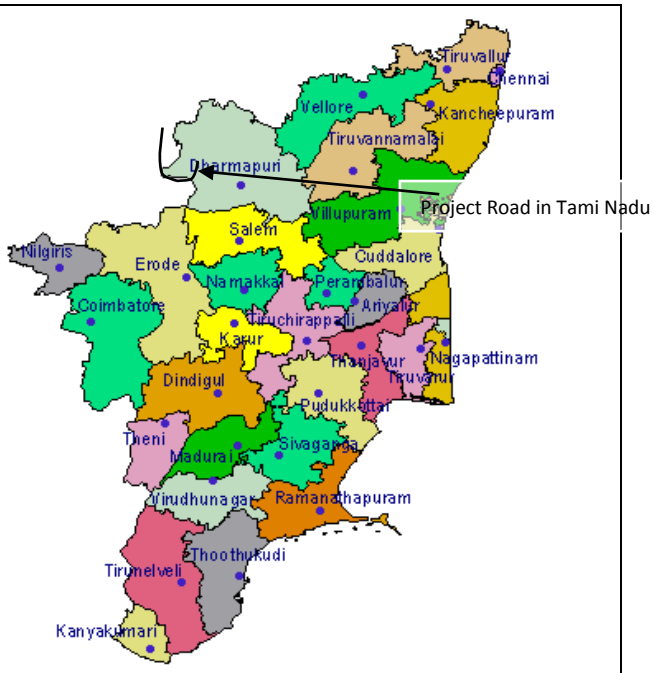


Figure 8.2: Physical Map of Tamil Nadu showing Project Area

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-gray 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 formed 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 resp. (**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.

Also, 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.

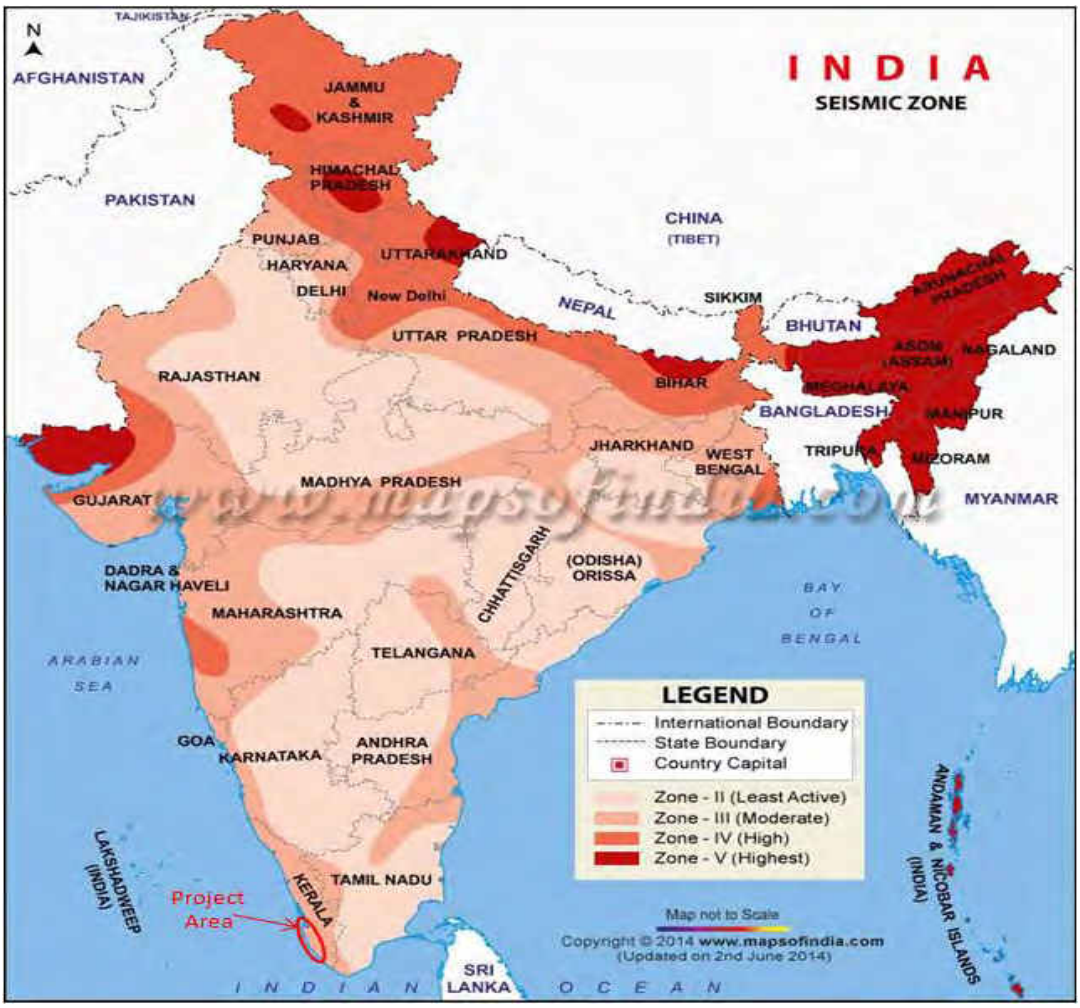


Figure 8.3: Seismic Zonation Map of India

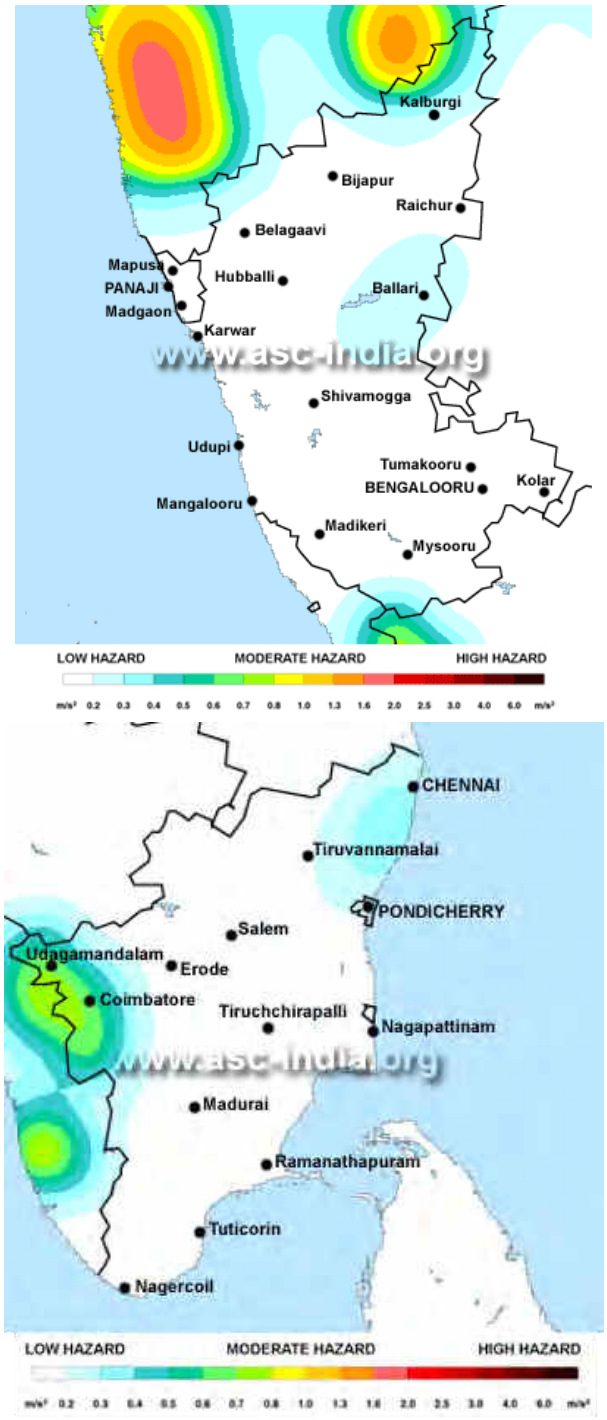


Figure 8.4: Seismic Zone Map of Karnataka & Tamil Nadu (GSHAP)

