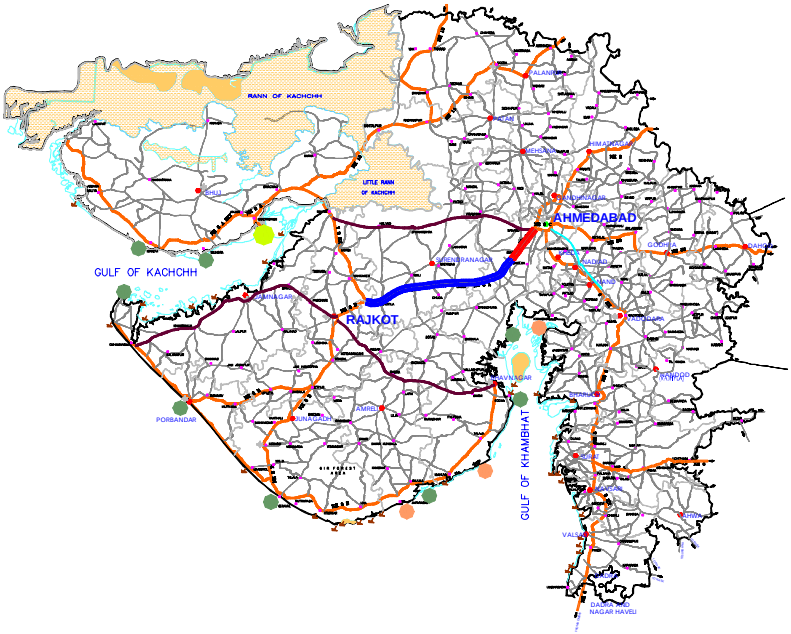
CONSULTANCY SERVICES
FOR THE PREPARATION OF FEASIBILITY REPORT FOR
DEVELOPING AN ACCESS CONTROLLED CORRIDOR
BETWEEN AHMEDABAD AND RAJKOT

DRAFT FINAL REPORT



VOLUME-I: MAIN REPORT

Gujarat Infrastructure Development Board

LEA Associates South Asia Pvt. Ltd., New Delhi

January, 2008

TABLE OF CONTENTS

VOLUME-I: MAIN REPORT

SECTION A: THE PROJECT–CONTEXT AND IMPORTANCE

1. STUDY INTRODUCTION

1.1 Project Background

Government of Gujarat (GoG) has identified core road network for priority development. Major efforts are on to undertake this mandate. Amongst the overall planned endeavors GoG has been contemplating of developing some major road corridors as access controlled and/or partially access controlled corridors. This is to enhance connectivity between major growth and activity centers by safer, faster and efficient transport facilities. This initiative is expected enable not only in sustaining the growth, but importantly in achieving more economically empowered Gujarat, by further boosting economy manifolds. Section between Ahmedabad and Rajkot[1] (NH-8A) is one such corridor identified by the GoG, for this purpose.

Gujarat has been setting examples on several facets of economic growth and infrastructure development. It is leading from front in terms of economic growth, by registering highest economic growth in India. The state now has distinction of attracting the highest Foreign Direct Investments (FDI), which is estimated to be about one fourth of national level figures. Efforts at several levels are on to further boost economy. Amongst the infrastructure sector, road sector has been accorded high priority by the Government of Gujarat.

Gujarat bags a fourth of corporate investments

ENS ECONOMIC BUREAU
MUMBAI, AUGUST 16

ECONOMY

GUJARAT has cornered nearly one-fourth of the country's total investment, becoming the top investment destination in 2006-07. Bagging projects with total investment intentions amounting to Rs 73,170 crore from 86 projects, Gujarat displaced Maharashtra, which claims to be the most industrialised state, for the top slot, according to a study on corporate investments by the RBI.

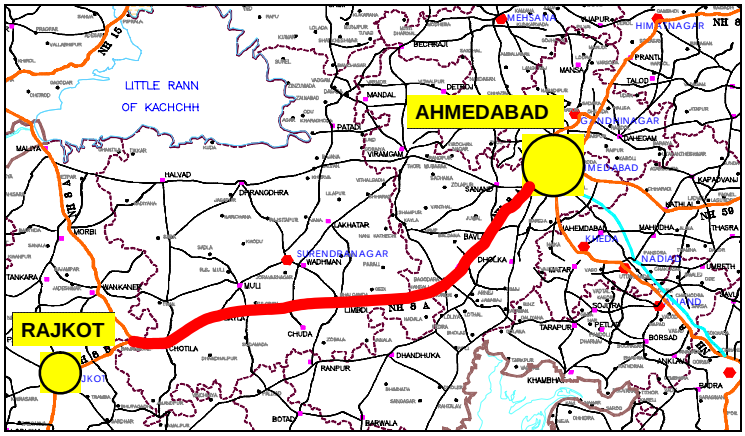
TOP 10 DESTINATIONS

STATE	Projects 2005-06	Amount 2005-06	Projects 2006-07	Amount 2006-07
Gujarat	95	24,531	86	73,170
Andhra Pradesh	76	11,254	105	25,173
Maharashtra	121	24,828	142	24,330
Tamil Nadu	124	12,160	157	24,299
Karnataka	51	4,537	91	19,930
Orissa	20	4,525	23	14,806
Uttar Pradesh	50	10,415	60	9,836
Rajasthan	27	2,466	38	9,806
Jharkhand	8	367	13	7,174
Delhi	24	2,127	19	6,359

(in Rs crore)

Source: Indian Express, Ahmedabad (August 17, 2007)

Knowing the importance of Ahmedabad–Rajkot corridor, GoG, R&BD entered in to MoA with GoI and took loan from HUDCO, and widened it to four lane highway, during 1998-2001. Recognizing the growing importance of corridor, the GoG is now contemplating to develop on (and/or impress upon GoI to develop) priority this corridor as access controlled and/or partially access controlled facility (Map 1-1), subject to MoA conditionalities and/or stipulations. This project corridor connects apart from Ahmedabad and Rajkot districts, passes through the Central Gujarat and Saurashtra.[2] It further establishes connectivity with Kutchh on the Western side and, North and South Gujarat on Eastern side of the state.



Map 1-1: Project Corridor under study – NH 8A connecting Ahmedabad – Rajkot

It is believed by development of this corridor that economy of Saurashtra will get boost. The GIDB in consultation with R&BD have initiated this feasibility study[3] and LEA Associates South Asia Pvt Ltd (LASA) are privileged to be part of this important effort.

[1] The Corridor is also important because of the further connectivity to two important centers of Saurashtra-Porbandar and Jamnagar from Rajkot. This link would be serving other important centers of Saurashtra to the main line of Gujarat.

[2] It further establishes connectivity with Kutchh on the Western side and, North and South Gujarat on Eastern side of the state. The major cities in themselves have about 6 million population of 52 million population of Gujarat. This means that about 12% of state population is in these two cities. In addition the three districts through which the corridor traverses together have about 12 million population size and 5.5 million employment.

[3] The Existing corridor has fair proportion of local traffic at some locations. Therefore needs to be segregated to allow through traffic to move at high speed. It is essential in order to have traffic moves fast and safe, resulting in economic benefits and this economic development of the area of Saurashtra. Therefore, it is envisaged to convert this link to an access controlled corridor.

1.2 Project Corridor and Importance

1.2.1 Corridor in Context

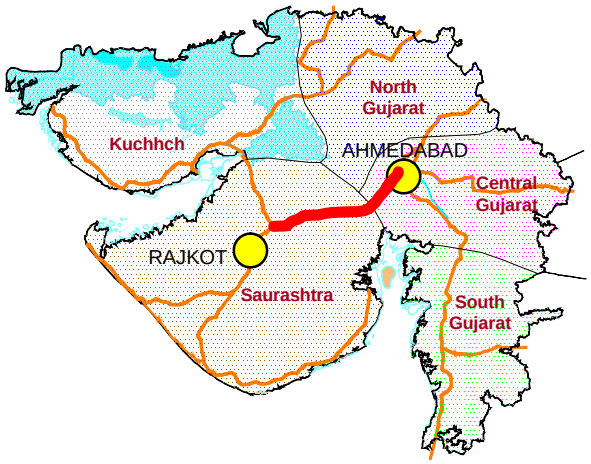
Project corridor, as noted earlier starts in the outskirts of Ahmedabad, traverses through the Central Gujarat and then leads in to Saurashtra. It connects Bamanbore near Rajkot, which is within the region of Saurashtra. Apart from connectivity considerations, the development of corridor perceived to be important from enhanced mobility levels of people and with time more importantly towards achieving development in Gujarat at large and in Saurashtra region in particular. The Roads and Buildings Department (R&BD), Government of Gujarat (GOG) as noted earlier have developed this corridor as four lane facility. Towards doing this GoG, R&BD had entered MoA with GoI, MoSRTH and took loan assistance from HUDCO.[4]

1.2.2 Regional Perspective

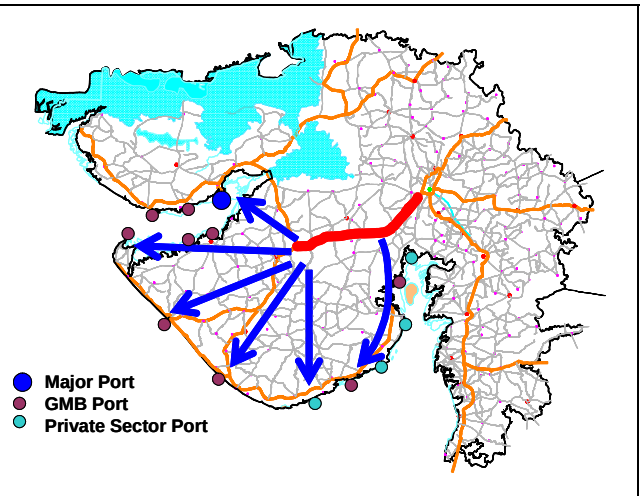
The state of Gujarat comprises of five defined regions. They are North, Central, South Gujarat, Kutchh and Saurashtra regions. Saurashtra has exhibited its importance in state's development and is pivotal to the Gujarat's growing economy. As can be seen the corridor enables connectivity amongst regions (Map 1-2). It may be appropriate to underline that importance of corridor as the life line for Saurashtra region (Map 1-2 and Map 1-3).

1.2.3 Strategic Perspective

The schematic map of project corridor is shown in (Map 1-3). It may be noted that it is strategically important from national perspective as it connects economic activity centres and leading towards international boundary. This corridor very importantly establishes connectivity with the longest coastal line of 1600 km, of Gujarat (Map 1-3).



Map 1-2: Corridor and Regional Connectivity

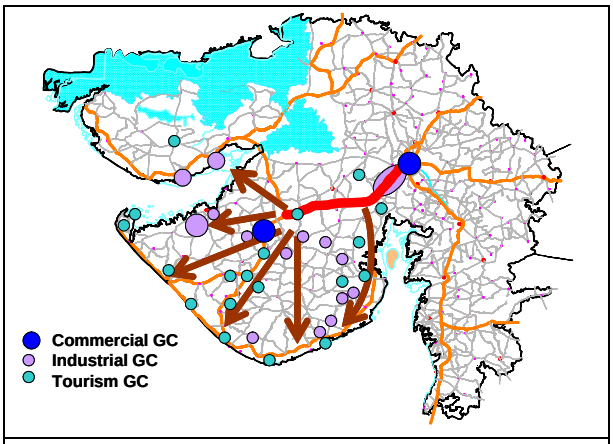


Map 1-3: Strategic Positioning of Corridor

[4] . The Highway was developed by R&BD and it is being tolled since 2003. The toll collection is done by the private operators and is deposited in to the state exchequer. The Loan is repaid by GoG as per the terms of loan agreement. The MoA entered by GoG with GoI is up to 2018.

1.2.4 Connectivity with Major Growth Centers

Further, project corridor is vital in establishing connectivity with major growth centers (Map 1-4), and does not limit it self to connectivity of Ahmedabad with Rajkot. Hence, it is anticipated that it really plays much bigger role in overall growth paradigm of Gujarat.

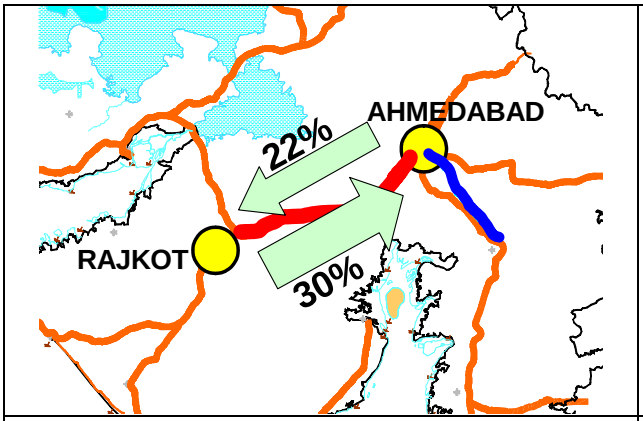


Map 1-4: Corridor Connectivity with Growth Centers

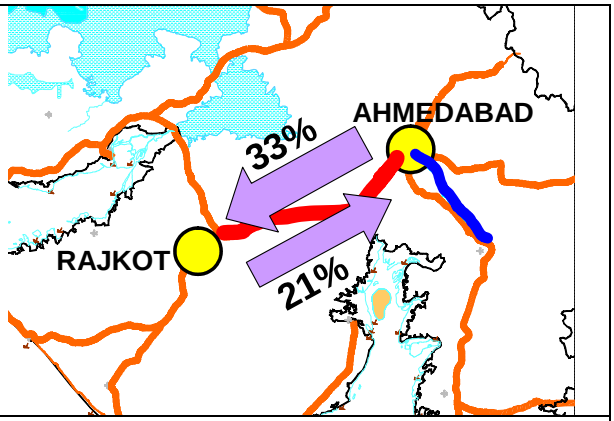
1.2.5 Revealed Importance – Some Insights

After development of NH-8A Ahmedabad-Rajkot link as four lane divided facility, considerable time saving was realized.[5] This initiative enabled in accomplishing major mile stone by R&BD in terms of highway development, which is vital for various reasons/considerations. This significantly helped in stepping up mobility, production and consumption patterns of people and goods.

The project corridor plays a very critical role in meeting the mobility demands of traffic, both goods and passenger, moving between the cities and districts of Ahmedabad and Rajkot. These findings are based on the trips intercepted on the project corridor during the traffic surveys[6]. Maximum interaction has been observed between the two cities – 22% of total person trips produced from the city of Ahmedabad are destined to Rajkot city, the reverse flow being 30% of the total trips produced in Rajkot (Map 1-5). In case of goods' movement, it is observed that 33% of the quantity starting from the city of Ahmedabad get destined to the city of Rajkot, whereas 21% of the quantity getting produced from Rajkot city get attracted to the city of Ahmedabad (Map 1-6).



Map 1-5: Person trip Interactions between Ahmedabad Rajkot

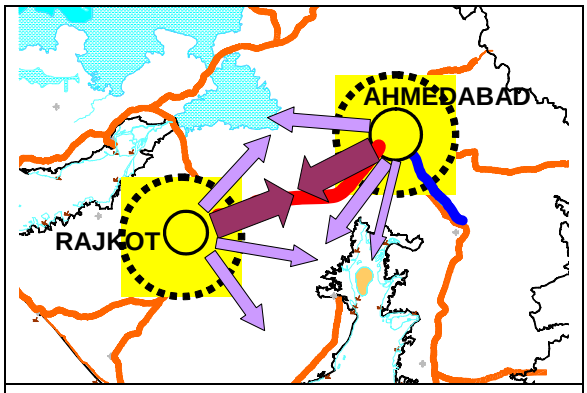


Map 1-6: Goods Movement and Interactions Patterns

[5] It is learnt through discussions with R&BD officials and our experience on this very road section, before commissioning of four lane divided facility; then existing two lane road was providing connectivity from Ahemedabad to Rajkot with about 5 hours travel time. The first major direct benefit of travel time saving was about 1.5 to 2 hours. But since then vehicle population is growing, local/side friction is increasing. Also the national economy is getting stronger and stronger along with state's robust economic performance in the recent past. Collectively it calls for enhanced speeds, safety and mobility.

[6] The stated observations have been derived from the origin destination survey.

If seen at the district level, it is observed that almost 50% of the passenger trips get produced from the districts of Ahmedabad and Rajkot alone, and they together attract 49% of the total passenger trips. In case of movement of quantum of goods, 36% of the total goods traffic using the corridor get produced from the two districts put together, whereas these districts attract 37% of the goods traffic (Map 1-7).



Map 1-7: District Level Interaction Patterns

It is, however, observed that the goods' traffic moving to and from the ports in Kutchh, do not much use this corridor any more, as presently only 8.3% of the total commodity movement on the corridor gets produced at these ports whereas they attract only 7.5% of the total commodity movement on the same.

The corridor between Rajkot and Ahmedabad is very critical in providing connectivity between Rajkot and rest of Gujarat and especially Ahmedabad.

1.2.6 Corridor Development Initiative – Some Considerations

The project corridor as noted before is important for various reasons. Traffic level is moderate to high amongst sections of highway. It is likely to only increase with time. Local traffic in some sections is moderate. Given the present situation and anticipated growth patterns, development of corridor is warranted. However, it is felt appropriate, based on discussions had with R&BD, to explore options of improvement, with and without disturbing present MoA.