8.2.5 Climate and Meteorology

Climate

The State enjoys three main types of climates. For meteorological purposes, the State has been 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 is 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 north-east monsoon which affects the south-eastern 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 is 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 divided 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 are indicated below:

Project Start Road (Km Ch. 0.700)

Religious Structures falling adjacent to proposed alignment (Km. Ch. 14.366)

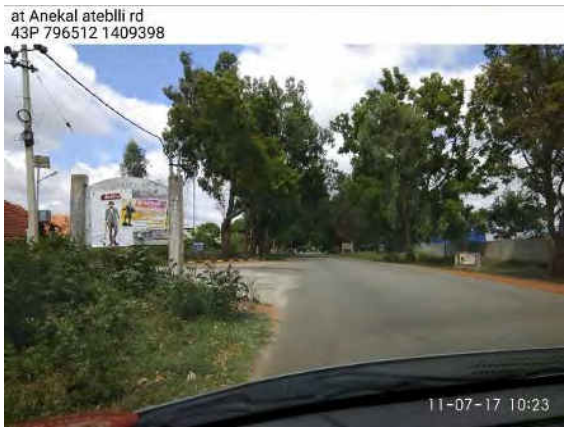
Existing road condition of SH-3 (Km Ch. 27.500)

Savanadurga Forest (Km Ch. 37.800)

Plantation along the greenfield alignment (Km Ch. 49.400)

Entry Point of Bannerghatta National Park (Km Ch. 141.77)

Karadikkal – Madeswara Elephant Corridor along the existing road (Km Ch. 107.500)



Road Site Plantation along the Road

(Km Ch. 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 are given below in **Table 8.3**:

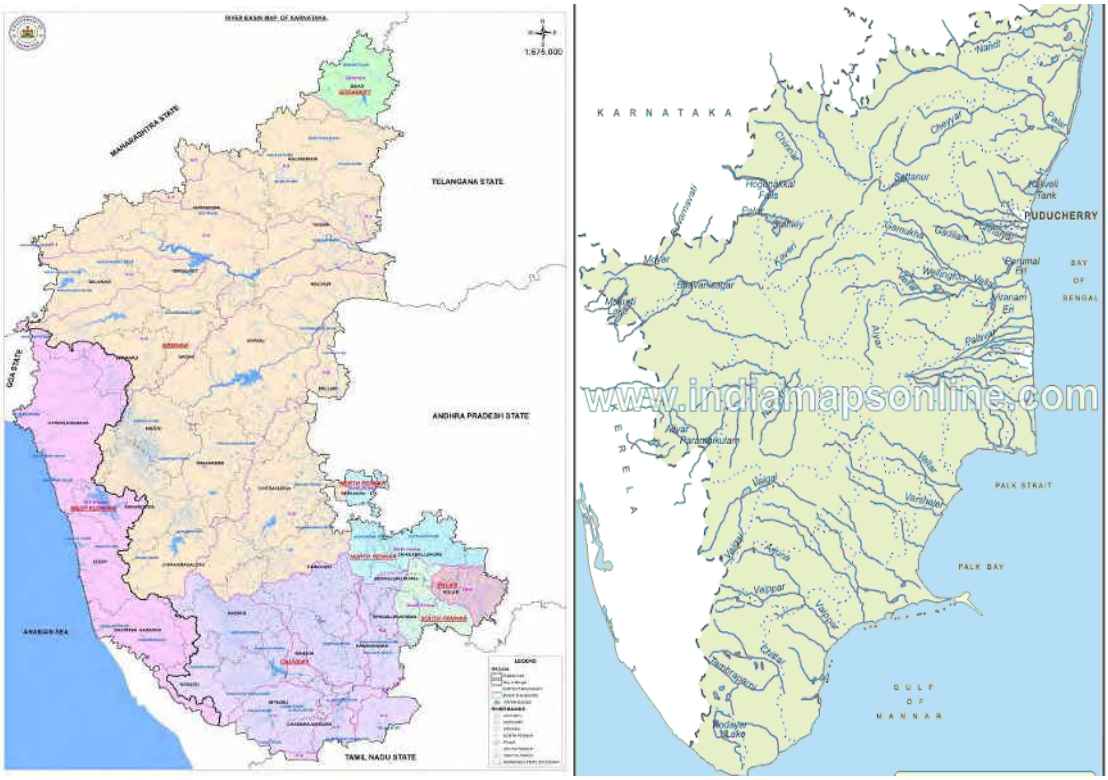
Table 8.3: Water Bodies crossing the project road

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 is 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 described as semi dendritic to dendritic. The river basin maps of Karnataka and Tamil Nadu are given below in **Fig 8.5**.



Source: Karnataka & Tamil Nadu Water Resources Department

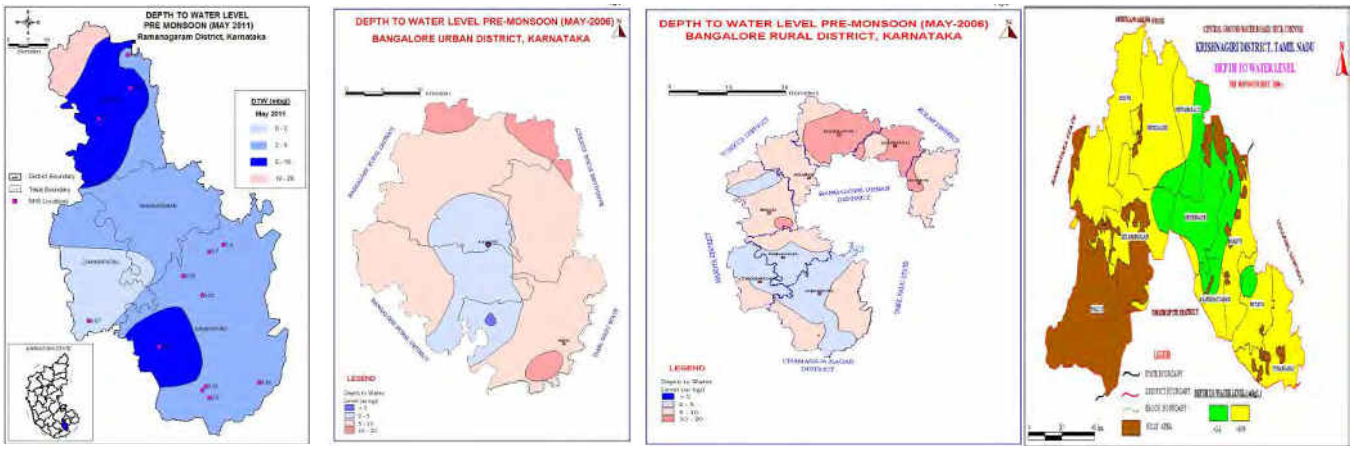
Figure 8.5: River Basin Map of Karnataka and Tamil Nadu

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.

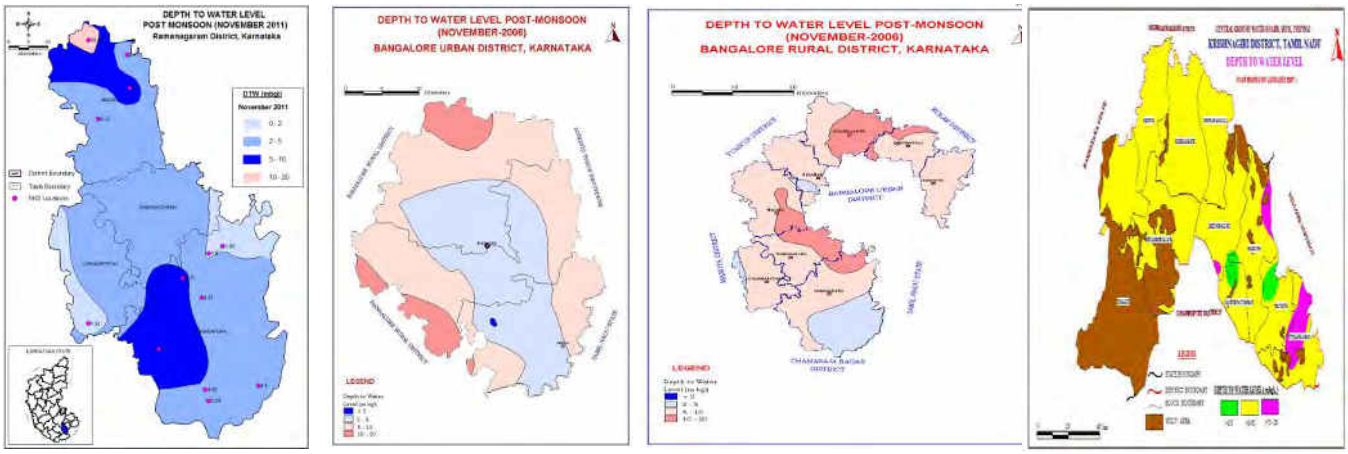
The thickness of weathering in major part of the district ranges from 5-10m and more than 10m in rest of the district. Unconfined aquifer system is taped by dug wells and shallow bore wells. This zone extends down to 25 mbgl. Pre and Post Monsoon trends of Water level in all the project districts are 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 is presented in **Table 8.4** and the forest cover map with marked project area is presented in **Figure 8.5.**

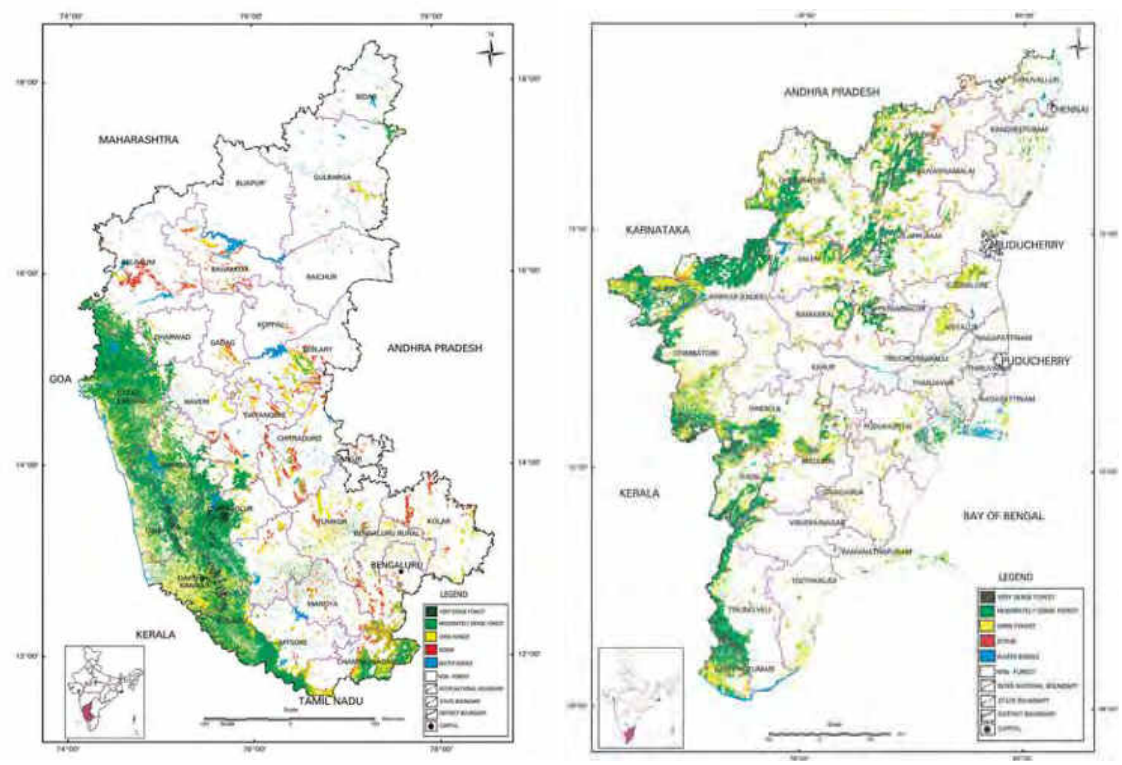
Table 8.4: Forest Cover in the Project Districts (km^2)

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 represented 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 divided 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 maintained 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* is found almost throughout the forests division. Trees of *Terminalia paniculata* (Hunalu) *Dalbergia latifolia* (Beete), *Pterocarpus marsupium* (Honne), *Hardwickia binata* (Karacha), *Vitex altissima* (Lakki) etc. are 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. But most of them species are unfit to be used as Timber in the traditional sense. However, Sandalwood and bamboo are found in good quantities over considerable areas of the Division. The forests under division are developed to its natural equilibrium with climate and soil.

c) Fauna

The district forest have significant areas which 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. Also 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). The ESZ of the Bannerghatta National Park is also notified by MoEFCC, 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 recommended to avoid the proposed road within the eco-sensitive boundary of Ramdevara Betta Vulture Sanctuary. Subsequently, the alignment is being re planned 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 also been estimated on the basis of visual assessment within 30.0 m on either side of the center line. The final design will avoid the community structures as much as possible. The detailed list is 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 are 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	Dabaspete
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 are 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
Ramangara	1082,636	548,060	534,576
Karnataka State	**61,095,297**	**30,966,657**	**30,128,640**
Krishna giri	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 subjected 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 are 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 dt. 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 be provided 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 been 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 the sensitive road stretches shall be carefully analyzed during Environmental Impact Assessment study and accordingly safeguard measures will be provided 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 certain development projects specified under the schedule of the Notification. The projects and activities under the Notification have been classified into two categories- Category A and Category B, based on the spatial extent of potential impacts on human health, natural and man-made resources. As per Schedule of the Notification, the Highway project has been classified under Physical Infrastructure including Environmental Services and is 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 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).

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 forest land 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 obtained 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 obtained by the Contractor for the project before commencing the construction work:

Table 8.9: Clearances/Permissions to be obtained 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 been 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 been developed and is 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 avoided 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 removed & 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 allowed 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 enforced. Proper scheduling of the operation of equipment. • The stationary noise generating equipment should be installed 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 be taken 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 Asphalt odour and dust due to asphalt and crusher plant and laying of pavement	D D	M M	S 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
	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 be 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 be reduced 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. Details shall be provided in final feasibility report.

Chapter-9 :
Initial Social Assessment and Preliminary Land Acquisition/ Resettlement Plan

TABLE OF CONTENTS

LIST OF TABLE

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 been 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 is 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 quantified, the project is 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 been 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 were observed, recorded and 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 is 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

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
27	26.000	27.000	Agriculture	Vacant
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

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
60	59.000	60.000	Agriculture	Agriculture
61	60.000	61.000	Agriculture	Agriculture
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

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
93	92.000	93.000	Agriculture	Agriculture
94	93.000	94.000	Hilly	Hilly
95	94.000	95.000	Forest	Forest
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

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
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
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

Sl. No.	Existing Chainage		Land Use Pattern	
	From km	To km	Left	Right
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
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 is 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

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
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

S No	Location Along STRR (km) approx.	Name of Village/Built-up Location
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
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


near 74800
43P 756904 1397804
07-07-17 12:03
near singasandra vill
43P 755848 1398691
07-07-17 12:34
near km 74
43P 747956 1417315
08-07-17 09:48
near 41200
43P 746921 1425942
08-07-17 11:15

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 179.629km. There are seven talukas involve in both states. The land acquisition details are as below as per revised draft 3A details submitted to PD/PIU/Bangalore on 17/03/2018.