In this context, it is considered as a mandate that relief by providing higher LOS to road users is more than important. Towards this it seems more realistic at this stage to curb the local/side friction and in the process provide enhanced level of service to road users by improved speeds and safety.

Providing access to settlements and industrial estates, along the highway that are presently affecting through and un-interrupted traffic movement is important.

The development of highway shall lead to direct benefits to the community by way of VOT and VOC savings. This will have further potential of enhancement of safety to the road users and/or vulnerable road users[7].

Box-1: Objectives of Assignment

1. To establish the technical, economical, and financial viability of the project and prepare feasibility reports for rehabilitation and upgrading of the existing 4-lane National Highway No. 8 A (NH 8A) section (between km 15/0 to km 182/4) to a fully/ partially access controlled highway with provision for a emergency parking and overtaking lane on either side of the main carriageway, and service roads for local traffic and slow moving vehicles.
2. The viability of the project designed as a fully/ partially access controlled facility shall be established taking into account the requirements with regard to rehabilitation, upgrading and improvement based on highway design, pavement design, provision of service roads, type of intersections, underpasses / flyovers / ROB's, rehabilitation and widening of existing and/or construction of new bridges and structures, curve improvements, bypasses, road safety features, quantities of various items of works and cost estimates vis-à-vis the investment and financial return through toll and other revenues.
3. The Project Feasibility Report would inter-alia include preliminary highway design for incorporating service lanes and paved side shoulders on either side, design of pavement and overlay, design of bridges and cross drainage structures and grade separated structures, design of service roads, quantities of various items, preliminary drawings, preliminary cost estimates, economic and financial viability analyses, environmental and social feasibility, social and environmental action plans as appropriate and documents required for bidding the project on commercial basis for international / local competitive bidding.

1.3 Objectives and Scope of the Report

The focus of the services (Box-1) is on exploring feasibility in terms of technical, economic and financial viability of developing (the Ahmedabad – Rajkot) Corridor as access controlled and/or partially access controlled corridor by evaluating various options under the given present conditions. Scope of services as given in the ToR is given in Volume-II (Appendix-1).

[7] Assessment of these benefits shall be important with each option of improvement, both in economic terms, as well as in financial terms, for the decisions to be made.

1.4 Deliberations and Report Focus

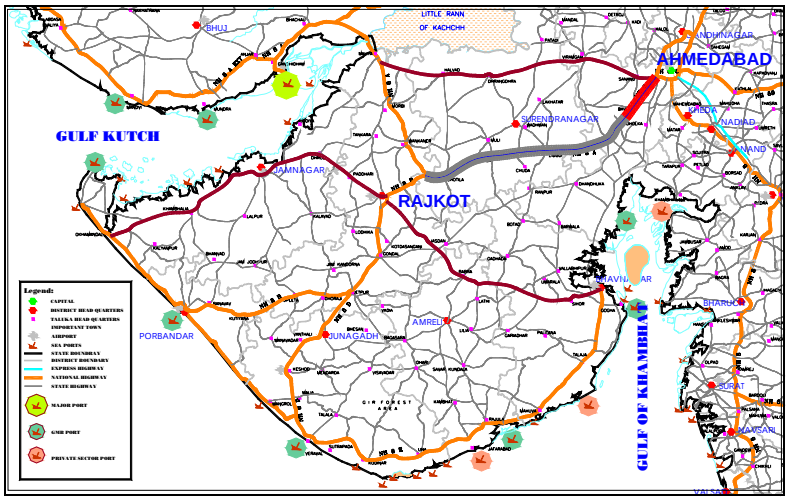
Extensive deliberations on the project were held with R&BD and GIDB. The project domain and focus of the services were getting evolved and refined with time. This indeed led to, being more realistic in terms of exploring options and assessing the implications. The preliminary feasibility report, which was submitted earlier, contained preliminary analysis and findings of various options of corridor development with respect to their technical, economic and financial aspects. This enabled GoG to take a view and advice on the shortlisted option, for carrying forward the further work looking at assessed economic benefits to the connectivity. It has been decided to consider the option of six lane, with grade separated intersections and service roads from km 14.5 to km 35. Thereafter, the corridor has been kept as 4 lane facility with grade separated intersections and provision of service roads in urban sections. Further, it has been discussed and agreed upon, given the present MoA with GoI, the implementation program be considered under two packages km 14.5 to km 61.4 as Package-1 and from km 61.4 to km 182.4 as Package-2, presenting the alternative implementation options/improvement scheme. Implementation strategies have been presented in this report to aid the decision making process, and also to initiate a dialogue with the GoI.

2. PROJECT CORRIDOR - PROFILING INFLUENCE REGIONS

2.1 Project Corridor- Network and Influence Area

The state of Gujarat comprises five regions – North Gujarat, South Gujarat, Central Gujarat, Kutchh and Saurashtra. Project corridor starts form the outskirts of Ahmedabad, traverses through Central Gujarat and connects the region of Saurashtra to rest of Gujarat and India. The corridor also connects major centres of the region, ie, Jamnagar and Porbandar. It provides connectivity to the coastline and the ports along it. Further, it also provides connectivity to Jamnagar and Mundra with the rest of the nation. These centres are to become crucial given the likely high level of investments getting attracted in the SEZs therein.

It seems more likely and appropriate that the traffic plying from/to Central and North Gujarat will prefer the use of corridor, apart from meeting the exhibited present mobility patterns and interactions.



Map 2-1: Map Showing the Corridor vis-à-vis the Ahmedabad – Viramgam – Maliya Road and Connectivity to Ports/Kutchh

2.2 Socio Economic Profile

Socio-economic characteristics of the project influence region would normally have a bearing on the present traffic and would further influence the traffic levels even in the future. Given this, the socio-economic profile of the project influence area has been studied and presented in brief in the ensuing sections. The project corridor, which passes through two major regions of the Gujarat state including Saurashtra and the Central Gujarat, are characterised by the presence of districts that are the major economic drivers of the state. The Central Gujarat region includes districts such as Anand, Kheda, Panchmahals, Dohad, Ahmedabad and Surendranagar. The Saurashtra region includes six districts namely Rajkot, Jamnagar, Porbandar, Junagadh, Amreli and Bhavnagar.

2.2.1 Demographic Characteristics

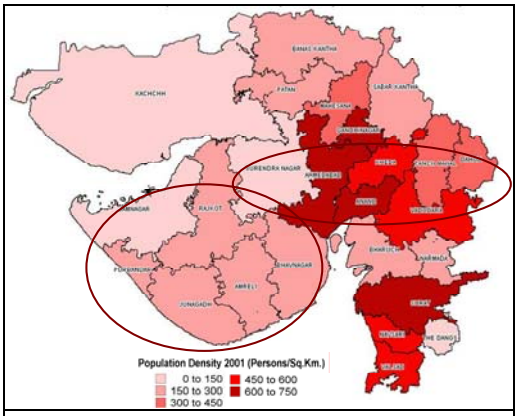
Gujarat has been experiencing relatively a higher population growth rate as compared to the rest of India (Table 2-1). Saurashtra and Central Gujarat constitute 24% and 29% of the total population of Gujarat respectively, totalling to over 50% of state population. The population growth rates in the two regions have considerable variation. While Central Gujarat has population growth trends similar to the state averages; Saurashtra shows a decline in population growth rates.

Table 2-1: Population Growth Profile

Year	Gujarat		Saurashtra		Central Gujarat		India	
	Population (Mi)	AAGR	Population (Mi)	AAGR	Population (Mi)	AAGR	Population (Mi)	AAGR
1971	26.7	–	6.65	–	7.90	–	548.16	–
1981	34.09	2.47%	8.55	2.55%	10.05	2.45%	683.33	2.23%
1991	41.31	1.94%	10.02	1.60%	12.18	1.94%	846.3	2.16%
2001	50.67	2.06%	11.92	1.76%	14.87	2.02%	1027.02	1.95%

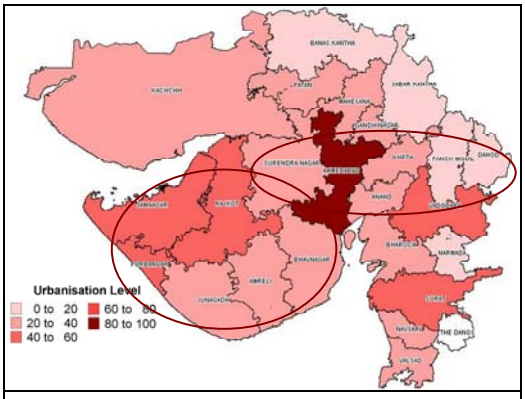
Source: Census 2001& Socio-Economic Review Gujarat State 2003-04

Substantial variations are seen in the population growth rates across the districts. Within Saurashtra, Rajkot has the highest growth rate of population. Surendranagar and Ahmedabad are the districts of high growth rate in the Central Region. High urbanisation levels can be said to be the major reason for such high growth rates in these districts. This aspect is further discussed in the subsequent sections. In terms of the density of population, Central Gujarat shows higher density as compared to Saurashtra (Map 2-2).



Map 2-2: Population Density 2001

2.2.2 Urbanisation Pattern and Growth Trends



Map 2-3: Urbanisation Levels- 2001

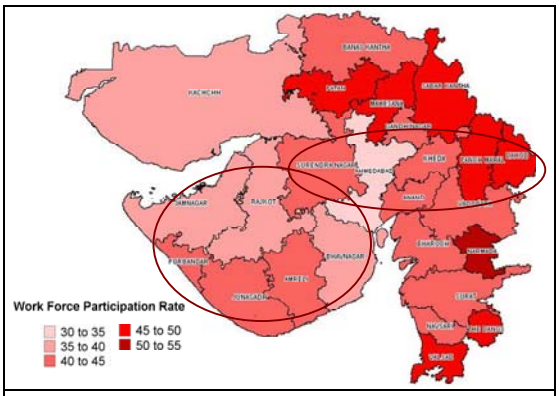
Gujarat has an urbanization level of 37.4%, higher than all India average of 27.8% (2001). Amongst the two regions being studied here; most of the districts of Saurashtra have higher urbanisation levels as compared to the state average. In Central Gujarat, Ahmedabad district is the only exception of high urbanisation levels that is primarily due to the presence of Ahmedabad UA (Map 2-3). A large number of urban centres in Saurashtra are major urban agglomerations. These include Rajkot, Jamnagar, Porbandar, Bhavnagar and Junagadh.

2.2.3 Economic Characteristics

2.2.3.1 Worker Characteristics

a) Work force participation rate

The workforce participation rates of Gujarat have been showing steady growth. The workforce participation rate of the state has gone up to 42% in 2001. The District level work force participation rates in Saurashtra region is lower (except Amreli) than the state average and also as compared to districts in Central Gujarat. The low WPR is due to high urbanization level. The districts with lower work force participation rate are Rajkot, Jamnagar, Junagagh, Bhavnagar (Map 2-4).



Map 2-4: Work Force Participation Rate by Districts-2001

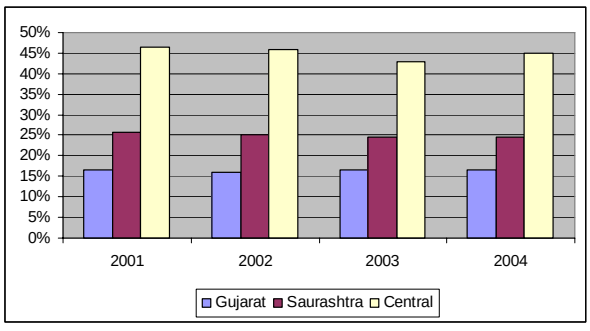


Figure 2-1: Growth of Employment

b) Growth of Employment

An assessment of the growth of employment has also been done in the following sections. Central Gujarat shows a high proportion of growth of employment primarily due to the presence of Ahmedabad and the neighbouring areas (Figure 2-1). The growth of employment in this region is nearly twice as that of Saurashtra region.

2.2.3.2 Sectoral Income

An assessment of the sectoral composition of the NSDP and GDP has been done to assess the major economic characteristics of the state. The sectoral composition of Gujarat shows that the secondary i.e, the manufacturing sector of the state is very strong. Nearly 35% of the NSDP is constituted by the secondary sector (Table 2-2). For the country as a whole, the same is only 26%. Manufacturing is therefore, an important economic activity in Gujarat. A detailed description of the type of industrial development in the state and the project influence area has been done in the subsequent sections.

Table 2-2: Sectoral Composition of NSDP and GDP (% of Total)

Year	Gujarat			India		
	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
93-94	26.88	33.29	39.83	29.50	24.88	45.62
94-95	31.13	32.69	36.18	29.68	21.18	49.15
95-96	26.66	34.7	38.64	27.64	22.27	50.08
96-97	30.69	33.72	35.6	28.05	22.05	49.91
97-98	28.1	31.6	40.3	26.44	22.34	51.24
98-99	27.7	31.81	40.49	26.83	22.01	51.16
99-00	19.81	35.44	44.75	24.00	27.00	49.00
2000-01	18.28	33.74	47.98	24.44	26.67	48.89
2001-02*	21.84	30.84	47.32	24.36	25.16	50.48
2002-03	17.58	34.99	47.43	21.86	25.94	52.20
2003-04	23.30	32.89	43.81	22.18	25.74	52.08
2004-05	20.07	34.65	45.28	20.78	26.00	53.22
2005-06	-	-	-	19.91	26.08	54.01
2006-07**	-	-	-	17.23	27.13	55.60

**Revised percentage as per the new series 1999-2000 prices*
***For the Month of April and September*
Source: State Domestic Product of Gujarat State 2003-04

2.2.3.3 Industrial Development

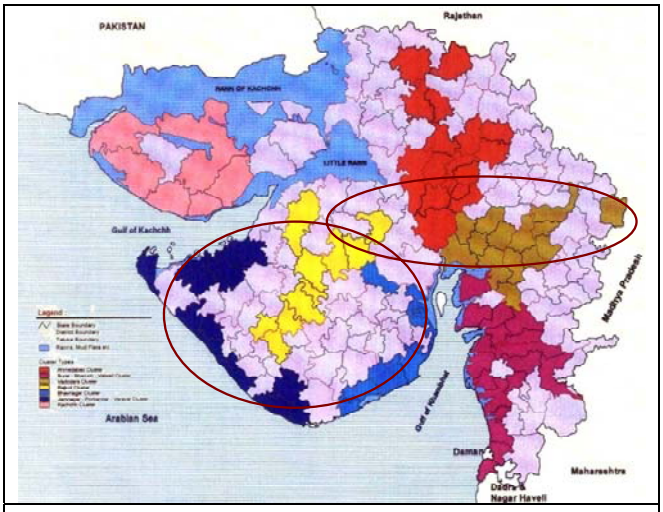
Gujarat has achieved on impressive industrial development since its formation. As discussed above, the share of manufacturing sector in State Domestic Product has continuously improved. The State has achieved diversification in industrial base and has gained importance in production of chemicals and petrochemicals, textiles, mineral based industries, food processing and others. Gujarat has also achieved industrial dispersal to a large extent registering impressive development in different districts of the State.

Table 2-3 shows the number of working industries in the two regions. 17.5% and 31.5% of industries of the state are concentrated in Saurashtra and Central Gujarat respectively. The mobility levels will be higher in these regions due to the regular movement of employees / labour, movement of goods – both raw material and finished goods.

Table 2-3: Industries- Saurashtra and Central Gujarat

District	No. of Working Industries	Average No. of Workers
Gujarat	**19661**	**815462**
Saurashtra	**3448**	**122644**
Rajkot	1724	44706
Jamnagar	406	17155
Porbandar	47	3542
Jaunagadh	250	17342
Amreli	36	2643
Bhavnagar	429	19342
Anand	556	17914
Central Gujarat	**6185**	**216559**
Kheda	317	13690
Panchmahals	394	20818
Dohad	67	4837
Ahmadabad	4997	166098
Surendranagar	410	11116

A number of Special Economic Zones have been announced within the state, and a number of Export Oriented Units have been set up. Map 2-5 shows the industrial clusters in the state. In Saurashtra alone, there are three industrial clusters viz., Bhavnagar, Porbandar-Jamnagar-Veraval and Rajkot cluster.



Map 2-5: Location of Major Industrial Clusters

2.2.3.4 Ports

Gujarat has the longest coastline of 1600 km, amongst all the states of India. This provides the state with major advantage of having the largest share of ports in the country. In all, there are 41 ports, of which the port at Kandla is the major port. Saurashtra handles about 816 lakh tones of cargo of the state (2006-07). The ports in Saurashtra include Navlakhi, Bedi, Sikka, Okha, Mul(Dwarka), Porbandar, Veraval, Jafrabad, Pipava (GPPL), and Bhavnagar. The movement of cargo to and fro from these ports constitute the major traffic in this region. Along the project corridor, the goods movement is mainly to Kandla port.