Sl. No	state	District	Taluka	Chainage (km)		Amount of land Only for mainline in hectares
				From	To	
1	Karnataka	Bangalore Rural	Nelamangala	0.000	19.500	146.2500
2		Ramanagara	Magadi	19.500	55.803	272.2725
3			Ramanagara	55.803	86.078	227.0625
4			Kanakapura	86.078	119.630	251.6400
5		Bangalore Urban	Anekal	119.630	134.641	112.5825
6	Tamil Nadu	Krishnagiri	Hosur	134.641	141.760	53.3925
7				148.711	154.457	43.0950
8			Denikinikotta	141.760	148.711	52.1325
9				154.457	179.969	191.3400

Total land Involvement are as follow:

- Karnataka state: 1009.8075hectares only for mainline and without considering for Interchanges.
- Tamil Nadu state: 339.96hectares only for mainline and without considering for Interchanges

Total land requirements envisaged only for 75m corridor and without consideration of Interchanges, Toll plazas, truck lay byes etc. The other details are currently under design stage.

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. 2. Amount equivalent to current stamp duty and registration charges on compensation amount for replacement of lost assets.	▪ Applicable as per RTFCTLARRA 2013. ▪ PAPs that have received the compensation on or before 31st December 2013 will be provided 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,*

Sl. No.	Category of Impact	Eligibility for Entitlement	Relevant RTFCTLARRA 2013 Provisions	
			Entitlement	Provisions
1	2	3	4	5
				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 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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ANNEXURES

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 is based only on square/running meters.

10.4 UNIT RATES

10.4.1 Road Construction Items

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

I. Karnataka

- The rates for cement, bitumen and steel are considered from market rate without GST.
- 5% escalation has been considered over the schedule of rate 2016-17 for arriving the rate for year 2017-18.
- Tentative lead has been take for rate analysis.

II. Tamil Nadu

- The rates for cement, bitumen and steel are considered from market rate without GST.
- Schedule of rate 2017-18 has been adopted for estimate
- Tentative lead has been take for rate analysis.

The lead of bitumen is 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. For Granular Sub Base, Mix in place Method is used while analysing the rate for the item in rate analysis.

Abstract of unit rates, worked out using Standard Data Book, adopted for major items are given in the **Table 10.1** below.

Table 10.1: Adopted Unit Rates for Road Part

Sl. No.	Items Description	Unit	Rates (Rs.) without GST	
			Karnataka	Tamilnadu
1	Clearing and Grubbing of road land	Ha	53,057	53,556
2	Embankment fill using borrow materials	Cum	401	282
3	Sub grade & earthen / un paved	Cum	442	329
4	Median fill	Cum	356	330
5	Granular Sub-base	Cum	2,551	3,111
6	Wet mix macadam	Cum	2,863	3,594
7	Cement treated base layer	Cum	3,171	3,620
8	Prime Coat	Sqm	31	32
9	Tack Coat	Sqm	13	13
10	Dense Bituminous Macadam	Cum	7,532	8,406
11	Bituminous Concrete	Cum	7,999	8,804
12	DLC	Cum	4,265	4,686
13	PQC	Cum	7,578	7,601

10.4.2 Adopted rates for structures

Table 10.2: Adopted Per Sqm Rates for Structure Part

S. No.	Items Description	Unit	Rates (Rs.)
1	BOX/SLAB Culvert	Sqm	42,000.00
2	Pipe Culvert	Per Meter	18,000.00
3	Minor Bridge	Sqm	56,000.00
4	Major Bridge	Sqm	52,000.00
5	ROB	Sqm	55,0000.00
6	Elevated Structure	Sqm	48,000.00
7	VUP	Sqm	48,000.00

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.
- The cost estimate has prepared with three pavement options:-

  i) Flexible Pavement: INR 5,690 Cr.

  ii) Rigid Pavement: INR 6,171 Cr.

  iii) Cement Treated Base: INR 5,654 Cr.

  Based on life cycle cost analysis, it is recommended to propose flexible pavement. The details are given in **Annexure 10.1**

10.6 TOTAL PROJECT COST

The project is worked out for three pavement options considering Flexible type pavement, rigid type pavement and Cement treated base type pavement. The summary costs for all three options are given as below.

Table 10.3: Summary of Project Cost

Flexible Pavement

SUMMARY OF COST - FLEXIBLE PAVEMENT			
Sr. No.	**Description**	**Total Amount**	**Amount (Rs. in Cr.)**
1	Bill No. 1: Site clearance and Dismantling	118,864,133	11.886
2	Bill No. 2 : Earth Work	6,848,232,647	684.823
3	Bill No. 3 : Granular Sub Base Courses and Base Courses (Non-Bituminous)	7,271,168,751	727.117
4	Bill No. 4 : Bituminous Courses /Rigid Pavement	5,802,644,895	580.264
5	Bill No. 5 : Culverts	624,888,000	62.489
6	Bill No. 6A : Minor Bridges	446,028,800	44.603
7	Bill No. 6B : Major Bridges	885,248,000	88.525
8	Bill No. 6C : Flyover/ROB,RUB	8,379,690,000	837.969
9	Bill No. 6D :VUP/PUP	1,635,600,000	163.560
10	Bill No. 6E :Interchange	5,500,000,000	550.000
11	Bill No. 7 :RE Wall/Retaining wall Cost	4,080,000,000	408.000
12	Bill No. 8 : Drainage & Protective Works	1,735,386,484	173.539
13	Bill No. 9 : Traffic signs, Road markings and other road appurtenances	719,876,000	71.988
14	Bill No. 10: Toll Plaza	2,080,000,000	208.000
15	Bill No. 11 : Wayside Amenities	60,000,000	6.000
16	Bill No. 12 : Miscellaneous Works	4,618,762,771	461.876
	Total Civil Cost (In Rs.)	**50,806,390,481**	**5,081**
	GST @ 12% on the Civil Cost	**6,096,766,858**	**610**
	Total Civil Cost	**56,903,157,338**	**5,690**
	Total Civil Cost (In Cr.)	**5,690**	
	Civil Cost per Km (In Cr.)	**31.62**	

Rigid Pavement

SUMMARY OF COST - RIGID PAVEMENT			
Sr. No.	**Description**	**Total Amount**	**Amount (Rs. in Cr.)**
1	Bill No. 1: Site clearance and Dismantling	118,864,133	11.886
2	Bill No. 2 : Earth Work	6,965,851,004	696.585
3	Bill No. 3 : Granular Sub Base Courses and Base Courses (Non-Bituminous)	3,307,505,664	330.751
4	Bill No. 4 : Bituminous Courses /Rigid Pavement	13,546,781,921	1354.678
5	Bill No. 5 : Culverts	624,888,000	62.489
6	Bill No. 6A : Minor Bridges	446,028,800	44.603
7	Bill No. 6B : Major Bridges	885,248,000	88.525
8	Bill No. 6C : Flyover/ROB,RUB	8,379,690,000	837.969
9	Bill No. 6D :VUP/PUP	1,635,600,000	163.560
10	Bill No. 6E :Interchange	5,500,000,000	550.000
11	Bill No. 7 :RE Wall/Retaining wall Cost	4,080,000,000	408.000
12	Bill No. 8 : Drainage & Protective Works	1,735,386,484	173.539
13	Bill No. 9 : Traffic signs, Road markings and other road appurtenances	719,876,000	71.988
14	Bill No. 10: Toll Plaza	2,080,000,000	208.000
15	Bill No. 11 : Wayside Amenities	60,000,000	6.000
16	Bill No. 12 : Miscellaneous Works	5,008,572,001	500.857
	Total Civil Cost (In Rs.)	**55,094,292,008**	**5,509**
	GST @ 12% on the Civil Cost	**6,611,315,041**	**661**
	Total Civil Cost	**61,705,607,048**	**6,171**
	Total Civil Cost (In Cr.)	**6,171**	
	Civil Cost per Km (In Cr.)	**34.29**	