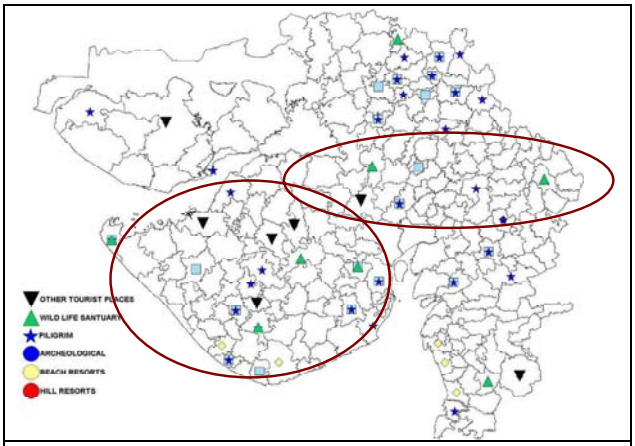
Table 2-4: Cargo Handled (Lakh Tonnes) by Ports in Gujarat and Saurashtra

District	Intermediate Ports	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
Rajkot	Navlakhi	16.21	17.34	11.7	8.55	12.5	18.22	17.68
Jamnagar	Bedi	32.68	30.9	28.35	29.05	32.37	44.38	41.65
	Sikka	407.86	471.95	458.1	498.2	515.1	521.53	602.52
	Okha	14.83	12.57	14.85	12.15	14.41	12.78	32.03
	Mul(Dwarka)	30.2	32.6	38.43	37.77	39.26	38.49	40.78
Porbandar	Porbandar	5.87	10.36	13.34	14.49	22.87	20.71	24.69
Junagadh	Veraval	0.53	0.23	0.1	0	0.36	0.47	0.57
Amreli	Jafrabad	39.32	40.36	41.24	45.16	46.02	43.64	55.03
	Pipava (GPPL)	19.09	15.61	14	19.42	NA	NA	NA
Bhavnagar	Bhavnagar	4.33	4.16	6.34	3.54	2.79	2.33	1.75
Total		**570.92**	**636.08**	**626.45**	**668.33**	**685.68**	**702.55**	**816.7**

Source: Gujarat Maritime Board, Gandhinagar

2.2.3.5 Tourism

Within the two region, Saurashtra boasts of some of the major tourist locations (Map 2-6). This includes Junagadh, Rajkot, Jamnagar, Porbandar, etc. Apart from archeological heritage, there are wild life sanctuaries and other important pilgrim centres in the region. Tourist movement along the project corridor is also significant.



Map 2-6: Major Tourism Centers

2.2.3.6 Primary Sector

Agriculture development is significant in the project influence area. The important crops include cotton, groundnut, bajra. Irrigation stretches of land can also be seen in project influence areas.

Jamnagar, Surendranagar, Porbandar, Ahmedabad, Sabarkatha, Vadodara, Surat, Rajkot, Junagadh are the major upcoming regions of the state. Stone, manganese, other clay, bauxite and gypsum.

2.2.4 Major Economic Drivers

2.2.4.1 Foreign Direct Investment (FDI)

Gujarat attracts a high proportion of FDI, destined for India. The total investment made by the other countries in the state went up to as high as 23% in 2001. The share of investment attached by Gujarat has been summarized in Table 2-5. Gujarat has been attracting a fairly high share of the total FDI flow into the country.

Table 2-5: FDI Flow into Gujarat

Year	India (Rs. Million)	Gujarat (Rs. Million)	Share of Total (%)
1996	361498.5	8489.07	2.35
1997	548913.47	31326.23	5.71
1998	308135.03	33487.06	10.87
1999	283665.34	11151.54	3.93
2000	370394.4	959.63	0.26
2001	268746.69	61860.83	23.02

Source: www.indiastat.com

In terms of traffic generation, the location and concentration of economic activities become relevant, as they act as major traffic production and/or attraction points. Mostly such locations are likely to have maximum concentration of population and support infrastructure. It is therefore relevant to understand the spread and magnitude of the selected economic drivers, especially in context to the study corridors. In the following section, the proposed investments in the region and the likely employment to be generated have been discussed.

2.2.4.2 Proposed Investment

Investments to the region have been proposed in the form of industries and special economic zones (SEZs). Table 8 shows these proposed investments in the project influence area. Of the total proposed investments in the state, 27% are in Saurashtra and 13% in Central Gujarat. A significant number of employment generation is anticipated in the region due to the creation of such economic activities. There are at least two SEZs proposed along the project corridor as well- Gallops and pharmaceutical SEZ of Zydus Cadilla.

Table 2-6: Proposed Investments in SEZs- Project Influence Area

State/District	Investment (Rs.in Crore) (MoUs signed)	Employment
Gujarat	170889	632640
Saurashtra		
Rajkot	800	9000
Jamnagar	45550	44500
Amreli	212	2000
Total	46562	55500
Central Gujarat		
Ahmedabad	21486	108390

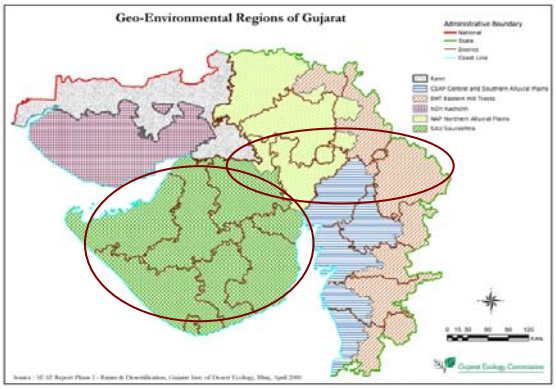
Source: Vibrant Gujarat Global Investors' Summit 2007

2.3 Environmental Characteristics

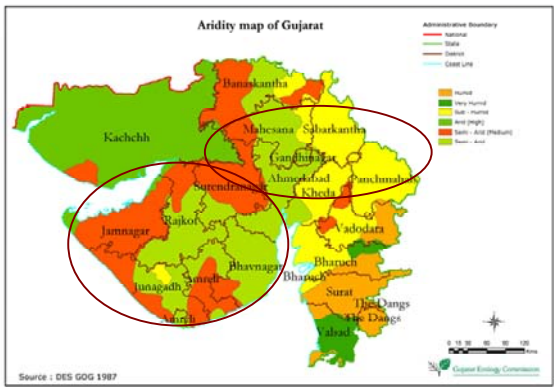
The project influence area falls under two major geo environmental regions. These include Saurashtra and the Northern Alluvial Plains (Map 2-7). Each of these regions are characterized by

typical environmental conditions. The major characteristics have been summarized as under. Supporting maps have been given wherever required.

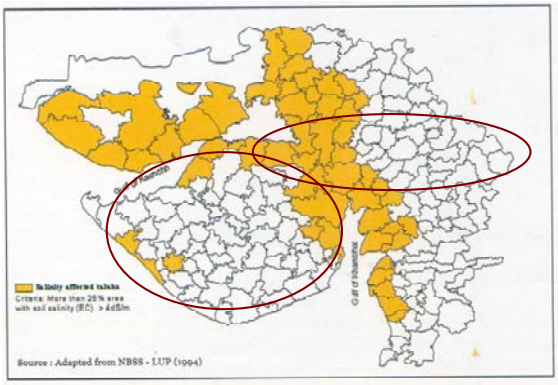
- Both these regions fall in semi-arid region with significant levels of dryness (Map 2-8).
- Due to the relatively low humidity characteristics, problems such as excess groundwater withdrawal and salinity ingress exist. Map 2-9 shows that several areas in the two regions have problems have ground water salinisation.
- Ground water pollution is also an environmental issue in the region. Several talukas in both Saurashtra and Central Gujarat have to contend with the problem of ground water pollution (Map 2-10).
- Despite this, the region has considerable agricultural development. Also, there is presence of pasture land in some of the talukas of Saurashtra (Map 2-11). Conservation of these would be an important issue.



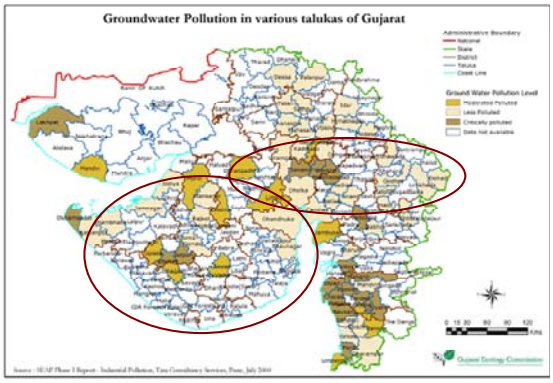
Map 2-7: Geo-Environmental Regions



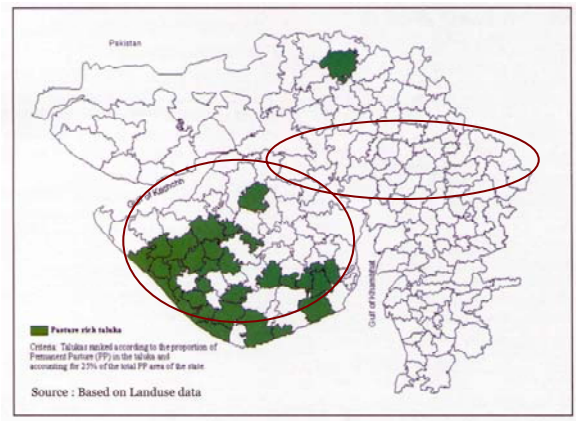
Map 2-8: Aridity



Map 2-9: Salinity Affected Talukas



Map 2-10: Ground Water Pollution



Map 2-11: Pasture Rich Talukas

SECTION B: PROJECT CORRIDOR APPRECIATION AND ANALYSIS

In order to appreciate the characteristics of the project corridor, a detailed investigation through surveys and reconnaissance has been undertaken. The appropriateness of the present corridor as against the demand levels which are likely to be in the future, have been understood to identify the gaps in the corridor configuration, while justifying the need to widen/improve it. The present section of the report focuses on these aspects.

3. TRAFFIC CHARACTERISTICS

3.1 Traffic Flow and Movement Pattern

The traffic volume on corridor varies from 22,000 PCU to 60,000 PCU. First section from km 14 to km 34 is presently experiencing traffic level over 60,000 PCU. At other four locations on corridor the volume levels are in the range of 22,000 PCU to 30,000 PCU. The assessed Annual Average Daily Traffic (AADT) by locations is presented below in Table 3-1.

Table 3-1: Annual Average Traffic Volume (AADT in Vehicles and PCU)

Location Name	Near Navapura km 17	Near Bhayla km 42	Near Bagodara Toll Plaza km 63.2	Baldev km 104	Borianesh km 182 before Bamanbore Toll plaza	*Near km 31on SH-8 Galiyana village, Bagodara – Vasad Toll Road	*NH-8A near Maliya km 266+130
Sc/Mc	8380	1471	792	1498	1628	1738	1297
Auto Rickshaw / Chakda	5096	970	402	754	823	775	501
Car/Jeep (Old Tech)	1258	287	123	256	537	115	238
Car/Jeep (New Tech)	6205	2160	3585	3171	3857	2495	1890
Mini Bus	1173	275	64	118	255	66	65
Std. Bus	2452	1257	983	930	1089	988	410
Tempo / LCV	2540	900	813	1073	1193	713	543
2-Axle Trucks	5383	2033	2209	2138	2118	1688	2663
3-Axle Trucks	2655	1116	2458	2247	2700	2399	4373
M-Axle Trucks	957	435	591	745	654	500	648
Tractor with Trailer	433	139	60	215	56	192	64
Tractor without Trailer	248	86	35	99	23	81	48
Cycle	751	193	47	265	16	52	42
Cycle-Rickshaw	44	4	2	22	3	2	1
Animal Drawn	55	4	4	5	2	3	1
Others	55	3	2	89	47	1	38
AADT (VEH)	**37685**	**11333**	**12169**	**13625**	**15003**	**11808**	**12822**
AADT (PCU)	**60376**	**21754**	**25725**	**27693**	**29262**	**23749**	**29937**

*Volume count locations on project influence area.

Traffic composition generally is same across locations, except location near Navapura at km 17 which has significant share of scooters, motor cycles and auto-rickshaws. This is due to close proximity to Ahmedabad and also is attributable to local traffic movement along industrial belt.

The hourly variation in the total traffic by different locations on the project corridor is presented in Figure 3.1. Peak hour volume in PCU and Peak hour share of traffic are shown in Table 3-2.

It has been observed that there is not much variation in traffic intensity over the day, except near Navapura (km 17/00). From the Table 3-2 it can be seen that Peak hour share varies between 5.1% and 6.1%, by different locations.

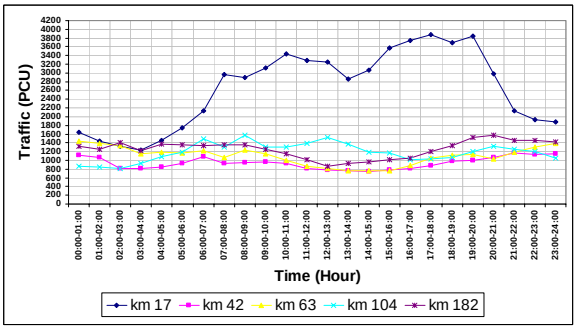


Figure 3-1: Location Wise Hourly Variation in Traffic Intensity

Table 3-2: Peak Hour Volume and Peak Hour Share

Location Name	Peak Hour Volume (PCU)	Peak Hour Share
Near Navapura km 17	3875	6.1%
Near Bhayla km 42	1175	5.2%
Near Bagodara Toll Plaza km 63+200	1438	5.5%
Baldev km 104	1579	5.5%
Borianesh km 182 before Bamanbore Toll plaza	1572	5.2%
Near km 31on SH-8 Galiyana village, Bagodara – Vasad Toll Road	1504	6.1%
NH-8A near Maliya km 266+130	1758	5.7%

Location wise daily volume recorded are given in Volume-II (Appendix-2)

3.2 Traffic Desire and Travel Characteristics

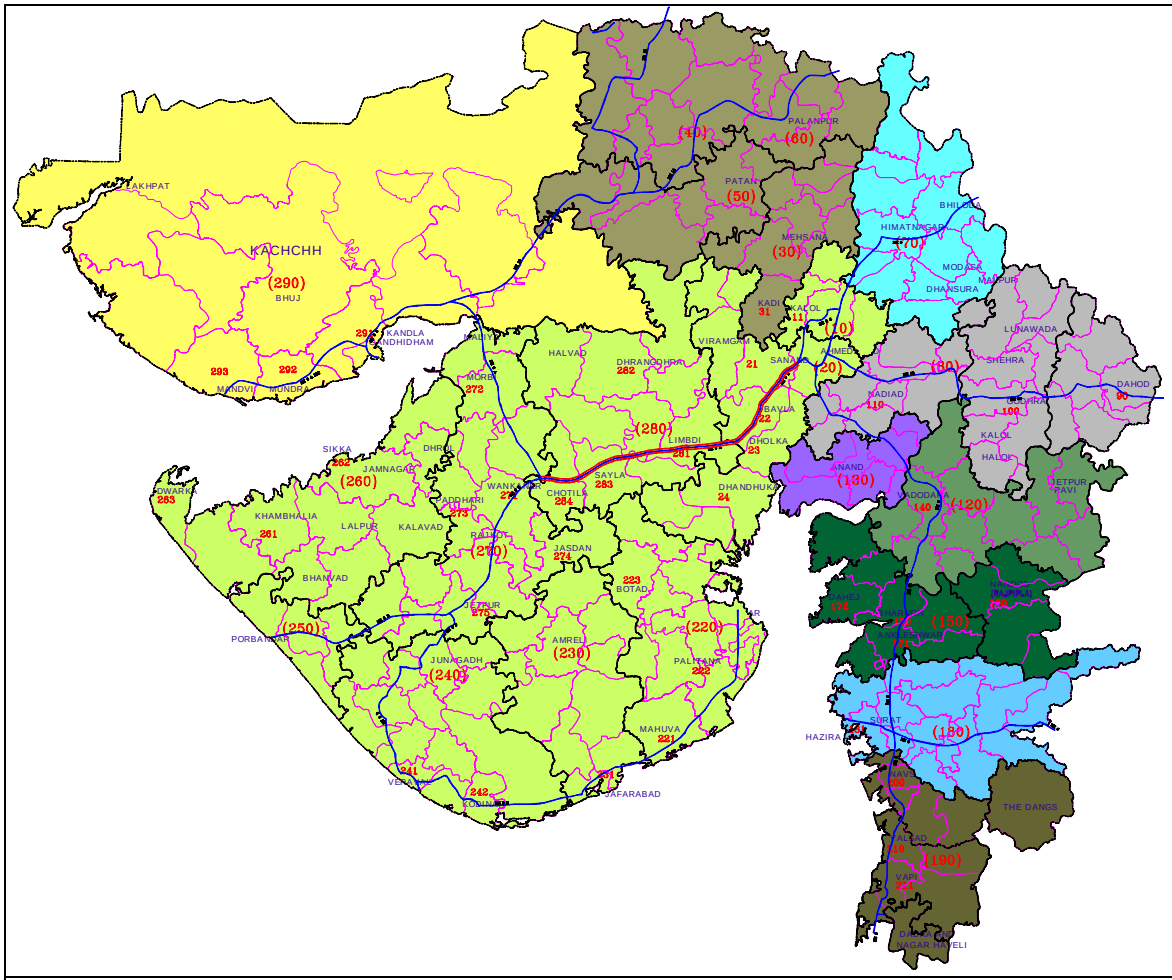
3.2.1 Traffic Desire

Along with the traffic volume survey, Origin-Destination (O-D) surveys were also conducted on the project corridor to reveal the traffic movement and travel desire patterns. The data collected was analyzed to obtain the travel characteristics of the road users. The desire patterns of the road users have been established on the basis of the origin and destination patterns of sample traffic interviewed (Maps 3-1 and 3-2 presents adopted traffic zoning scheme).