Cement Treated Base

SUMMARY OF COST - CEMENT TREATED BASE			
Sr. No.	**Description**	**Total Amount**	**Amount (Rs. in Cr.)**
1	Bill No. 1: Site clearance and Dismantling	118,864,133	11.886
2	Bill No. 2 : Earth Work	6,859,072,685	685.907
3	Bill No. 3 : Granular Sub Base Courses and Base Courses (Non-Bituminous)	8,632,602,924	863.260
4	Bill No. 4 : Bituminous Courses /Rigid Pavement	4,132,773,669	413.277
5	Bill No. 5 : Culverts	624,888,000	62.489
6	Bill No. 6A : Minor Bridges	446,028,800	44.603
7	Bill No. 6B : Major Bridges	885,248,000	88.525
8	Bill No. 6C : Flyover/ROB,RUB	8,379,690,000	837.969
9	Bill No. 6D :VUP/PUP	1,635,600,000	163.560
10	Bill No. 6E :Interchange	5,500,000,000	550.000
11	Bill No. 7 :RE Wall/Retaining wall Cost	4,080,000,000	408.000
12	Bill No. 8 : Drainage & Protective Works	1,735,386,484	173.539
13	Bill No. 9 : Traffic signs, Road markings and other road appurtenances	719,876,000	71.988
14	Bill No. 10: Toll Plaza	2,080,000,000	208.000
15	Bill No. 11 : Wayside Amenities	60,000,000	6.000
16	Bill No. 12 : Miscellaneous Works	4,589,003,070	458.900
	Total Civil Cost (In Rs.)	**50,479,033,765**	**5,048**
	GST @ 12% on the Civil Cost	**6,057,484,052**	**606**
	Total Civil Cost	**56,536,517,817**	**5,654**
	Total Civil Cost (In Cr.)	**5,654**	
	Civil Cost per Km (In Cr.)	**31.41**	

Annexure 10.1: Life Cycle Cost

Life Cycle Cost Per Kilometre

CONVENTIONAL METHOD

			Discount Rate	12%
Option - 1	***Bypass with Flexible 6 Lane***			
	Total Construction Cost		***684.24***	**Lacs**
	Routine Maintenance (lakhs per yr)		***7.09***	**Lacs**
Overlay	After 5 years	40 mm BC	**89.77**	**Lacs**
	After 10 years	40mmBC	**89.77**	**Lacs**
	After 15 years	40 mm BC+50mmDBM	**184.00**	**Lacs**
	After 20 years	40mmBC	**89.77**	**Lacs**
	After 25 years	40 mm BC	**89.77**	**Lacs**
Option - 2	***Bypass with Rigid Pavement 6 Lane***			
	Total Construction Cost		***945.41***	**Lacs**
	Routine Maintenance (lakhs per yr)		***8.10***	**Lacs**
	After 5 years	Panel replecement ,concrete spalling ,Crack Sealing etc	**6.60**	**Lacs**
	After 10 years	Panel replecement ,concrete spalling ,Crack Sealing etc	**13.38**	**Lacs**
	After 15 years	Panel replecement ,concrete spalling ,Crack Sealing etc	**13.38**	**Lacs**
	After 20 years	Panel replecement ,concrete spalling ,Crack Sealing etc	**13.38**	**Lacs**
	After 25 years	Panel replecement ,concrete spalling ,Crack Sealing etc	**13.38**	**Lacs**
Option - 3	***Bypass with Cemented Base Both on side 6 Lane***			
	Total Construction Cost		***655.64***	**Lacs**
	Routine Maintenance (lakhs per yr)		***7.09***	**Lacs**
Overlay	After 5 years	40 mm BC	**89.77**	**Lacs**
	After 10 years	40mmBC	**89.77**	**Lacs**
	After 15 years	40 mm BC+ 50mm DBM	**184.00**	**Lacs**
	After 20 years	40mmBC	**89.77**	**Lacs**
	After 25 years	40 mm BC	**89.77**	**Lacs**

Year	Option- 1 Flexiable Pavement	Option- 2 Rigid Pavement	Option- 3 CTB Pavement	Elapsed year	Discounted value for Option-1	Discounted value for Option-2	Discounted value for Option-3
2018	684.24	945.41	655.64	0	684	945	656
2019	7.088	8.100	7.088	1	6.328	7.232	6.328
2020	7.088	8.100	7.088	2	5.650	6.457	5.650
2021	7.088	8.100	7.088	3	5.045	5.765	5.045
2022	7.088	8.100	7.088	4	4.504	5.148	4.504
2023	96.86	14.70	96.86	5	54.960	8.342	54.960
2024	7.088	8.100	7.088	6	3.591	4.104	3.591
2025	7.088	8.100	7.088	7	3.206	3.664	3.206
2026	7.088	8.100	7.088	8	2.863	3.271	2.863
2027	7.088	8.100	7.088	9	2.556	2.921	2.556
2028	191.08	21.48	191.08	10	61.523	6.917	61.523
2029	7.088	8.100	7.088	11	2.037	2.329	2.037
2030	7.088	8.100	7.088	12	1.819	2.079	1.819
2031	7.088	8.100	7.088	13	1.624	1.856	1.624
2032	7.088	8.100	7.088	14	1.450	1.657	1.450
2033	96.86	21.48	96.86	15	17.696	3.925	17.696
2034	7.088	8.100	7.088	16	1.156	1.321	1.156
2035	7.088	8.100	7.088	17	1.032	1.180	1.032
2036	7.088	8.100	7.088	18	0.922	1.053	0.922
2037	7.088	8.100	7.088	19	0.823	0.940	0.823
2038	96.86	21.48	96.86	20	10.041	2.227	10.041
2039	7.088	8.100	7.088	21	0.656	0.750	0.656
2040	7.088	8.100	7.088	22	0.586	0.669	0.586
2041	7.088	8.100	7.088	23	0.523	0.598	0.523
2042	7.088	8.100	7.088	24	0.467	0.534	0.467
2043	96.86	21.48	96.86	25	5.697	1.264	5.697
2044	7.088	8.100	7.088	26	0.372	0.425	0.372
2045	7.088	8.100	7.088	27	0.332	0.380	0.332
2046	7.088	8.100	7.088	28	0.297	0.339	0.297
2047	7.088	8.100	7.088	29	0.265	0.303	0.265
NPV (Rs in lacs)					**882.262**	**1023.061**	**853.663**

Option-1 ***Bypass with Flexible Pavement 6 Lane***

Layers	Thickness	Width (m)	Length (m)	Unit	Quantity	Rate	Amount
BC	50	25	1000	cum	1250	8327	10408750
DBM (New portion)	110	25	1000	cum	2750	7538	20729500
Tack coat (Bit)					50000	0	0
Tack coat (Non Bit)					25000	13	325000
Prime coat					25000	31	775000
WMM (New portion)	250	25.55	1000	cum	6388	2863	18287412.5
GSB (New portion)	200	35.04	1000	cum	7008	2554	17898432
					Per Km cost		**68424094.5**

Maintenance

Layers	Thickness	Width	Length	Unit	Quantity	Rate	Amount
Tack coat	2	25	1000	sqm	50000	13	650000
BC	40	25	1000	cum	1000	8327	8327000
DBM	50	25	1000	cum	1250	7538	9422500
							18399500

Option-2 ***4 Lane Rigid on Bypass***

Layers	Thickness (mm)	Width (mm)	Length (m)	Unit	Quantity	Rate (Rs)	Amount in Rs.
PQC	310	25	1000	cum	7750	7578	58729500
DLC	150	28	1000	cum	4200	4265	17913000
GSB	200	35.04	1000	cum	7008	2554	17898432
					Per Km cost		**94540932**

Rigid Pavement Maintenance for every 5 Years Interval per Km

After 5 years

S.no.	Maintenance Type	Length (Km)	Effective Maintenance Area in %	Unit	Rate (Rs.)	Amount (Rs.)
1	Crack Sealing with Sealing Com	1000	100	Rm	65	6500
2	Repair of concrete spalling	1000	100	Sqm	275	27500
3	Panel replacement (Slab settlement faulting) 25 no.(4.5mX4.5m)	1000	12	Sqm	52175	626094
						660094

After 10 years

S.no.	Maintenance Type	Length (Km)	Effective Maintenance Area in %	Unit	Rate (Rs.)	Amount (Rs.)
1	Crack Sealing with Sealing Com	1000	100	Rm	65	6500
2	Repair of concrete spalling	1000	100	Sqm	275	27500
3	Panel replacement (Slab settlement faulting) 25 no.(4.5mX4.5m)	1000	25	Sqm	52175	1304363
						1338363