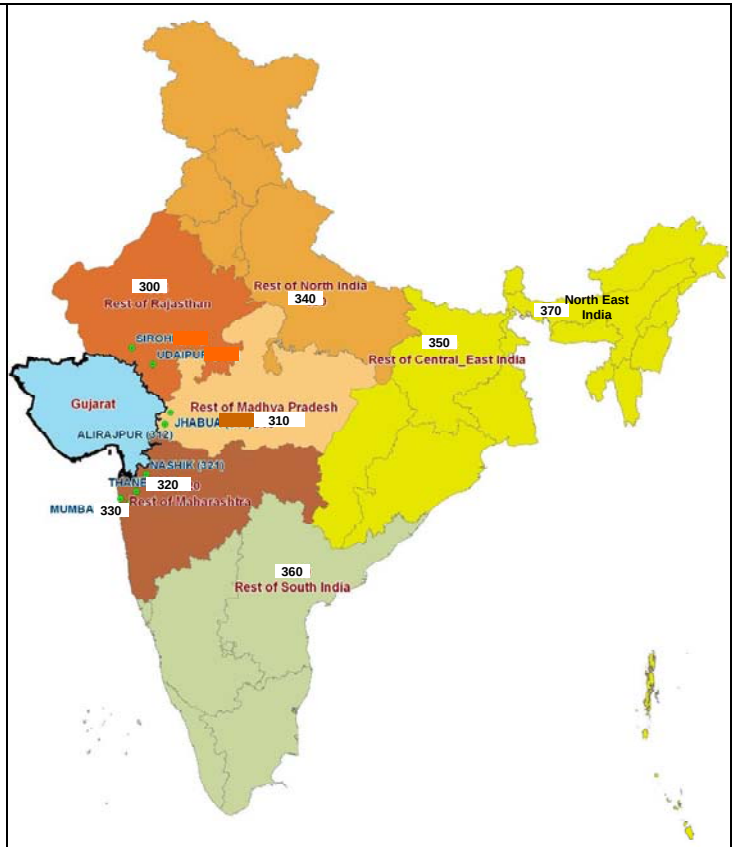
Passenger and Goods trip end matrices have been prepared and mode wise break-up of passenger and goods trips, thereafter have been derived. High level (over 50%) of interaction between Ahmedabad and Rajkot districts alone has been observed. If, instead of Rajkot, Saurashtra is considered, this figure shall go up to about 80%. This amply reveals how critical this corridor is for Saurashtra and Gujarat. Location wise break up of passenger and Goods vehicles are given in Table 3-3.

Table 3-3: Break-up of trips internal to Gujarat and External (to and From Gujarat)

Section		PASSENGER VEHICLES					GOODS VEHICLES				
		Both Trip ends on The Corridor	With one trip ends on the corridor - second generated in Gujarat	With one trip ends on the corridor - second generated outside Gujarat	Both trip end in Gujarat but not on corridor	with one trip end in Gujarat and other outside gujarat but not on corridor	Both Trip ends on The Corridor	With one trip ends on the corridor - second generated in Gujarat	With one trip ends on the corridor - second generated outside Gujarat	Both trip end in Gujarat but not on corridor	with one trip end in Gujarat and other outside gujarat but not on corridor
		ISZ -ISZ	ISZ-IG & IG - ISZ	ISZ-EG & EG-ISZ	IG-IG	IG-EG & EG-IG	ISZ -ISZ	ISZ-IG & IG - ISZ	ISZ-EG & EG-ISZ	IG-IG	IG-EG & EG-IG
km 42	Vehicles	501	16524	234	1394	197	244	9423	672	1910	1248
	%	2.7%	87.7%	1.2%	7.4%	1.0%	1.8%	69.5%	5.0%	14.1%	9.2%
km 63	Vehicles	637	14304	377	2476	426	89	9377	1721	4322	3673
	%	3.5%	78.5%	2.1%	13.6%	2.3%	0.46%	48.88%	8.97%	22.53%	19.15%
km 104	Vehicles	38	14499	696	2970	439	125	10591	1695	3514	3076
	%	0.2%	77.8%	3.7%	15.9%	2.4%	0.66%	55.74%	8.92%	18.50%	16.19%
km 182	Vehicles	100	21806	559	3224	553	64	10020	2531	4291	3688
	%	0.4%	83.1%	2.1%	12.3%	2.1%	0.31%	48.64%	12.29%	20.83%	17.90%
km 31	Vehicles	191	2964	142	2410	328	47	1194	558	2906	1198
	%	3.2%	49.1%	2.3%	39.9%	5.4%	0.79%	20.18%	9.43%	49.11%	20.24%
km 266	Vehicles	0	2386	3	2283	225	0	3491	80	4368	1033
	%	0.0%	48.7%	0.1%	46.6%	4.6%	0.00%	38.89%	0.89%	48.65%	11.51%



Map 3-1: Traffic Zones – Gujarat



Map 3-2: Traffic Zones – Adjoining States and Rest of India

3.2.1.1 Passenger Vehicles' Desire Pattern

Salient characteristics of the passenger vehicles desire pattern, as observed, by the locations, where O-D survey has been conducted, is given under:

Bhayla (km 42/000):

- about 88% of the vehicles have one of the trip ends on the corridor and second within Gujarat;
- 7.5% of the trips have both trip ends within Gujarat but not on the corridor;
- 3% of the trips have both trip ends on the corridor;
- 1% of the vehicles have one trip end within Gujarat and the other out side Gujarat.

Bagodara Toll Plaza (km 63/200):

- about 79% of the vehicles have one of the trip ends on the corridor and second within Gujarat;
- 14% of the trips have both trip ends within Gujarat but not on the corridor;
- 3.5% of the trips have both trip ends on the corridor;
- 2.3% of the vehicles have one trip end within Gujarat and the other out side Gujarat.

Hotel Baldev (km 104/00):

- about 78% of the vehicles have one of the trip ends on the corridor and second within Gujarat;
- 16% of the trips have both trip ends within Gujarat but not on the corridor;
- 0.2% of the trips have both trip ends on the corridor; and
- 2.4% of the vehicles have one trip end within Gujarat and the other out side Gujarat.

km 182 Bamanbore Toll Plaza:

- about 83% of the vehicles have one of the trip ends on the corridor with the other being within Gujarat;
- 12% of the trips have both trip ends within Gujarat but not on the corridor,;
- 0.4% of the trips have both trip ends on the corridor; and
- 2.1% of the vehicles have one trip end within Gujarat and the other out side Gujarat.

km 31 Near Wataman Toll Plaza:

- about 50% of the vehicles have one of the trip ends on the corridor and other within Gujarat;
- 40% of the trips have both trip ends within Gujarat but not on the corridor;
- 5.4% of the vehicles have one of the trip ends within Gujarat and the other out side Gujarat; and
- 3.2% of the trips have both trip ends along the corridor.

Maliya km 266 on NH 8A:

- about 49% of the vehicles have one of the trip ends on the corridor with the second being within Gujarat;
- 47% of the trips have both trip ends within Gujarat but not on the corridor;
- 4% of the vehicles have one trip end within Gujarat and the other out side Gujarat.

From the desire pattern of passenger vehicles, it is clearly revealed that predominant share of Passenger vehicles ply within and between Ahmedabad, Surendranagar and Rajkot districts. Desire line diagram for motorized passenger vehicle trips are shown in Figure 3-2 (Refer to Volume-II (Appendix-3).

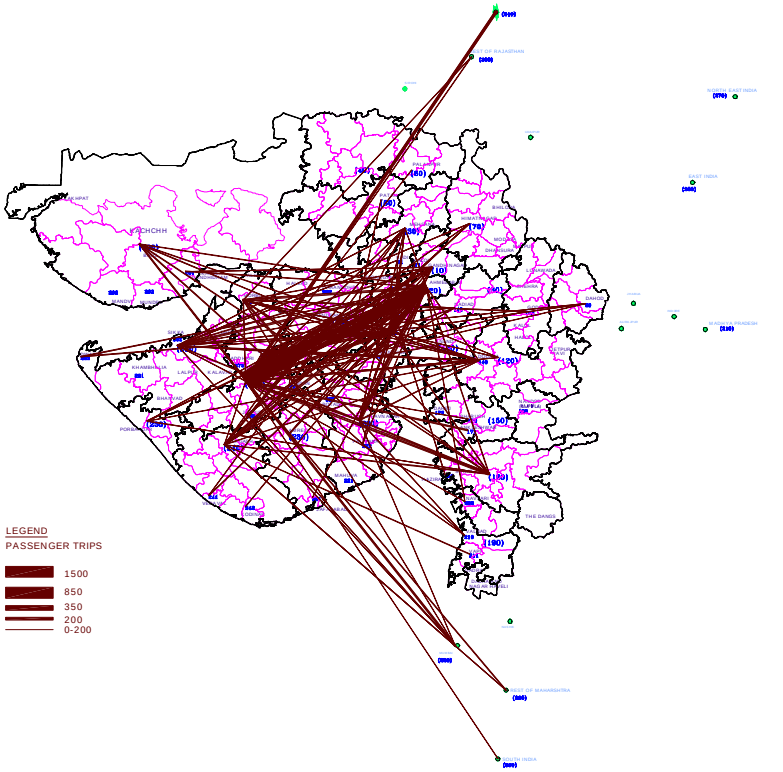


Figure 3-2: Passenger Vehicle Desire Line Diagram

3.2.1.2 Goods Vehicles Desire Pattern

The desire pattern of goods vehicles is slightly different from that of the passenger vehicles. The salient desire characteristics of goods' vehicles is given below by the locations:

Bhayla (km 42/000):

- Approximately 70% of the vehicles have one trip end on the corridor and the other within Gujarat;
- 14% of the trips have both trip ends within Gujarat but not on the corridor;
- 9% of the vehicles have one trip end within Gujarat and the other out side Gujarat;
- About 5% of the trips have been observed to have one trip end on the corridor and the other out side Gujarat; and
- Only 2% of the vehicles have both trip ends on the corridor.

Bagodara Toll Plaza (km 63/200):

- About 49% of vehicles have one trip end on the corridor and second within Gujarat;
- 23% of the trips are with both trip ends withinGujarat but not on the corridor;
- 19% of the vehicles have one trip end within Gujarat and the other out side Gujarat; and
- About 9% of the trips are observed with one trip end on the corridor and the other out side Gujarat.

Hotel Baldev (km 104/00):

- About 56% of the vehicles have either of the two trip ends on the corridor with second within Gujarat;
- 18% of the trips have both trip ends within Gujarat but not on the corridor;
- 16% of the vehicles have been observed to have one trip end within Gujarat and the other out side Gujarat;
- About 9% of the trips are observed having one trip end on the corridor and the second out side Gujarat; and
- Only 1% of the vehicles have been observed to have both trip ends on the corridor.

km 182 Bamanbore Toll Plaza:

- Approximately 50% of the vehicles have either one trip end on the corridor and second generated within Gujarat;
- 21% of the trips have both trip ends within Gujarat but not on the corridor;
- 18% of the vehicles have been observed with one trip end within Gujarat and another out side Gujarat; and
- 12% of the trips are observed to have one trip end on the corridor and another out side Gujarat.

km 31 Wataman Toll Plaza:

- Around 20% of the goods vehicles have either of the trip end on the corridor and second within Gujarat;
- 50% of the trips have both trip ends withinGujarat but not on the corridor;
- 20% of the trips have one trip end within Gujarat and another one out side Gujarat;
- About 9% of the trips are observed with one trip end on the corridor and another out side Gujarat; and
- Only 1% of the vehicles have been observed with both trip ends on the corridor.

Figure 3-3: Goods Vehicle Desire Line Diagram

Maliya on NH 8A:

- About 39% of the goods vehicles' trips have one trip end on the corridor and second within Gujarat;
- 49% of the trips have both trip ends within Gujarat but not on the corridor;
- 12% of the vehicles with one trip end within Gujarat and another out side Gujarat; and
- Only 1% of the trips are observed with one trip end on the corridor and another out side Gujarat.

Desire line diagram for goods' motorized vehicular trips is given at Figure 3-3.

3.3 Travel Characteristics

3.3.1 Passenger Vehicles

(a) Trip Purpose

It has been observed that 37% of trips are performed for work and business purposes, followed by social and recreation. For work and business purposes, cars and two-wheelers are the most

preferred modes. Figure 3-4 presents the distribution of trips by vehicle type and purpose and Figure 3-5 presents percentage distribution of trips by purpose.

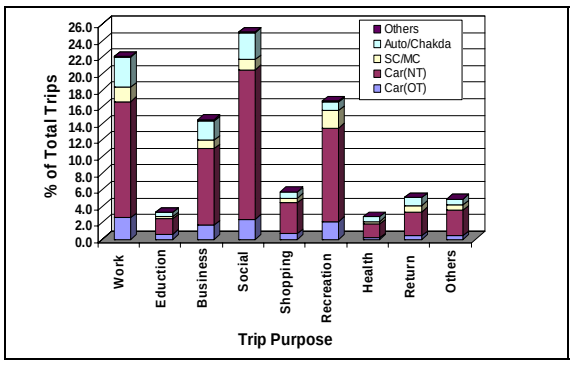


Figure 3-4: Distribution of Trips by Vehicle Type and Purpose

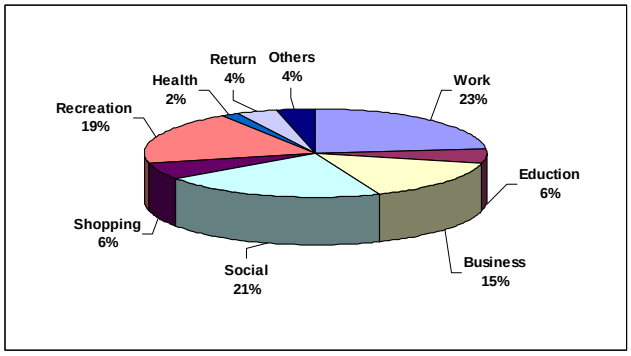


Figure 3-5: Distribution of Trips by Purpose

(b) Trip length / Time Frequency Distribution Curve

Figure 3-6 and Figure 3-7 present the trip length and time frequency distribution curves for passenger vehicles on the project corridor. The analyses reveal that about 50% of the trips are performed with a mean trip length of 375 km and with a mean trip time of 6 hours. Around 15% of the passenger trips have a mean trip length of 35 km followed by 22% of trips with a mean trip length of 250 km. Only 8% of the trips have a trip length of more than 500 km.

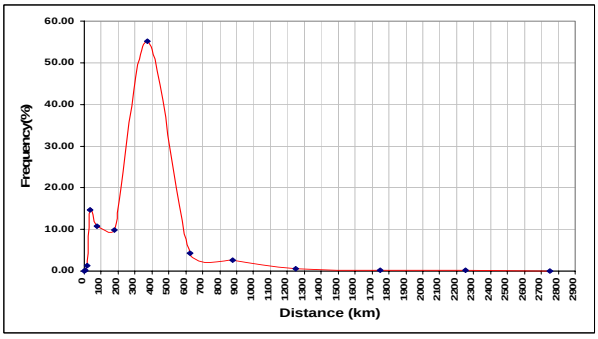


Figure 3-6: Trip Length Frequency Distribution Curve for Passenger Vehicles

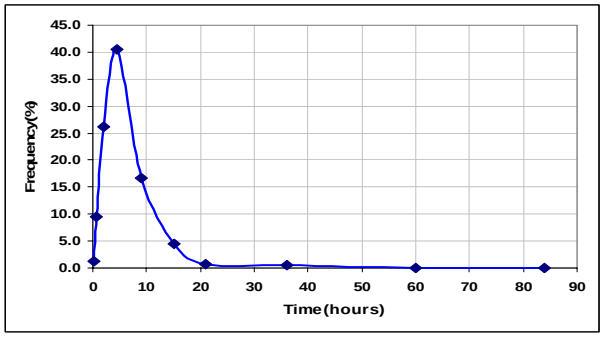


Figure 3-7: Trip Time Frequency Distribution Curve for Passenger Vehicles

Table 3-4 gives mode wise average trip length and trip time for passenger vehicles on the project corridor. The highest trip length and trip time have been observed for new technology cars (290 km and 5 hours), followed by car/jeep (OT) and two wheelers. The least trip length and trip time are observed in case of scooters and motor cycles.

Table 3-4: Average Trip Length and Average Trip Time of the Passenger Vehicles

Mode	Car/Jeep (OT)	Car/Jeep (NT)	Sc/Mc	Auto Rickshaw/ Tempo/ Chakada	Others	All Vehicle
Average Trip Length (km)	249.2	290.0	127.4	134.4	113.8	**249.0**
Average Trip Time (Hour)	4.5	4.9	3.2	5.4	4.6	**4.7**

3.3.2 Goods Vehicles

(a) Distribution of Trips by Vehicle Type and Commodity

Distribution of trips by vehicle type and commodity are presented in Table 3-5 and in Figure 3-8. The analyses reveals that LCV/Tempo is mainly used to carry food grains and fruits/vegetables, which are very local in nature. Two-axle trucks and three axle trucks are being used for transporting almost all types of commodities. Multi-Axle trucks are however the preferred mode for transporting only Iron/steel, minerals, machines and machine parts and fertilizers/chemicals.

Table 3-5: Distribution of Trips by Vehicle Type and Commodity Carried

Commodity / Vehicle	Food Grains	Fruits & Vegetables	Textiles & Clothing	Petroleum Products	Minerals & Ores	Iron &Steel	Wood Products	Coal/Coke	Machine Parts	Fertilizers / Chemicals	Others	Empty
LCV/Tempo	1.9	1.8	0.6	0.4	1.1	1.1	0.6	0.2	1.1	0.5	3.1	3.9
2-Axle truck	3.0	1.7	1.5	1.1	4.2	2.7	1.6	0.9	2.2	2.0	7.3	6.8
3-Axle truck	2.8	1.2	1.9	1.7	3.3	3.6	1.8	1.4	2.1	3.3	6.5	6.0
M-Axle truck	0.3	0.3	0.4	0.7	0.9	3.1	0.5	0.4	0.7	0.8	1.0	1.7
Tractors	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.3	0.5
Others	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1
All vehicle Type	**8.2**	**5.2**	**4.5**	**4.0**	**9.6**	**10.7**	**4.5**	**3.0**	**6.2**	**6.7**	**18.3**	**19.0**

It is further observed (Figure 3-8), that major commodity types carried by goods vehicles are iron and steel (11%) followed by minerals/ores (10%) and food grains (8%). A considerable share of fertilizers/chemicals, machines and parts, textile/clothing, and petroleum products can be attributed to the existing industrial development along the project corridor. Other significant commodities include building materials (viz. cement, bricks and stone) and household goods.

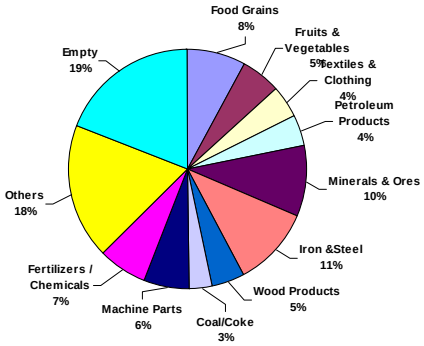


Figure 3-8: Distribution of Trips by Commodity Carried

2) Trip Length / Time Frequency Distribution Curve

Figure 3-9 and Figure 3-10 present the trip length and time frequency distribution curves for goods vehicles on the project corridor. The analyses of goods traffic trip length/time reveal that about 37% of the trips are performed within 350 km and in 10-hour time range. Around 27% of the trips have a mean trip length of 175 km, followed by 20% of trips with 700 km trip length and about 6% of trips with 50 km trip length. A high trip length of more than 1500 km is observed in the case of only 6% of the goods vehicles.

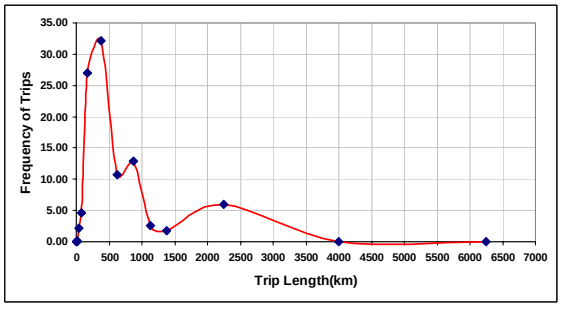


Figure 3-9: Trip Length Frequency Distribution Curve for Goods Vehicles

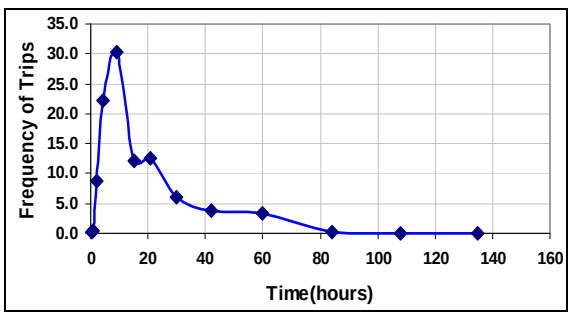


Figure 3-10: Trip Time Frequency Distribution Curve for Goods Vehicles

The mode wise average trip length and trip time for goods vehicles on the project corridor are given at Table 3-6 It is observed that the highest mean trip lengths and trip time are in the case of multi axle trucks, at around 650 km and 20 hours respectively followed by three-axle trucks and two-axle trucks. As expected, least trip lengths and trip times are observed in the case of LCVs and Tempos.

Table 3-6: Average Trip Length and Average Trip Time of the Goods Vehicles

Type of Vehicle	LCV	2-Axle	3-Axle	M-Axle	Tractors	Others	All Mode
Average Trip Length(km)	362.8	442.3	656.9	655.2	371.9	461.9	**528.1**
Average Trip Time (Hours)	8.1	11.1	16.4	21.8	14.9	23.1	**13.8**

3.4 Intersection/Junction Volumes

To appreciate the traffic volume characteristics at intersections, turning movement surveys have been conducted at twelve intersections. The salient features of traffic volume levels and same characteristics at these intersections are presented in Table 3-7.

Table 3-7: Traffic Volume Characteristics at Intersections

Location	Type of Intersection	Survey Duration (Hrs)	Total Volume in Vehicles	Total Volume in PCU	Peak Hour Volume in Vehicles	Peak Hour Volume (PCU)	Peak Hour	Right Turning Traffic in PCU	% Right Turning Traffic
Km 14+500	4-arm	12 Hrs	60877	103245	6227	10391	19:00-20:00	4316	42%
Km 32+300	3-arm	12 Hrs	2619	2965	311	360	16:00-17:00	360	100%[8]
Km 32+800	4-arm	12 Hrs	27341	37185	2792	3745	11:00-12:00	692	18%
Km 56+300	3-arm	12 Hrs	8717	15110	1076	1805	09:00-10:00	96	5%
Km 59+800	3-arm	12 Hrs	18891	37778	2750	5422	19:00-20:00	1691	31%
Km 61+300	3-arm	12 Hrs	9800	17949	1046	2089	12:00-13:00	78	4%
Km 61+800	3-arm	12 Hrs	9867	19532	1178	2566	19:00-20:00	199	8%
Km 101+800	4-arm	12 Hrs	12878	17923	1392	1962	10:00-11:00	327	17%
Km 102+600	4-arm	12 Hrs	18221	28536	1905	2940	08:00-09:00	618	21%
Km 136+600	3-arm	12 Hrs	10761	21151	980	1993	17:00-18:00	274	14%
Km 148+200	4-arm	12 Hrs	13593	21514	1258	2053	10:00-11:00	326	16%
Km 167+400	3-arm	12 Hrs	12431	19514	1515	2705	19:00-20:00	61	2%

The peak hour flow has been observed to be maximum at Sardar Patel Ring road junction at km 14/600 (10,391 PCU) followed by Tarapur Junction at km 59/800 (5,422 PCU), Bavla –Sanand Junction at km 32/800 (3,745 PCU) and Surendranagar-Limdi Junction (2,940 PCU). The number of right turning traffic in peak flow is the index value, which indicates the intensity of vehicle-vehicle conflict at the intersection. The highest number of right turning traffic has been observed at Sardar Patel Ring Road Junction (the starting point of the project corridor) followed by Tarapur Junction and Surendranagar-Limdi Junction.

From the flows it is inferred that among the three armed junctions, maximum right turning traffic is at Tarapur junction (692 PCU), followed by junction at km 136/600. Among the four arm intersections, high right turning traffic is observed at Sardar Patel Ring Road Junction at km 14/600 (around 4,316 PCU) followed by Bavla - Sanand (692 PCU) and Limdi – Surendranagar (618 PCU). The share of right turning traffic is observed to be high at km 14/600 (42%), followed by Tarapur (31%) and Surendranagar Limdi Jumction at km 102/600 (21%). The peak hour volume along with right turning traffic at all the intersections are also presented in Figure 3-11.

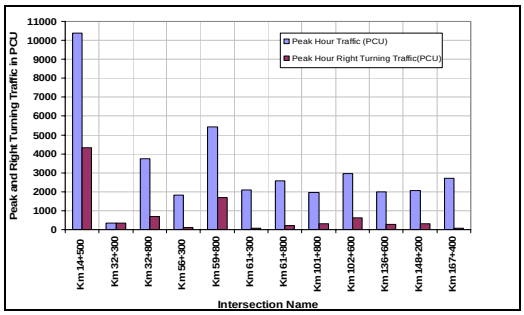


Figure 3-11: Peak Hour Traffic Volume Vs Right Turning Traffic at all the Major Intersections

[8] At km 32/300 near Bavla , only Right Turning Movements were counted

3.5 Pedestrian Flow Characteristics

The pedestrian count surveys were conducted at nine identified locations (mostly at intersections) where there is a high concentration of pedestrians crossing the project corridor due to the urbanized nature of the road section. The survey has been conducted to estimate the number of pedestrians crossing the project corridor and therefore to estimate a hazard index (an indicator of the level of conflict between pedestrians and vehicles). The peak hour pedestrian flows at intersections and traffic volume for the respective arms are presented in Table 3-8.

Table 3-8: Peak Hour Pedestrian Flows at Different Locations

S. No	Location	Chainage	Peak Flow (Pedestrian/Hr)		Peak Traffic(Veh/Hr)	Peak Traffic(Veh/Hr)
			Ahmedabad Arm	Rajkot Arm	Ahmedabad Arm	Rajkot Arm
1	Sanathal Chowkdi	km 14.6	205	195	1067	701
2	Bavla Jn	km 32.8	232	161	576	760
3	Dholka Jn.	km 56.3	98		287	
4	Nalsarovar Jn	km 61.3	405		331	
5	Dhanduka Jn	km 61.8	288		604	
6	Lakthar Chowkdi	km 101.8	107	227	444	505
7	Surendranagar Chowkdi	km 102.6	168	163	427	613
8	Sayla Jn	km 148.2	118	142	388	317
9	Chotila Jn	km 169.0	123		489	

Table 3-9 presents the PV^2 values, which are a measure of intensity of vehicular and pedestrian conflict (Reference: IRC 103:1988 "Guidelines for Pedestrian Facilities") for all the surveyed locations. The analyses reveal that highest pedestrian and vehicular conflict is at Sardar Patel Ring Road Junction. In general, it can be observed that at most of the locations, hazard index, with present levels of traffic are within the acceptable limit ($2X10^8$) in case of divided carriageway facility. Considering future growth of traffic and other developmental activities along the corridor, this may not be the case. It may be imperative that suitable control measures and facilities are provided for ensuring pedestrian safety with appropriate facilities.

Table 3-9: PV^2 Values for All Surveyed Locations

S.No	Location	Chainage	PV^2 values (in 10^8)	
			Ahmedabad Arm	Rajkot Arm
1	Sanathal Chowkdi	km 14.6	2.33	0.96
2	Bavla Jn	km 32.8	0.77	0.93
3	Dholka Jn.	km 56.3	0.08	
4	Nalsarovar Jn	km 61.3	0.44	
5	Dhanduka Jn	km 61.8	1.05	
6	Lakthar Chowkdi	km 101.8	0.21	0.58
7	Surendranagar Chowkdi	km 102.6	0.31	0.61
8	Sayla Jn	km 148.2	0.18	0.14
9	Chotila Jn	km 169.0	0.29	

3.6 Speeds on the Project Corridor

The speed delay studies were conducted on entire corridor. The details as per the format were recorded. The Journey and Running speeds on the corridor are presented in Table 3-10:

Table 3-10: Speeds on the Project Corridor

Section	Direction	Length	Journey Time (Min.)	Journey Speed (Kmph)
Km 14.6 to Km 60	A'bad to Rajkot	45	39	58
	Rajkot to A'bad	45	41	63
Km 60 to Km 100	A'bad to Rajkot	40	39	61
	Rajkot to A'bad	40	42	60
Km 100 to Km 182.4	A'bad to Rajkot	82	59	60
	Rajkot to A'bad	82	74	61

3.7 Parking Study

To provide an uninterrupted flow of traffic on corridor, it is felt important to cater to the road-side parking demand. To understand the extent of demand, parking studies have been carried out along the project corridor at eight identified stretches.

At most of the locations, besides predominance of goods vehicles, there were considerable number of passenger vehicles including autos, jeeps, and two-wheelers.

Vehicle-wise, parking demand at different locations has been estimated for 12 hours duration and then peak parking demand was determined (in ECS).

The peak hour parking demand for all locations is presented in Table 3-11. It has observed that the highest parking demand was near Bagodara (on the stretch between km 60/00 to km 62/00), followed by location between chainage km 168/00 and km 171/00. At other locations, truck was the predominant mode.

Table 3-11: Peak Hour Parking Demand on the Project Corridor

Location	Length(km)	Peak Hour	Parking Demand(ECS)
Km 14.6 - Km 17	2.4	18:30-19:30	337
Km 20 - Km 22	2	17:00-18:00	212
Km 32 - Km 34	4	11:00-12:00	190
Km 60 - Km 62	2	14:30-15:30	705
Km 101- Km104	3	10:00-11:00	327
Km 168- Km171	3	13:00-14:00	408
Km 172 - Km175	3	17:00-18:00	218
Km 60- 62 Off Street	2	18:30-19:30	224

4. ENGINEERING CHARACTERISTICS

4.1 Introduction

This section covers the general road characteristics which includes the existing lane configuration, type of terrain, average embankment height, and type of soil. The pavement condition which results into total distress of the project corridor is discussed in this section. The riding quality of the project corridor in terms of IRI is also described in this section. Further, the axle loading pattern of commercial vehicles plying on the project corridor is also discussed. The existing condition of CD structures on the project corridor which include major bridges, minor bridges and culverts are also discussed in this section.

4.2 Existing Roadway Characteristics

In this section the existing roadway characteristics are discussed where the characteristics are recorded by conducting road inventory survey at every 200 m interval which is then averaged to each km length. The following sections present each roadway characteristic for the entire corridor.

4.2.1 Road Inventory

The corridor passes through plain terrain with predominant black cotton soil for about 43% length, followed by sandy clay for almost 32% length, 21% length encounters clayey soil and silty clay is present for about 4% of length.

The project corridor reveals a four lane carriageway. It is flanked by paved and hard shoulder. Median width along most of the length is 5 m, but varies at few locations. ROW of 45 m has been observed with 18 m and 5 m clear width on left and right side respectively, of the carriage in up direction from Ahmedabad. The pictures below depict the roadway features of the project corridor

Some Pictures of Project Corridor

It was observed that along most of the length of the corridor, embankment is at a height. For almost 48.5% of corridor length (i.e. 81.4 km), embankment height was assessed to be more than 1.5m. Figure 4-1 present the project corridor cross section, of carriageway along with other characteristics at km 166.4.

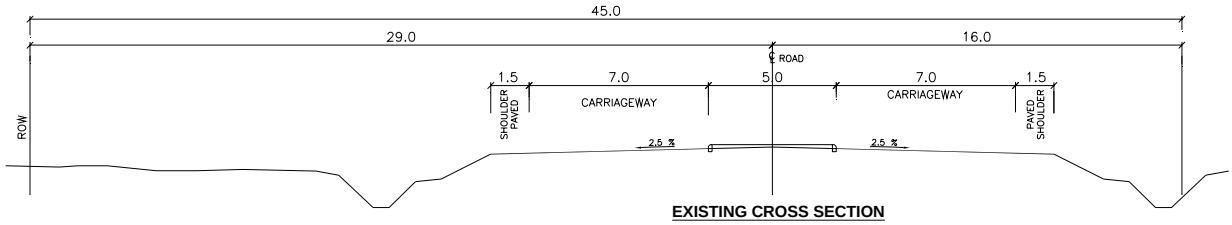


Figure 4-1: Existing Cross Section

There are approximately 58 horizontal curves along the entire length of the corridor. Further, the corridor enroutes 40 villages and passes through 9 major junctions.

4.2.2 Pavement Condition

This section presents the pavement condition which was recorded along the entire length of the project corridor. The severity and extent of the pavement distress have been noted for each 200 m section and thereafter the results averaged for each kilometer as presented in the table below. Table 4-1 and Table 4-2 below present the extent of different types of pavement distress along the project corridor.

Table 4-1: Pavement Distress

Ahmedabad-Rajkot						
Range of Distress	Length in KM					
	Total Cracking	Patching	Ravelling	Edge damage	Rutting	Shoving
0-5 %	160.8	157.8	105.8	163.8	167.8	165.8
5-15 %	6	6	15	3	0	2
15-30 %	1	3	13	0	0	0
30-50 %	0	1	18	1	0	0
>50 %	0	0	16	0	0	0
	167.8	**167.8**	**167.8**	**167.8**	**167.8**	**167.8**

Table 4-2: Pavement Distress

Rajkot- Ahmedabad						
Range of Distress	Length in KM					
	Total Cracking	Patching	Ravelling	Edge damage	Rutting	Shoving
0-5 %	114.8	160.8	108.8	166.8	166.8	159.8
5-15 %	42	5	26	0	1	7
15-30 %	6	2	19	1	0	1
30-50 %	5	0	13	0	0	0
>50 %	0	0	1	0	0	0
	167.8	**167.8**	**167.8**	**167.8**	**167.8**	**167.8**

Very few potholes have been observed on the project corridor. The pictures below represent the total distress area which was observed on both sides along the project corridor. A maximum of 97% area of distress was observed between km 70 to km 71 in left lane from Ahmedabad and a maximum distress of 67% was observed between km 101and km 102 in the right lane.