After 15 years

S.no.	Maintenance Type	Length (Km)	Effective Maintenance Area in %	Unit	Rate (Rs.)	Amount (Rs.)
1	Crack Sealing with Sealing Com	1000	100	Rm	65	6500
2	Repair of concrete spalling	1000	100	Sqm	275	27500
3	Panel replacement (Slab settlement faulting) 25 no.(4.5mX4.5m)	1000	25	Sqm	52175	1304363
						1338363

After 20 years

S.no.	Maintenance Type	Length (Km)	Effective Maintenance Area in %	Unit	Rate (Rs.)	Amount (Rs.)
1	Crack Sealing with Sealing Com	1000	150	Rm	65	9750
2	Repair of concrete spalling	1000	150	Sqm	275	41250
3	Panel replacement (Slab settlement faulting) 25 no.(4.5mX4.5m)	1000	37	Sqm	52175	1930458
						1981458

After 25 years

S.no.	Maintenance Type	Length (Km)	Effective Maintenance Area in %	Unit	Rate (Rs.)	Amount (Rs.)
1	Crack Sealing with Sealing Com	1000	150	Rm	65	9750
2	Repair of concrete spalling	1000	150	Sqm	275	41250
3	Panel replacement (Slab settlement faulting) 25 no.(4.5mX4.5m)	1000	37	Sqm	52175	1930458
						1981458

Cement Treated
Bypass Pavement Option

Option-1 ***Bypass with Cemented Base and Granular Sub-base Both side***

Layers	Thickness	Width	Length	Unit	Quantity	Rate	Amount Rs.
BC	50	25	1000	cum	1250	8327	10408750
DBM	50	25	1000	cum	1250	7538	9422500
Tack coat (Bit)					25000	0	0
Tack coat (Non Bit)					25000	13	325000
Prime coat					25000	31	775000
WMM	100	25.5	1000	cum	2550	2863	7300650
CT Base	185	25.50	1000	cum	4717.5	3171	14959192.5
GSB	250	35.04	1000	cum	8760	2554	22373040
					Four lane Per Km cost		**65564132.5**

Chapter-11:
Economic & Financial Analysis

TABLE OF CONTENTS

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 180km between Dobbaspet and Karnataka/ Tamil Nadu border 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 of Rs.5062.19 crores at current prices inclusive of Civil and Non Civil works.

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	1407101	938067	562840	1266390	844260	506556
Periodic Maintenance	9045645	6030430	3618258	8141081	5427387	3256432

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	32000	337000	2500	60		80000	75	13	
2 Wheeler	600	32000	60000	900	40		6625	40	7	
3 Wheeler	600	32000	103000	900	40		24000	40	7	
Mini Bus	3000	100000	765000	5000	100	160	83725	50	9	
Bus	3000	100000	1530000	7500	125	80	155000	50	9	
LMV	2000	50000	535500	3500	100	80	66980			21
LCV 4 Wheeler	3000	100000	765000	3500	100	80	83725			35
LCV 6 Wheeler	3000	100000	841500	5000	100	80	92098			35
2 Axle Truck	3000	100000	1009800	7075	100	160	184195			35
3 Axle Truck	3000	100000	1211760	7075	100	160	258000			60
MAV (4-6 Axle)	3000	100000	1454112	7075	100	160	283800			60
MAV (> 6 Axle)	3000	100000	1744934	7076	100	160	283800			60
Tractor Without Trailer	3000	100000	765000	5000	100	80	92098			35
Tractor With Trailer	3000	100000	918000	7075	100	160	184195			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

Scenario	EIRR (%)	NPV (million)
Scenario 1:Base Costs and Base Benefits	18.3	42,346
Scenario 2:Base Costs Plus 15% and Base Benefits	17.9	37,887
Scenario 3:Base Costs and Base Benefits Minus 15% 12.32% 519.4	16.5	33,373
Scenario 4:Base Costs Plus 15% and Base Benefits Minus 15% 12.00% 434.6	16.1	28,916

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
Run Date: 08-05-2018
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 Cost	Savings i NMT Trave & Operating Costs	Reductio in Acciden Cost	Net Social / Exogenou Benefit	Net Economi Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	58,458.54	82.33	0.00	310,290.61	108,251.82	0.00	0.00	0.00	360,166.23
Discounted	59,852.62	29.92	0.00	76,503.04	25,666.12	0.00	0.00	0.00	42,346.46

Economic Internal Rate of Return (EIRR) = 18.3% (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 Cost	Savings i NMT Trave & Operating Costs	Reductio in Acciden Cost	Net Social / Exogenou Benefit	Net Economi Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	56,396.23	82.33	0.00	290,550.05	93,378.71	0.00	0.00	0.00	325,614.86
Discounted	58,036.34	29.92	0.00	74,696.83	22,997.45	0.00	0.00	0.00	37,667.86

Economic Internal Rate of Return (EIRR) = 17.9% (No. of solutions = 1)

HDM-4 Version 2.1 Page 1 of 2

HDM-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 Cost	Savings i NMT Trave & Operating Costs	Reductio in Acciden Cost	Net Social / Exogenou Benefit	Net Economi Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	67,227.32	-94.68	0.00	310,290.61	108,251.82	0.00	0.00	0.00	351,409.80
Discounted	66,830.50	-34.40	0.00	76,503.04	25,686.12	0.00	0.00	0.00	33,373.04

Economic Internal Rate of Return (EIRR) = 16.5% (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 Cost	Savings i NMT Trave & Operating Costs	Reductio in Acciden Cost	Net Social / Exogenou Benefit	Net Economi Benefit (NPV
	Capital	Recurrent	Special						
Undiscounted	67,155.87	-94.68	0.00	290,550.05	93,378.71	0.00	0.00	0.00	316,867.81
Discounted	66,814.09	-34.40	0.00	74,898.83	22,997.45	0.00	0.00	0.00	28,916.59

Economic Internal Rate of Return (EIRR) = 16.1% (No. of solutions = 1)

HDM-4 Version 2.1 Page 2 of 2

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 Rs. 5062.19crores.

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.

Year	Daily Rs Lacs)	Yearly Rs (Cr)	Year	Daily Rs Lacs)	Yearly Rs (Cr)
2018	22.9	83.7	2035	407.6	1487.9
2019	26.1	95.4	2036	462.7	1693.4
2020	29.8	109.1	2037	525.8	1919.1
2021	46.1	168.3	2038	597.0	2178.9
2022	66.3	242.0	2039	678.6	2476.7
2023	86.6	316.2	2040	770.7	2820.9
2024	98.7	361.1	2041	874.6	3192.2
2025	112.3	409.9	2042	991.7	3619.8
2026	127.9	466.8	2043	1125.5	2190.1
2027	145.5	531.1	2044	1278.2	2482.0
2028	165.5	605.7	2045	1450.5	2818.0
2029	188.5	688.1	2046	1643.8	3203.3
2030	214.7	783.5	2047	1864.1	3648.4
2031	243.8	890.0	2048	2114.7	4128.6
2032	277.4	1015.3	2049	2396.8	4681.6
2033	315.4	1151.0	2050	2717.8	9920.1
2034	358.3	1307.9	2051	3075.3	11224.8

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 **10.6%** and **11.4%.** 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

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 MAT Tax	Profit after Tax (PAT)	Net Cash Flow after Tax	Principal Repay-ment	Total Expense	Equity Cash Flow	Cum. Cash Flow	DSCR
	Construction	Insaurance	Maintenance		Toll Admn.	Total					WDV	SLM									
			Routine	Periodic																	
2018	10144					10144		-10144	6763							-10144			-3381	-3381	
2019	13525					13525		-13525	9017							-13525			-4508	-7890	
2020	10144	42.3	124.0		171.7	10482		-10482	6763		2818	1025	-13300		-13300	-10482			-3381	-11271	
2021		80.3	260.3		360.6	701		-701	20288	2384	5354	2049	-8439		-8439	-701	2254	5339	-5339	-16610	-0.2
2022		72.3	273.3		378.6	724		-724	18034	2119	4818	2049	-7662		-7662	-724	2254	5097	-5097	-21708	-0.2
2023		65.0	287.0		397.5	750	1683	934	15780	1854	4337	2049	-5257		-5257	934	2254	4858	-3175	-24882	0.2
2024		58.5	301.3		417.4	777	2420	1643	13525	1589	3903	2049	-3849		-3849	1643	2254	4621	-2201	-27083	0.4
2025		52.7		2034	438.3	2525	3162	637	11271	1324	3513	2049	-4200		-4200	637	2254	6104	-2942	-30025	0.2
2026		47.4	332.2		460.2	840	3611	2772	9017	1059	3161	2049	-1449		-1449	2772	2254	4154	-542	-30567	0.8
2027		42.7	348.8		483.2	875	4099	3224	6763	795	2845	2049	-416		-416	3224	2254	3924	175	-30391	1.1
2028		38.4	366.3		507.4	912	4668	3756	4508	530	2561	2049	666	216	450	3540	2254	3912	756	-29635	1.3
2029		34.6	384.6		532.7	952	5311	4359	2254	265	2305	2049	1790	581	1209	3778	2254	4052	1259	-28376	1.5
2030		31.1	403.8		559.4	994	6057	5062	0	0	2074	2049	2988	969	2019	4093	2254	4218	1839	-26537	1.8
2031		28.0		2726	587.3	3341	6881	3540			1867	2049	1673	298	1375	3242		3639	3242	-23296	
2032		25.2	445.2		616.7	1087	7835	6748			1680	2049	5068	940	4128	5808		2027	5808	-17488	
2033		22.7	467.5		647.5	1138	8900	7762			1512	2049	6250	1143	5107	6619		2281	6619	-10869	
2034		20.4	490.9		679.9	1191	10153	8962			1361	2049	7601	1383	6218	7579		2574	7579	-3290	
2035		18.4	515.4		713.9	1248	11510	10263			1225	2049	9038	1643	7395	8619		2891	8619	5329	
2036		16.5	541.2		749.6	1307	13079	11771			1102	2049	10669	1945	8724	9826		3252	9826	15156	
2037		14.9		3653	787.1	4455	14879	10424			992	2049	9432	1676	7756	8748		6130	8748	23904	
2038		13.4	596.6		826.4	1436	16934	15498			893	2049	14605	2691	11914	12807		4127	12807	36711	
2039		12.1	626.5		867.8	1506	19191	17685			804	2049	16881	3128	13753	14556		4635	14556	51267	
2040		10.8	657.8		911.1	1580	21789	20209			723	2049	19486	3633	15853	16576		5213	16576	67843	
2041		9.8	690.7		956.7	1657	24767	23110			651	2049	22459	7287	15172	15823		8944	15823	83667	
2042		8.8	725.2		1004.5	1739	28209	26470			586	2049	25885	8398	17486	18072		10137	18072	101739	
2043		7.9		4895	1054.8	5958	31922	25964			527	2049	25437	8253	17184	17711		14211	17711	119450	
2044		7.1	799.6		1107.5	1914	36198	34284			475	2049	33809	10969	22840	23314		12884	23314	142764	
2045		6.4	839.5		1162.9	2009	21901	19893			427	2049	19466	6316	13150	13577		8324	13577	156341	
2046		5.8	881.5		1221.0	2108	24820	22712			384	2049	22328	7244	15083	15468		9352	15468	171809	
2047		5.2	925.6		1282.1	2213	28180	25968			346	2049	25622	8313	17309	17655		10526	17655	189463	
						Pre Tax FIRR ==>		**12.0%**	**30-Years**					Post Tax FIRR ==>		**10.6%**	Equity FIRR ===>		**11.4%**		**0.7**

Chapter-12:
Proposed Phasing

CHAPTER-12: PROPOSED PHASING

The proposed alignment of 179.969km passes through three districts of Karnataka state and one district of Karnataka 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 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 is falling at km 95.525 to km 138.000 (include BNP core area) of proposed STRR. Considering the time requirements of BNP Wildlife Clearances from Wildlife Board, the overall project could be consider in 3 phases as below. The details are marked in the map and enclosed for references.

Phase-1:

The portion start from Km 0 (NH 207 - km 131.255) to km 82.200 (cross point of existing SH 3 - km 52.700) (total length 82.200Km). In order to consider the phase with existing road connectivity the start and end points could be consider to the nearest NH/SH cross point junction. Even though the nearest existing junction 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 82.200 (exiting Km 52.700 of SH-3) as the entire proposed portion falls out of preview of Bannerghatta National Park (BNP).

Phase-2

The portion from km 82.200 (cross point of existing SH 3 - km 52.700) to km 138.000 (total length 55.800km) is considered as Phase 2. It will attract Wildlife Clearances from National Board for Wildlife (NBWL).

Phase-3

The portion from km 138.000 to km 180.262 (total length 42.262 km) consider as Phase 3 as this portion falls out of preview of BNP

The proposals are accordingly submitted for approval from NHAI.

• • •

77°15'0"E | 77°31'20"E | 77°47'40"E | 78°4'0"E

13°26'40"N | 13°10'20"N | 12°54'0"N | 12°37'40"N | 12°21'20"N

NH48 | NH73 | SH33 | SH3 | SH94 | SH9 | NH69 | SH5 | SH74 | SH104 | SH35 | NH648 (NH 207) | NH44 (NH 7) | SH 104 | SH82 | NH75 (NH 4) | SH95 | Bangalore Chennai Expressway | SH99 | SH85 | SH39 | SH96 | SH92 | SH17

To TUMKUR | To HYDERABAD | To KOLAR | To HASSAN | To MYSORE | To CHAMARAJANAGAR | To CHENNAI

4 Lane Project Under Implementation (NH-207) by NHAI

Tumakuru | Nijagal Kempohalli | Sirganahalli | Appagondanahalli | Hegganda | Obalapura | Jakkasandra | Agalakuppa | Manne | Chandanahosahalli | Kengal | Kodigebommanahalli | Kambal | Vaddarahalli | Shivaganga | Gudemaranahalli | Lakkenahalli | Gorur | Harthi | Nasarumavinakatte | Karlamangala | Panakanakallu | Magadi | Pura | Siddedevar | Melahalli | Arehalli | Harisandra | Ragihalli | Bagganadoddi | Thattekere | Thammanaikanahalli | Anekal | Hosur City | ONNALVADI | Hoskote | Sarjapura | Attibele | NALLUR | Gudighattanahalli | Geratiganabele | Kallanakuppe | Banavasi | Godur | Kunigal | Ramanagaram Tmc | Ramanagara | Bilagumba | Huliketegunnur | Paduvanagere | Kulahalli | Rayasandra | Bachahalli | Huyalappanahalli | Thammasandra | M Maniyambal | Aralasandra | KAMANDODDI

Bengaluru | ಬೆಂಗಳೂರು

NIJAGAL Reserved Forest | KENGAL Reserved Forest | ADARANGI NORTH Reserved Forest | ADARANGI SOUTH Reserved Forest | KUDUR MINOR Reserved Forest | CHILUR Reserved Forest | BANTARAKUPPE Reserved Forest | PANAKANAKALLU Reserved Forest | SAVANDURGA | Savanadurga State Forest | ADEVARABETTA Reserved Forest | SIDDADEVARABETTA | ANKANAHALLI Reserved Forest | HOOTAR Reserved Forest | AREHALLI Reserved Forest | RAMADEVARABETTA | HANDIGUNDI Reserved Forest | Handigundi State Forest B | TENGINKAL Reserved Forest | GANGADHARAN GUDDA Reserved Forest | BANANTHIMARI Reserved Forest | CAUVERY NATIONAL PARK | SANAMAVU Reserved Forest | Reserved Forest

0+000 Start of Phase-1 | 59+000 | 66+500 | 95+525 | 112+500 | 134+150 | 136+500 | 138+000 | 139 275 | 142+000 | 151+500 | 161+500 | 166+500 | 171+500 | 176+000 | 179+969