Pavement Condition at Km 23.000: Development of Block Cracking

Pavement Condition at Km 97.600: Side Settlement

Ravelling

Longitudinal cracking

Shoulder and Edge failure

Shoving

Ratings[9] of pavement condition of project corridor ranging from Very Good – Fair – Poor was done. Table 4-3 gives ranges that are adopted to arrive at the present serviceability of project corridor.

Table 4-3: Adopted Pavement Serviceability Rating

Total Distress	Adopted PSR
Upto 5%	Very Good
5 – 10%	Good
10 – 25%	Fair
25 – 50%	Poor
Above 50%	Very Poor

The analysis reveals that about 60% of corridor length (i.e. 100 km) was rated to be in very good service, with only about 18% corridor length service rating being poor on the left lane from Ahmedabad. On the newly constructed portion nearly 70% of length was very good to fair service in terms of pavement service rating with only 10% (of corridor length i.e. 17 km) as in poor service rating. Table 4-4 and Table 4-5 and Figure 4-2 below summarise the PSR for the entire corridor.

Table 4-4: Percentage of Length by Pavement Serviceability Rating (PSR)

Ahmedabad-Rajkot			
Total Distress	**PSR**	**Length**	
		Km	**% of Total**
Upto 5%	Very Good	99.8	59.5
5 – 10%	Good	7	4.2
10 – 25%	Fair	16	9.5
25 – 50%	Poor	30	17.9
Above 50%	Very Poor	15	8.9
	Total	167.8	100

Table 4-5: Percentage of Length by Pavement Serviceability Rating

Rajkot-Ahmedabad			
Total Distress	**PSR**	**Length**	
		Km	**% of Total**
Upto 5%	Very Good	57.8	34.4
5 – 10%	Good	26	15.5
10 – 25%	Fair	59	35.2
25 – 50%	Poor	17	10.1
Above 50%	Very Poor	8	4.8
	Total	167.8	100

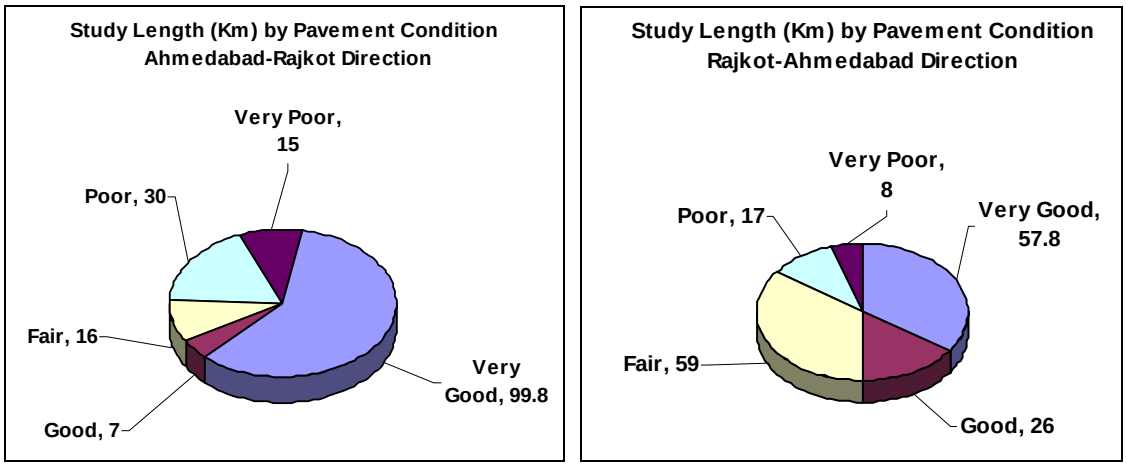


Figure 4-2: Pavement Condition by study length

[9] Pavement serviceability rating is one of the method used to rate the serviceability of the road section. PSR presents the picture of condition of road pavement and accordingly the level of service. Ministry of Road Transport & Highways, Government of India, has also given guidelines for derivation of PSR.

4.3 Riding Quality

The ride ability (an inverse of the roughness of the pavement running surface) is an important parameter for representing the functional efficiency of a road. Increasing roughness results in higher vehicle operating costs.

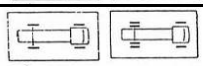
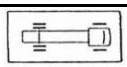
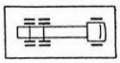
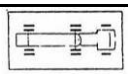
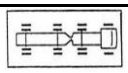
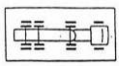
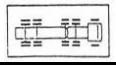
Roughness of the project corridor was measured using a response type road roughness meter, namely a Road Measurement and Data Acquisition System (ROMDAS), and the data was subsequently converted to International Roughness Index (IRI) units of m/km using standard calibration techniques. Kilometre wise IRI values for both the directions, for each traffic lanes are provided at Volume-II (Appendix-10). On and average IRI values are 3.8 and 4.1 for up and down directions respectively.

4.4 Axle Load and VDF

The Loading pattern of commercial vehicles was obtained by carrying out axle load survey and the damaging effect by extent of axle loads represented by Vehicle Damage factor (VDF) was assessed.

The axle loading pattern of commercial vehicles was assessed by conducting a 48 hours axle load survey at km 62 on the project corridor. The out come of the survey has been summarised in the Table 4-6 for different vehicle types[10].

Table 4-6: Vehicle Damage Factor by Modes

Type		Type of Vehicle	VDF
	1	Two axles single/twin tyred Mini Bus	0.58
	2	Two axles single/twin tyred LCV	0.87
	3	Two axles twin tyred Std. Bus	1.27
	4	Two axles twin tyred Truck	8.85
	5	Tandem axle twin tyred Truck	8.1
	6	3 axle twin tyred Truck	10.31
	7	Multi axle twin tyred Truck	8.13
	8	Multi axle twin tyred Truck	6.24
	9	Multi axle twin tyred Truck	7.95

4.5 Structures–Inventory and Condition

As noted earlier, the project corridor was earlier a State Highway, hence the structures on old carriageway (LHS) were constructed in 1966, and are old. When the highway was declared as a National Highway and widening of the facility was done by R&BD, GoG on one side only (RHS while

[10] The vehicles moving in both directions have been covered in the survey.

going from Ahmedabad). The structures on the RHS are therefore new. However, on the old stretch of the carriageway, looking in to the present NH loading and the traffic density, these structures will not remain serviceable for long duration. The structures have already reached nearly 80% of their design lives, assuming a 50-year life. The condition was assessed to be just tolerable as most of the structures have started showing distress. Therefore widening of existing structures does not appear to be technically feasible option. Hence, for the better service of the highway, most of the existing structures need to be replaced by new structures which are designed for NH loading. The inspection was carried out as per guidelines of IRC (SP-35: 1990) and the following aspects were documented.

The general distresses observed are:

- honeycombing, leaching, exposed and corroded reinforcement in cantilever portion of deck or at the edges of solid slab superstructure;
- lack of expansion joints or non functioning expansion joints.
- mortar less joints in masonry structures;
- railings either broken or cracked in most cases;
- cracks in return wall and abutment wall in major and minor bridges due to blockage of expansion gaps;
- longitudinal joints between concrete and masonry where widening has already been done, are not water proofed;
- settlement of approach slabs

4.5.1 Major Bridges

The project corridor has 3 major bridges. All the new bridges (RHS) are designed as RCC T-girder type of super-structure, resting on RCC/PCC sub-structure, supported by Well/Open foundation. The old (LHS) bridges are of RCC solid slab, resting on PCC sub-structure, with Well/Open type foundations. The overall width of new structures is 12.00 m and old structures nearly 8.00 m.

The condition of old bridges is poor due to distress like spalling of concrete, exposed and corroded reinforcement and honey combing in deck slab.

The drainage arrangement was assessed to be deficient in all the three structures, with the outlets of drainage spouts having been flushed away with the superstructure, leading to rusting of reinforcement. Some details of select structures are given below:

Bridge No : 66/1 (Bhogavo River Bridge)

	LHS	RHS
No of Span	134	67
Length of Span	9.15 m	18.30 m
Carriageway width	7.00 m	7.50 m & 1.50 m footpath bothside
Total width	7.90 m	12.00 m
Year of Construction	1966	2001
Type of Bridge	Submersible	High level
Recommendation	Reconstruction	RETAINED

Bridge No : 70/1 (Nalla Bridge)

	LHS	RHS
No of Span	14	7
Length of Span	9.15 m	18.30 m
Carriageway width	7.20 m	7.50 m & 1.50 m footpath bothside
Total width	8.00 m	12.00 m
Year of Construction	1966	2001
Type of Bridge	Submersible	High level
Recommendation	Reconstruction	RETAINED

Bridge No : 72/1 (Harbad River Bridge)

	LHS	RHS
No of Span	40	10
Length of Span	4.57 m	18.30 m
Carriageway width	7.60 m	7.50 m & 1.50 m footpath bothside
Total width	8.50 m	12.00 m
Year of Construction	1966	2001
Type of Bridge	High level	High level
Recommendation	Reconstruction	RETAINED

4.5.2 Minor Bridges

Out of 52 minor bridges, one at km 15/500 (two each), were over irrigation canal, 2 at km 32/600 and km 105/400 (two each) are over railroad crossings and the remaining 49 are across natural channels. The length of these structures was approximately 24.00 m.

For most of the bridges, the type of superstructure was observed to be RCC solid slab, and the sub-structures and retaining walls were of brick/stone masonry and C.C. gravity types.

The condition of most of the structures, which were constructed in the year 1966, was observed to be not good. They require reconstruction. Defects observed are spalled out concrete; exposed and corroded reinforcement in slabs. At many structures the drainage arrangement was observed to be deficient and in some structures the outlets of drainage spouts are flush with the superstructure and hence are a source for rusting of the reinforcement.

Details of one such structure at Canal Bridge (Structure No 16/3)

This bridge has three spans with 2 spans of 7.90m length and 1 span of 7.40m length with RCC solid slab resting on RCC pier and abutment. Carriageway width was of 7.60m with 1.50m wide footpath on one side.

It has been proposed that sub-structure and foundation shall be widened to same width keeping the same founding level as per existing.

4.5.3 ROB's

ROB's are located at km 32/600 at Bavla and km 105/400 near Limdi.

ROB at km 32/600 consists of single span of 13.30m length on LHS and 27.20m length on RHS. RCC T-beam deck slab type superstructure with PCC abutment was provided on both sides. LHS carriageway has a width of 7.50m and total width 8.40m. and RHS carriageway has width of 7.90m with 1.70m wide footpath on one side. On LHS the total width was of 10.35m.

ROB at km 105/400 consists of single span of 29.10m on LHS and RHS. It has skew-ness of 43 degrees. PSC T-beam deck slab type superstructure with PCC abutment was provided on both sides. The structure has carriageway of 7.60m with 1.80m wide footpath and total width of 9.90m on LHS and RHS.

4.5.4 Culverts

There are mainly two types of culverts i.e. RCC slab culvert and pipe culvert, which have been observed along this stretch. Almost all structures of two lane carriageway were widened either on one side or on both sides. Some of the old existing structures are pipe culverts but new culverts constructed are slab culverts for increasing waterway. In general the condition of pipe culverts was observed to be good, except some of them are partially choked or fully buried.

In most of the RCC slab culverts where the old structure consists of brick masonry piers and abutments, widening has been done by adding C.C. gravity type abutments, piers and retaining walls on one side. The condition of the old brick masonry and RCC slab was observed to be poor. In the RCC slab, the reinforcement was exposed and corroded. Generally, slabs have been plastered at least once without any treatment to the rusting reinforcement. As a result, the plaster has become dilapidated and the rusting of reinforcement was further aggravated. In few culverts, the old brick masonry abutments have suffered vertical and horizontal structural cracks. Reconstruction of these structures may. It is proposed that the entire culvert shall be extended to full construction width.

4.6 Soil and Material Investigations

4.6.1 Introduction

This section describes the general Geology/Geography of the Gujarat state, general soil types, specifications adopted for the construction materials that required for the Project Corridor and the methodology followed for the identification of different material sources.

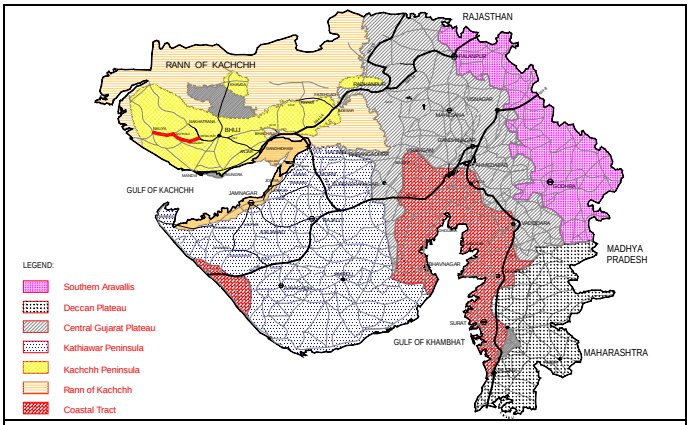
It presents the details on material investigations including existing material sources that are in use, field investigations for identification of new material sources, collection of samples, testing of samples, and identification of suitable material sources and assessment of available quantity of materials for the project corridor.

Summary of laboratory test results and strip maps showing identified material sources have been incorporated separately in the appendices to this report.

4.6.2 Geology/Geography of Gujarat

Physiographical the landforms of Gujarat can be broadly categorized into seven groups:

1. Southern Aravallis
2. Deccan Plateau
3. Central Gujarat Plateau
4. Kathiawar Peninsula
5. Kachchh Peninsula
6. Rann of Kachchh, and
7. Coastal Tract



Map 4-1: Map of Physiographic Areas

A map showing these groups is given in Map 4-1.

The Southern Aravallis occupies the northeast border area of the state and is mainly comprised of quartzite with local occurrences of granites, pegmatite, Himatnagar sandstone, basalt and marble. In general, the quartzite, granites and basalt make excellent road material; the sandstone is suitable for sub base and embankments.

The Deccan Plateau, which occupies the southeastern border area, is comprised primarily of basalt, an excellent road material.

The Central Gujarat Plateau is made up of deltaic plains and Aeolian sands. The alluvium can generally be used for embankment construction; however, many of these soils are susceptible to erosion. This can usually be controlled with suitable vegetative cover and protected channels to direct runoff to the drainage system.

The Kathiawar Peninsula is comprised primarily of basalt, often on or very near the ground surface. In the northeastern portion the older sandstone formation has not been overlain by the more recent Deccan Trap (basalt) lava flow.

The Kachchh Peninsula is dominated by a central plateau comprised primarily of sandstones and shales with a significant area of basalt and basic intrusive, providing a ready source of road construction material

The Rann of Kachchh is a flat, salt encrusted alluvial plain dotted with a few “islands” rising above the general level of the Rann. No project roads are located in this area.

The coastal tract is comprised of alluvium and sediments deposited by the major rivers of the state - the Tapi, Narmada, Mahi, Sabarmati, *etc.* Cement or lime stabilisation may be employed to improve the subgrade strength of these materials. This area includes Nal basin, which separates the central plateau from the Kathiawar peninsula is the remnant of a sea that once extended from the Gulf of Khambhat to the Rann of Kachchh.

The general soil types in the Gujarat state are classified in to seven categories (shown in Map 4-1), which are as given below:

1. Alluvial Sandy Loam
2. Alluvial Sandy Soil
3. Deep Black Soil

4. Medium Black Soil
5. Coastal Alluvial Soil
6. Saline Soil
7. Laterite Soil

4.6.3 Investigations and Findings

Review of existing data was carried out initially to assess the construction materials availability in the vicinity of the project roads keeping in view the requirements of material specifications. These reports identify significant geologic features and existing quarries. In addition, review information on the location of material sources currently utilized by the construction industry. The data were used for planning the field investigations. The entire material investigation including identification has been carried out in four phases as mentioned in the following paragraphs.

4.6.3.1 Field Investigation

Based on the review of the existing data and material sources, which are in use, have been identified. Many new locations were identified for fill materials like embankment, select sub-grade and shoulder materials with the help of local inquiry and field assessment of material properties. The quarry locations, which are identified, are in use. A rough estimate of available quantity of the fill material from all the identified borrow areas was assessed. A detailed inquiry has also been carried out for the existing quarries to estimate the likely available material from each of these quarries for this project. This includes assessment of remaining quantity in quarries, number of crushers using a particular quarry, capacity and daily output of these crushers and present supply / demand of the aggregate materials. The locations of all the material sources, which are identified for sample collection is given in Volume-II (Appendix-9).

4.6.3.2 Sample Collection

Samples collected from all the identified material sources that are already in use as well as from the new sources for conducting various tests in the laboratory. The samples for fill material are collected in gunny bags not less than 50 kg. The aggregate samples from both quarry and crusher locations are collected not less than 20 kg.

4.6.3.3 Laboratory Testing

All the samples that collected are tested for their suitability in the construction. The fill materials have been tested for classification, maximum dry density, CBR and free swell Index. The aggregate materials have been tested for grain size analysis, flakiness & elongation, specific gravity, impact and stripping test. The results for all the materials have been summarized and presented in the Volume-II (Appendix-9) to this report.

4.6.3.4 Identification of Suitable Material Sources

The suitable material sources have been identified based on the specifications set forth during the designs and laboratory test results. The available quantities from each of these sources were calculated from the information collected during the field investigations. Detailed discussions on material suitability, availability and subsequently pavement designs are provided in Section-D of this report.