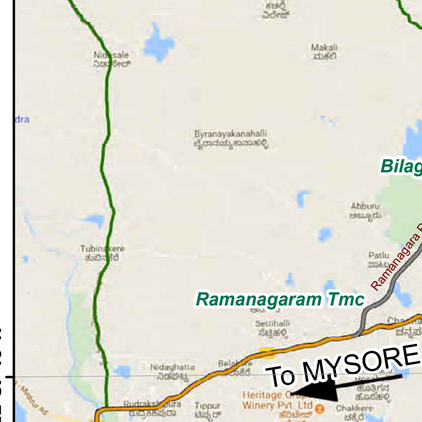
Exi.SH-3 Crossing
Km 52.700
Desgn Ch-82+200

Proposed MMLP | Proposed Rail Line for MMLP | Kelavarapalli reservoir | C1 | C2 | Tali | A | B

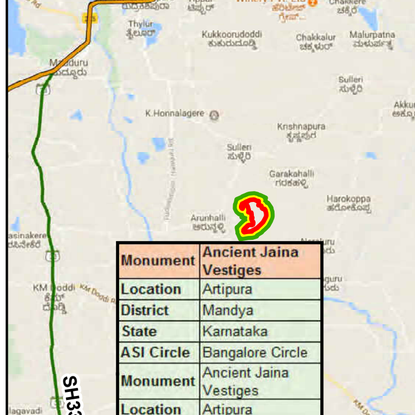
Monument	Pre-Historic Site
Location	Sevanadurga
District	Bangalore
State	Karnataka
ASI Circle	Bangalore Circle
Monument	Pre-Historic Site
Location	Sevanadurga
District	Bangalore
State	Karnataka
ASI Circle	Bangalore Circle
Distance	3.5km

Monument	Ancient Jaina Vestiges
Location	Artipura
District	Mandya
State	Karnataka
ASI Circle	Bangalore Circle
Monument	Ancient Jaina Vestiges
Location	Artipura
District	Mandya
State	Karnataka
ASI Circle	Bangalore Circle
Distance	28.5km

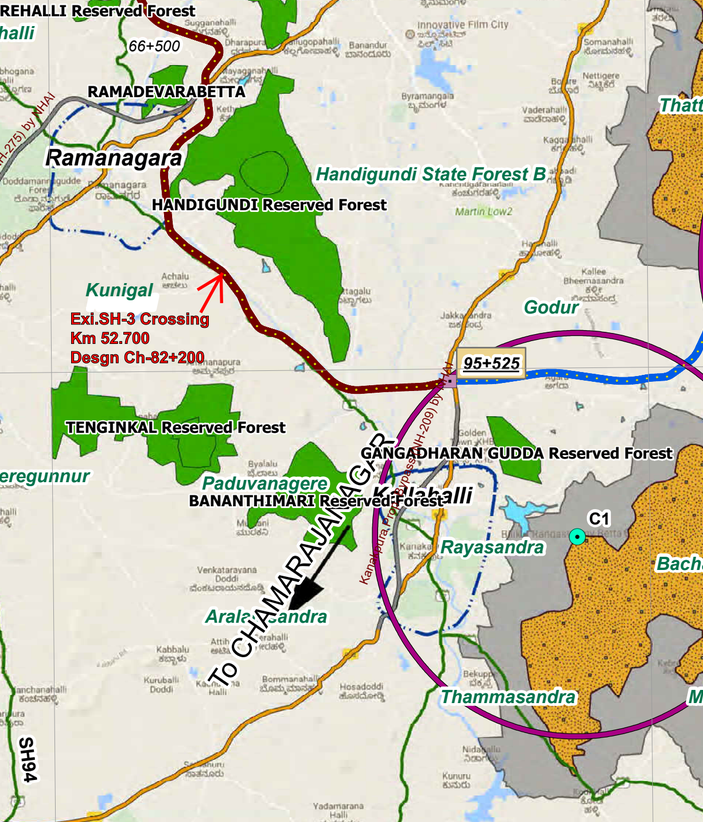
Monument	Hill Fort
Location	Krishnagiri
District	Krishnagiri
State	Tamil Nadu
ASI Circle	Chennai Circle
Monument	Hill Fort
Location	Krishnagiri
District	Krishnagiri
State	Tamil Nadu
ASI Circle	Chennai Circle
Distance	24km



State Boundary



State and District Boundary



Map Legend

- Alignment Phase-1
- Alignment Phase-2
- Alignment Phase-3
- Hill Fort
- Pre-Historic Site
- Prohibited Boundary
- Regulated Boundary
- Places
- Start Point
- CISF
- Hosur Airport
- Temple
- Directions
- NICE Ring Road
- Outer Ring Road
- Outer Peripheral Road
- State Border
- Existing NH
- 10km BNP Ourt Boundary
- Existing SH
- Bangalore Chennai Expressway
- Proposed Rail Line for MMLP
- ITRR
- KITCO
- Multipatches
- Tanks and Ponds-SOI
- Hosur City Limits
- Reservior
- Proposed MMLP
- Proposed KIADB
- Cauvery National Park
- ECO Sensitive Zone Bannerghatta National Park
- Core Zone Bannerghatta National Park
- Forest

N | W | E | S

CLIENT:- NATIONAL HIGHWAY AUTHORITY OF INDIA	DESIGN CONSULTANT:- Louis Berger	PROJECT:- 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	TITLE: **ASI - Prehistoric Sites and Forts Protected and Reserved Forest** Balance portion of Satellite Ring Road of Bangalore (West Side) including Hosur

Date: APRIL, 2018
Paper Size: A1
Projection: UTM84-43N

DRAWN	CHECKED & APPROVED
VISHAL D	DEEPAK M

Chapter-13:
Road Safety Audits

TABLE OF CONTENTS

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 NH 43 project (km 3.400 to km 72.000) 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	Yes
	• Signs / Markings	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

CHAPTER-14: CONCLUSIONS & RECOMMENDATIONS

14.1 GENERAL

The proposed STRR starts from Dobbasapete and ends in the border of Karnataka /Tamil Nadu state constituting a length of 179.969km of fully Greenfield highway. The proposed road passes through Bangalore Rural district (Nelamangala Taluka), Ramanagara district (Magadi, Ramnagara, Karanakapura talukas) and Bangalore Urban (Anekal Taluka) of Karnataka state and in Krishnagiri district (Denkinikottai and Hosur Talukas) 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 be provisioned with uninterrupted free flow traffic arrangement. The proposed road passes through 4 railway crossing points where ROBs will be envisaged. Preliminary investigation reveal that the road envisage about 315 box/pipe culverts, 15 minor bridges and 5 major bridges. The existing SH 3 criss-cross the proposed road at many locations and the SH 3 also needs to be realigned at these locations so to provide seamless connection to adjoining areas. The proposed road passes through Banneragatta National Park from km 115.000 to km 121.500 and its eco sensitive zone from km 92.540 to km 138.00.

14.2 CONCLUSIONS & RECOMMENDATIONS

- 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. Thus the project is necessitated.
- The proposed road facility will able to connect important towns such as Dobbasapete, Magadi, Ramanagara, Kanakapura and Anekal in Karnataka (134.331km) and Hosur in Krishnagiri district (.45.331km)
- 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 and this proposed facility will ease traffic in Hosur city. Thus addition of Hosur is absolute mandatory.
- Comprehensive set of traffic surveys conducted along the project road. The project road divided in 7 homogeneous sections. Traffic volume count conducted at 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 and other three sections HS1, HS2, and HS 3 require six lanes in later as per analysis. Therefore, a six lane facility to the entire corridor is proposed.
- The economic appraisal of the project carried out comprising costs of developing the project with direct benefits (Vehicle operating cost and time saving) to the road user likely to use the project road. The analysis reveal that the project as a whole is economically viable considering direct benefits. The indirect benefits such as environmental benefit, reduction in accident, reduction in congestion level in the area were however not considered.
- The financial analysis carried out and concluded that the project is economically viable at current price. Therefore is recommended to take up on Annuity or EPC mode for implementation.