5. ENVIRONMENTAL AND SOCIAL CHARACTERISTICS

5.1 Introduction

An appreciation of the environmental and social characteristics of the project corridor has been done as part of this chapter. Therefore, the chapter has been divided into two broad heads viz., environmental and social characteristics. The key environmental characteristics discussed include climate, physiography, geology, soil, landuse, water bodies, flora, fauna and the cropping pattern along the corridor. The social characteristics along the project corridor have been discussed in terms of population distribution and density, literacy levels, scheduled caste and scheduled tribes, workforce participation and economic activities. Each of these has been discussed in the subsequent sections.

5.2 Environmental Characteristics

5.2.1 Climate

The climate of the project area is hot through the months of March to June. The southwest monsoon brings a humid climate from mid-June to mid-September. During the months November to February, cold northerly winds are responsible for a mild chill in January. The relative humidity is high during the southwest monsoon season. The predominant wind direction is from West and North-West except in the months of June, July and August during which the wind direction is from South-West. The entire corridor receives an average annual rainfall of around 1000 mm during the monsoons.

5.2.2 Physiography and Terrain

The terrain is plain to gently sloping along the project corridor. The slope is less than 1^0 from Ahmedabad to Mithapur with the gradient towards Mithapur. Likewise, the gradient is towards Mithapur from Rajkot as well with the slope less than $1^{0.}$

5.2.3 Geology and Soil

Major part of the corridor from Ahmedabad to Rajkot traverses alluvium geological formation. The latter part of the project corridor passes through deformed meta-sedimentary and meta-volcanic with some portion covering basement crystalline (Figure 5-1).

The soil along the entire Project Corridor is primarily alluvium sandy loam soil and Medium Black soil. Alluvial Sandy Loam Soil is predominant in Ahmedabad district whereas medium black soil is predominant in Surendranagar District (Figure 5-2).

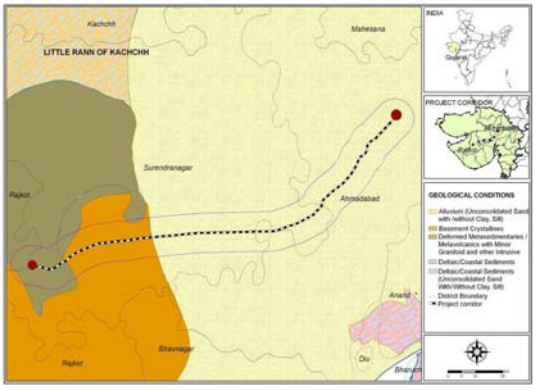


Figure 5-1: Geology

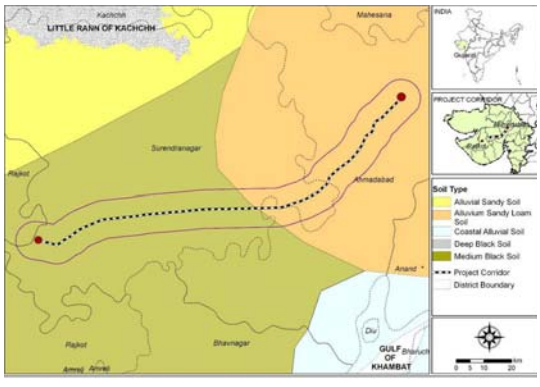


Figure 5-2: Soil

5.2.4 Land use Pattern

The land use along the corridor is predominantly agricultural with some stretches of residential and commercial use near the settlements. The proportion of barren land along the corridor is also high. Table 5-1 presents the detailed land use break-up along the project corridor.

Table 5-1: Land Use along Project Corridor

Chainage		Land use	Name of Stretch
From	To		
14+600	20+000	Commercial	Changodar
20+000	23+000	Industrial	Cheharmata
23+000	25+000	Industrial and Barren Land	Checharvadi
25+000	25+300	Barren Land	Checharvadi
25+300	25+700	Industrial	Checharvadi
25+700	26+000	Agricultural	Checharvadi
26+000	28+000	Agricultural and Industrial	Motoda
28+000	29+000	Agricultural	Motoda
29+000	29+200	Commercial	Motoda
29+200	30+700	Agricultural	Sari
30+700	31+000	Agricultural and Commercial	Sari
31+000	31+200	Barren land and Industrial	Sari
31+200	31+300	Industrial	Sari
31+300	32+000	Commercial	Sari
32+000	33+000	Commercial and Barren Land	Bavala
33+000	35+000	Commercial and Residential	Bavala
35+000	37+300	Industrial and Agricultural	Ropal
37+300	39+700	Agricultural and Barren Land	Kochariya
39+700	40+400	Industrial	Kochariya
40+400	42+600	Barren Land and Agricultural	Kerala
42+600	44+000	Agricultural, Barren Land and Residential	Dhanvada
44+000	46+000	Agricultural, Barren Land and Industrial	Dhanvada
46+000	56+100	Agricultural	Bhansara
56+100	56+400	Barren Land	Bhansara
56+400	57+100	Commercial and Residential	Bhansara
57+100	59+300	Barren	Rayka
59+300	60+400	Barren, Agricultural and Commercial	Rayka
60+400	61+600	Commercial and Residential	Rayka
61+600	65+600	Agricultural	Rayka
65+600	67+000	Barren Land	Rayka
67+000	70+900	Agricultural	Rayka
70+900	72+200	Agricultural and Barren Land	Jansali
72+200	75+800	Agricultural	Jansali
75+800	79+000	Barren Land	Devpura
79+000	83+000	Agricultural and other	Devpura
83+000	85+000	Barren Land	Devpura
85+000	100+000	Agricultural	Chorniya
100+000	102+000	Commercial and Barren Land	Chorniya
102+000	104+400	Commercial and Residential	Chorniya
104+400	105+200	Industrial and Agricultural	Chorniya
105+200	109+000	Agricultural and Barren Land	Chorniya
109+000	114+300	Agricultural	Bodiya (L)
114+400	116+000	Agricultural and Barren Land	Bodiya
116+000	128+700	Agricultural	Morvad
128+700	129+000	Agricultural and Barren Land	Morvad
129+000	130+700	Agricultural	Morvad
130+700	131+000	Agricultural, Commercial and Residential	Phulgam
131+000	135+900	Agricultural and Barren Land	Phulgam
135+900	137+700	Agricultural, Commercial and Residential	Phulgam

Chainage		Land use	Name of Stretch
From	To		
137+700	141+000	Agricultural and Barren Land	Phulgam
141+000	142+900	Agricultural	Nava Sudamda
142+900	144+000	Agricultural and Barren Land	Vakhatpur
144+000	147+000	Agricultural	Vakhatpur
147+000	150+000	Barren, Agricultural, Commercial and Residential	Doliya
150+000	155+000	Agricultural and Barren Land	Doliya
155+000	159+000	Barren, Agricultural, Commercial and Residential	Sapar
159+000	164+000	Agricultural	Magarikhada
164+000	167+000	Barren, Agricultural, Commercial and Residential	Sangahi
167+000	168+000	Barren, Agricultural, Commercial, Residential and Plantation	Sangahi
168+000	169+000	Agricultural and Commercial	Sangahi
169+000	170+600	Commercial	Chotila
170+600	172+000	Commercial, Barren land and residential	Chotila
172+000	175+500	Barren, Agricultural and Commercial	Chotila
175+500	176+200	Barren, Agricultural, Commercial and Plantation	Chotila
176+200	178+000	Commercial, Barren land and Agricultural	Chotila
178+000	180+300	Residential, Commercial and Agricultural	Boriyanesh
180+300	180+600	Barren land and Agricultural	Boriyanesh
180+600	182+000	Agricultural and Commercial	Boriyanesh

5.2.5 Water Bodies

The Bhogavo River is the one of the major surface water source of the entire corridor. In addition there are two road side ponds and canal stretches located close to the corridor and also there are two more cross drainage channels having major bridges and 51 cross drainage channels which require minor bridges. 135 culverts are present along the corridor stretch across minor water channels. Details of ponds and canals are presented in Table 5-2.

Table 5-2: Details of water bodies along the corridor

CHAINAGE		Location	Land Use		Water Body				
From	To		Left	Right	Type	Dist. from C/W edge (m)	Length along the road (m)	Left/ Right	Perennial/ Non-Perennial
22	23	Pilupara village	Industrial	Industrial	Pond	20	100	L	NP
46	47	Bhansara	Agricultural	Agricultural	Canal	10	100	R	P
61	62	Bagodara village	Agricultural	Agricultural	Pond	5	25	L	NP
47	48	Bhansara	Agricultural	Agricultural	Canal	10	1000	R	P
48	49	Bhansara	Agricultural	Agricultural	Canal	10	1000	R	P
49	50	Bhansara	Agricultural	Agricultural	Canal	10	500	R	P

Source: Field Survey, LASA, Feb, 2005

5.2.6 Flora

There is presence of forest at limited stretches along the corridor. A Protected Forest is present between chainage 175+000 and 177+000 (Table 5-3). The flora is mainly dominated by plants that flourish in semi arid climatic conditions. This includes Kikar, Babool, Neem, Casia variety and Eucalyptus. Avenue trees are practically absent in major part of the corridor. Roadside trees in Gujarat have been declared as protected forests as well. In all a total of approximately 2250 trees are present along the entire corridor (Table 5-4)

Table 5-3: Protected Forests along the Project Corridor

S. No	Chainage Details			Length (m)	District Name
	From	To	Side		
1	175+000	176+000	RHS	500	Surendranagar
2	176+000	177+000	RHS	200	Surendranagar

Source: Taluka & village maps of the Corridor and Source: Primary Survey, LASA, 2007

Table 5-4: Tree Details along the Project Corridor

S. No.	Chainage	No of Trees in the CoDI	
		LHS	RHS
1	15-25	339	10
2	25-35	291	5
3	35-45	424	40
4	45-55	95	0
5	55-65	18	10
6	65-75	0	0
7	75-85	2	0
8	85-95	2	10
9	95-105	30	40
10	105-115	64	34
11	115-125	100	40
12	125-135	27	33
13	135-145	16	30
14	145-155	41	81
15	155-165	69	118
16	165-175	45	78
17	175-182.4	142	52
Total		**1705**	**545**

Source: Primary Field Survey, LASA, 2007

5.2.7 Fauna

There is no protected wild life sanctuary within 10km from the project road. The edge of Nalsarovar Lake near Bagodara is located 27 km from the project road.

5.3 Social Characteristics

5.3.1 Population Distribution and Population Density

The project corridor traverses through 8 talukas in two districts. In Ahmedabad District, the talukas comprise Sanand, Dholka and Ahmedabad city taluka. In Surendranagar District the talukas comprise Wadhwan, Limbdi, Chuda, Sayla, and Chotila. The project corridor traverses through 40 villages, and 7 urban areas. The total population of the villages and urban areas, through which the corridor traverses is estimated to be 448627 according to Census of India, 2001. The population density is 6 of the entire project corridor. Table 5-5 shows the variation in population and density of talukas along the project corridor. Ahmedabad taluka has the highest density of 52 persons per hectare as it is an urban area. The population density is less than 10 in the rural areas.

Table 5-5: Population Distribution and Density along Project Corridor, 2001

S. No.	Taluka	District	Population			
			Male	Female	Total	Density (ppha)
1	Dholka	Ahmedabad	84875	76635	161510	7
	Sanand	Ahmedabad	8255	7514	15769	3
	Ahmedabad City	Ahmedabad	80784	74120	154904	52
2	Wadhwan	Surendranagar	5761	5413	11174	1
	Limbdi	Surendranagar	31561	29421	60982	3
	Chuda	Surendranagar	1389	1260	2649	3
	Sayla	Surendranagar	9491	8697	18188	2
	Chotila	Surendranagar	21645	19610	41255	19
Project Corridor Total			**244226**	**214313**	**448627**	**6**

Source: Census of India, 2001

The density of population in the villages has been shown in Figure 5-3. Urban Centres such as Ahmedabad, Bavla, Limbdi and Chotila have a high density of population.

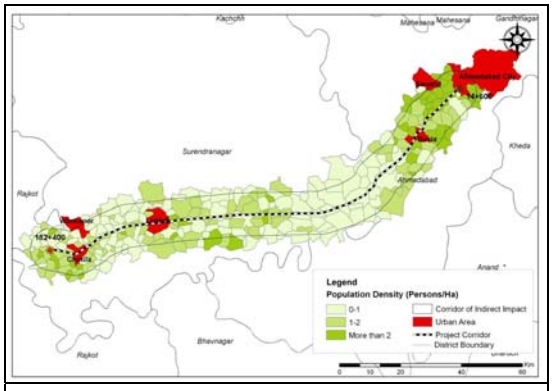


Figure 5-3: Population Density

In Ahmedabad district, the gender ratio is 907 whereas in Surendranagar district the gender ratio is 918. The gender ratio for the two districts and eight *talukas* show that Wadhwan has the highest sex ratio and Dholka records the lowest sex ratio (Table 5-6 and Figure 5-4). The proportion of scheduled tribes is not significant along the corridor. However, those of the scheduled caste are significant in number. Limbdi and Chotila have the highest proportion of the vulnerable groups with 19% of the population share followed by Dholka (Table 5-6).

Table 5-6: Social Characteristics- 2001

S.No.	Taluka	District	Sex Ratio	SC %	ST %
1	Dholka	Ahmedabad	903	11	5
	Sanand	Ahmedabad	910	14	1
	Ahmedabad City	Ahmedabad	918	7	7
2	Wadhwan	Surendranagar	940	11	0.03
	Limbdi	Surendranagar	932	16	3
	Chuda	Surendranagar	907	8	0
	Sayla	Surendranagar	916	11	0.4
	Chotila	Surendranagar	906	19	0.1
	Total		**915**	**12**	**2**

Source: Census of India, 2001

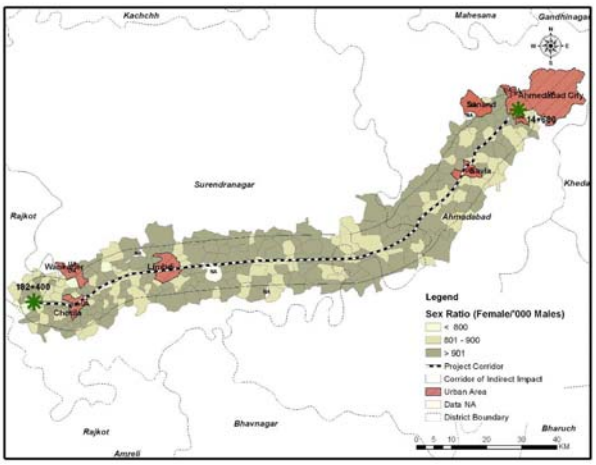


Figure 5-4: Gender Ratio

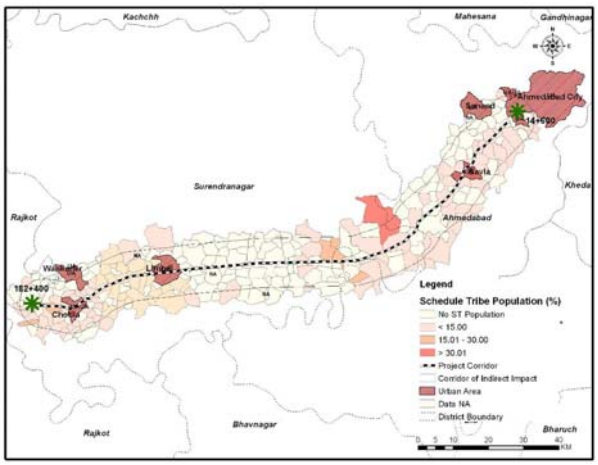


Figure 5-5: Vulnerable Population – SCs & STs

The literacy rate in the entire project area is 58%. The composition of male literates is 61% higher than the female literates. The highest share of literates is in Ahmedabad City (74%) and lowest in Chuda (34%) (Figure 5-6).

5.3.2 Workforce Participation

The average workers participation rate along the project corridor is 38% .Around 32% of the workers are Main workers while 7% are Marginal. In Wadhwan *taluka,* the participation rate is highest at 52% and lowest in Ahmedabad *taluka* at 32% (Figure 5-7). Majority of workers along the project corridor

are predominantly involved in tertiary sector activity. About 59% of the total workers are involved in tertiary sector activities as against 39% and 2% in primary and secondary sectors respectively. Majority workers in Dholka are involved in primary sector activities where as Chuda has the lowest corresponding figures. The high concentration of tertiary workers in Ahmedabad City *taluka* shows its urban character. The spatial distribution of workers has been shown in Table 5-7.

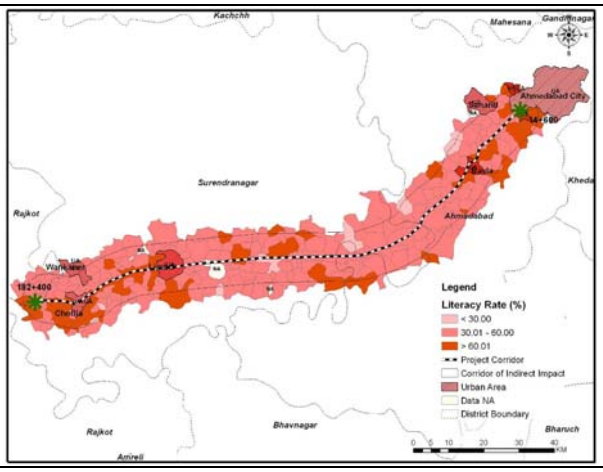


Figure 5-6: Literacy Rate

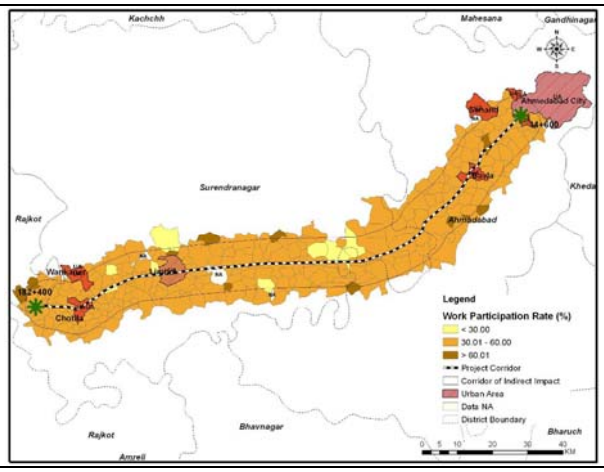


Figure 5-7: Workforce Participation

Table 5-7: Distribution of workers along Project Corridor, 2001

S. No	Taluka/District	Workers (%)			
		Total	Primary	Secondary	Tertiary
1	Dholka/Ahmedabad	70092	59	2	39
	Sanand/Ahmedabad	7485	59	3	38
	Ahmedabad City	54007	11	1	87
2	Wadhwan/Surendranagar	5766	83	4	14
	Limbdi/Surendranagar	22051	36	4	60
	Chuda/Surendranagar	1127	87	0.1	13
	Sayla/ Surendranagar	8188	49	2	49
	Chotila/ Surendranagar	14511	14	3	83
Project Total		**183585**	**71855**	**3915**	**107815**

Source: Census of India, 2001

5.3.3 Economic Activities Along Project Corridor

Along the project corridor, significant presence of industries can be seen in several stretches (Table 5-8). Several types of industries are present along the corridor including textiles, pharmaceuticals, agro foods, chemical and some petrochemical industries. Major industrial names such as Zydus Cadilla, Ramdev foods, etc are located along the corridor.

Table 5-8: Industrial Activity Along Project Corridor

Chainage		Land use	Name of Stretch
From	To		
20+000	23+000	Industrial	Cheharmata
23+000	25+000	Industrial and Barren Land	Checharvadi
25+300	25+700	Industrial	Checharvadi
26+000	28+000	Agricultural and Industrial	Motoda
31+000	31+200	Barren land and Industrial	Sari
31+200	31+300	Industrial	Sari
35+000	37+300	Industrial and Agricultural	Ropal
39+700	40+400	Industrial	Kochariya
104+400	105+200	Industrial and Agricultural	Chorniya

Nearly 67% of the corridor passes through agricultural land. The project corridor primarily passes through the central cotton belt of the state. Other crops grown in the region are ground nut and jowar. The eastern half of the corridor passes through irrigated agricultural lands.

6. SAFETY ASPECTS

6.1 Road Safety[11] Related Aspects – Some Insights and Deficiency Analysis

The project corridor is a National Highway. Since it was earlier a State Highway, it was developed as one, due to which a number of aspects which were to be considered in design for a NH, have been overlooked. Even when it was widened, the widening work was done parallel to the existing alignment, resulting in retaining of sharp curves etc along the road. Over time a number of industries and economic centres have come up along the corridor. These also generated substantial traffic. However, proper approaches for the traffic joining the main carriageway is missing, resuting in safety hazards. This has lead to a number of accidents which are happening on the road, as can be seen in the photographs. Probable reasons[12] for accidents, along with the type and condition of the safety features, are presented below:

Accident due to Mechanical Fault

Accident Occurred due to median opening

[11] . A road safety audit is a formal safety performance examination of an existing or future road or intersection by an independent audit team. Road safety audits can be used in any phase of project development from planning and preliminary engineering, design and construction.

[12] . Reducing the number of accidents requires sustained actions on a number of "fronts'" covering traditional areas of Engineering and Environment, Enforcement and Emergency services. This multi-faceted approach recognizes the fact that traffic accidents are rarely the result of a single cause or factor. The contributory factors in traffic accidents can be broadly categorized into Human Factors, Road and Environment factors and Vehicle Factors.

There are a number of reasons due to which accidents occur on the project corridor. The main reason is the increase in the number of motor vehicles on the road, which has lead to this major social problem[13]. The loss of lives and serious economic loss caused by the road accidents demand the attention of society and call for a solution to the problem. A multi- disciplinary approach is needed in understanding the problem and providing solutions. For this a road safety audit has been undertaken. Reasons for accidents have been identified, and solutions for overcoming these shortcomings have been suggested.

6.2 Road Safety Audit Review and Considerations

6.2.1 Focus

In this section a review of road safety audit carried out on the project corridor to examine the existing roadway, by an independent audit team, focusing solely on issues related to safety are discussed.

6.2.2 Review of Road Safety Audit

RSA is conducted by considering a broad checklist to identify issues and problems. The checklist considered all the factors to provide a reminder of potentially overlooked safety issues. Potential safety issues to be considered during a field review are:

- Roadside features,
- Road surface conditions,
- Pavement markings
- Signing and delineation,
- Intersections and approaches,
- Bridge structures,
- Consistency of design parameters.

6.2.2.1 Highway Deficiency

A highway deficiency inventory, including bridge and pavement sufficiency was prepared using available data. Locations that do not meet standards for horizontal alignment as per guidelines[14] for design of horizontal curves for Highways, have been identified along the full length of the project corridor. From the preliminary assessment it is observed that the design speed for the corridor is 80-100 kmph which drops down marginally at curves, especially at 'S' curves, from 80 to 65 kmph. These locations need to meet the design standards laid down for a speed of 80 kmph. But there are a number of locations on the corridor where the design deficiency has been felt.

The presents the details of the horizontal curves that do not meet the design standards specified for design speed of 80 kmph.

Table 6-1: Deficient horizontal Curves

Station	Radius (m)	Spiral Length (m)	Spiral Length Required(m)
60+300	200	40	110
108+600	350	60	63
109+400	200	80	110

[13]The accident situation in India is more serious because of the rapid growth of vehicles in past few years and the inadequacy of many of our roads and streets to cope with such traffic.
[14] IRC – 38.

Station	Radius (m)	Spiral Length (m)	Spiral Length Required(m)
134+000	280	75	79
158+000	360	60	61
173+500	250	50	88
174+000	200	75	110
178+400	220	85	100
178+700	400	25	55
179+400	275	15	80

6.2.2.2 Bridges

The inventory and condition of the bridges and culverts reveal that three major bridges, which are very old on the LHS from Ahmedabad to Rajkot are very poor in condition. There is a likelihood of their giving in to the traffic load, for which it is not designed. Therefore there is a need to reconstruct these bridges.

6.2.2.3 Road Marking and Road signs

About 125 km of the project corridor has poor road markings. The audit also reveals that there is necessity of proper road markings, which will help avoid a number of accidents. The tables below present the condition of road marking, on the project corridor.

Table 6-2: Condition of the Road Marking

Standards	Length in Km			Total Length in Km
	Good	Fair	Poor	
Overall Condition of Road Marking	8	121	38.8	167.8
Lane Marking	11	126.8	30	167.8
Edgeline	6	36.8	125	167.8

Table 6-3: Necessity of Marking on Curves

Standards on curves	Required at Number of Curves
Curve Warning and delineation	54
Guide posts and reflections	51

Table 6-4: Necessity of Road Signages

Standards	Required at Number of Locations
Informatory Signs	87
Directional Signs	161
Mandatory/Regulatory	20
Cautionary / Warning Signs	60

6.2.2.4 Intersections

The intersection audit for safety at selected major intersection reveals that there is requirement of speed reduction and necessity of improving the lighting at the intersection. The following Table 6-5 presents the observations made on selected intersections:

Table 6-5: Remarks at the Selected Intersection:

Standards at Intersection	Location of Intersection				
	31+500 31+800	56+300	57+300	60+000	61+200
Visibility (both entering and exiting)	Fair	Fair	Fair	Fair	Fair
Speed Limit / Speed Control	Required	Required	Required	Required	Required
Lighting Condition	Poor	Poor	Poor	Poor	Poor
Signs marking correctness and visibility	Poor	Poor	Poor	Poor	Poor
Road Marking Condition	Fair	Poor	Poor	Poor	Poor

6.2.2.5 RSA in Urban Area and at Toll Plaza

The RSA in urban areas reveals the following:

- Lack of visibility due to thick vegetation on the median
- Unsafe manoeuvring from access driveways
- Lack of speed control

The RSA at toll plaza reveals the following:

- Lack of lighting
- Lack of speed control
- Requirement of road signs
- Requirement of Road Marking

Table 6-6 presents these concerns by location.

Table 6-6: Safety Condition in Urban and Toll Plaza area

Standards	Urban Area				Toll Plaza Location	
Location	**Km 19-Km20**	**Km 32-Km34**	**Km 101.7 to Km 102.4**	**Km 168.7 to Km 170.6**	**Km 182.4**	**Km 63.2**
Visibility (both entering and exiting)	Fair	Fair	Fair	Poor	Fair	Fair
Speed Limit / Speed Control	Required	Required	Required	Required	Required	Required
Lighting Condition	Poor	Poor	Poor	Poor	Fair	Fair
Signs marking correctness and visibility	Poor	Poor	Poor	Poor	Poor	Poor
Road Marking Condition	Poor	Fair	Poor	Poor	Poor	Poor

6.2.3 Recommended Improvement Measures

Based on the RSA, the recommendations made for improving safety on the project corridor, are as follows:

- Remove sight distance obstructions
- Add turn lanes,
- Add illumination,
- Install median barriers where ever necessary,
- Consider pedestrian movement,
- Improve to super-elevation,
- Modify the roadway shoulders and lane widths,
- Manage driveway access, and
- Realign the approaches at intersections.

The following are the improvements considered while designing the highway for the proposed option in this study:

- Construction of new bridges replacing the old bridges with poor condition
- Elimination of spiral curves, and design to fit in a simple curve
- Maintaining super-elevation to achieve the design speed
- Improvement of minor junctions
- Limited access points by restricting median opening
- Provision of flyovers as grade separators at major intersections and
- Proper plan for road furniture

All these recommendations have been considered and accounted for at the time of designing the project corridor.

SECTION C: PROJECT IMPROVEMENT OPTIONS AND ASSESSMENT

7. TRAFFIC FORECAST

7.1 Forecasting Traffic – Methods and Inputs

The future traffic demand on the project corridor was assessed.[15] The traffic forecast was undertaken using the following three approaches:

- Trend based traffic forecast;
- Econometric method; and
- Consumption and Mobility Rate (CAM) Method

The first two methods adopt the traffic growth rates which have been derived (by us in) recently completed study for GoG, R&BD on the "Updated Strategic Options Study for the Core Road Network of Gujarat". The last of the three methods has been developed in the course of the present project. A brief on the derivation of each of the above stated methods of traffic forecast has been presented below in the ensuing sections and paragraphs.

7.1.1 Mapping Gujarat Growth & Economy[16]

Traffic is derived demand. Traffic flows on road system are resultant of several externalities. Based on study of several documents on Gujarat economy[17], a macro assessment of likely growth scenario is made by regions and sectors of economy of Gujarat.

In order to assess the development potential of the state, it has been divided into five regions North Gujarat, Central Gujarat, South Gujarat, Kutchh and Saurashtra. The classification has been done on the basis of the common characteristics shared by the five regions.

Region	Districts
North Gujarat	Mehasana, Patan, Banaskantha, Sabarkantha
South Gujarat	Surat, Valsad, Dangs, Navasari, Bharuch, Narmada
Saurashtra	Jamnagar, Probandar, Rajkot, Junagarh, Amreli, Bhavnagar, Sundranagar
Central Gujarat	Ahmedabad, Gandhinagar, Anand, Kheda, Panchmahal, Dahod, Vadodara
Kutchh	Kutchh Districts

The potentials/strengths by each of the region, and committed/planned investment till 2020 have been presented in brief below:

North Gujarat

- Rich in agriculture
- Potential for industrial development
- Proposed investment in Mehasana and Sabarkantha between 2005 to 2020 in areas of agro-based, textiles and pharmaceuticals industry.

[15] . It is being assessed from the perspective of the state as a whole. This is because the corridor is a National Highway, which is likely to cater to the mobility needs of the country in general and state in particular.

[16] The write-up has been taken from our earlier study, "Strategic Options Study for the Core Road Network of Gujarat". The forecast of the economy and the population had been undertaken considering the future plans and programs of the government, therefore it has been found appropriate for use in the present study. It even incorporates the proposed investments in the state by regions.

[17] This includes Five Year Plans, Socio-Economic Reviews and Vision – 2020

South Gujarat

- Industrialized region
- Incomes of people high
- Good infrastructure, water supply, manpower, power, road rail and ports
- SEZ proposed at Dahej and Hazira
- Investment planned in areas of textile, gems and jewellery, chemicals, pharmaceuticals, agro based industry etc.

Saurashtra

- Rich in agriculture
- Industrial development suffered due to water storage
- Narmada water to be available for irrigation
- Availability of Jetties, ports, fishing harbours
- Projects likely to come to make the region centre of marine excellence, agro-parks to ensure value addition to agriculture
- Proposed/committed investment in textiles, agro, auto mobiles, gems and jewellery, chemicals etc.

Central Gujarat

- Rich in cotton production
- A number of pharmaceuticals units are present in central Gujarat
- Investment of more than Rs. 5000 crores towards knowledge corridor
- Development of Sabarmati river for tourism
- Committed/Proposed investment in textiles, apparel, gems and jewellery, biotechnology, pharmaceuticals, auto – mobiles, etc.

Kutchh

- Rich in culture and crafts
- Committed investment of Rs 126 crores to develop Kutchh adventure trail
- Mundra port and SEZ
- Chemical park planned in Bhuj
- Committed/Planned investment in agro-based and apparel industries

Given the strength of each of the region, along with the committed/planned investments, it is expected that the development in the state of Gujarat will be more balanced in future, with each of the sectors growing fairly at the same rate.

7.1.2 Projected Development of State

Each of the regions, have their own strengths and weaknesses, as already discussed. An attempt has been made to understand the growth scenario of each of the region. For this, the only available data on income, by district, and by some of the sectors was the one compiled by Department of Economics and Statistics, Gandhinagar, in the form of Net Value Addition, and not the total income[18]. This data has formed the basis for the forecasts by region. It has been compiled to arrive at the region wise income growth by three sub-sectors - agriculture, industry and tertiary.

[18] Net Value Added is the increment to the value of goods and services that is contributed by the sector and is obtained by deducting the value of total inputs and depreciation from the value of output.

Table 7-1: Trends in Regional Income Growth

Region	Year	Growth Rate of Net Value Added (%)				Sectoral Contribution to Region (%)			Regional Contribution to State (%)
		Agriculture	Industry	Tertiary	Total	Agriculture	Industry	Tertiary	
South	1971					35.4%	17.7%	46.9%	14.4%
	1981	5.46%	10.31%	1.85	5.1%	36.8%	28.8%	34.4%	16.7%
	1991	6.07%	10.56%	7.49	8.0%	30.7%	36.4%	32.8%	21.2%
	1996	-3.82%	8.99%	6.52	4.8%	20.0%	44.4%	35.6%	20.6%
Central	1971	-	-	-	-	33.0%	15.8%	51.2%	33.3%
	1981	1.59%	12.48%	2.02	4.3%	25.4%	33.6%	41.0%	35.9%
	1991	2.07%	9.08%	6.96%	6.7%	16.3%	41.8%	14.9	40.5%
	1996	4.01%	3.42%	6.82%	5.0%	15.5%	38.8%	15.7	39.6%
North	1971					56.8%	2.8%	40.4	14.5%
	1981	2.49%	11.79%	1.00%	2.3%	57.8%	6.7%	35.5%	12.9%
	1991	-1.69%	14.54%	7.11%	3.8%	33.5%	18.0%	48.5%	11.0%
	1996	8.98%	7.96%	5.62%	7.2%	36.4%	18.65	45.0%	12.0%
Saurashtra	1971	-	-	-	-	51.7%	6.9%	41.4%	33.0%
	1981	2.22%	15.34%	0.25%	3.1%	47.5%	21.2%	31.3%	31.7%
	1991	-1.37%	4.52%	6.01%	2.7%	31.7%	25.3%	43.0%	24.3%
	1996	7.69%	6.57%	4.71%	6.28%	34.0%	25.8%	40.2%	25.1%
Kutchh	1971					59.8%	2.7%	37.6%	4.9%
	1981	-5.27%	11.21%	0.09%	-2.2%	43.3%	9.6%	47.2%	2.8%
	1991	3.71%	10.65%	7.12%	6.2%	34.2%	14.4%	51.4%	3.08%
	1996	-1.28%	5.69%	4.79%	3.0%	27.6%	16.4%	56.0%	2.7%
Total Gujarat	1971	-	-	-	-	44.3%	10.6%	45.1%	
	1981	2.19%	12.65%	1.27%	3.5%	39.0%	24.7%	36.3%	
	1991	1.09%	8.61%	6.82%	5.5%	25.5%	33.2%	41.3%	
	1996	4.08%	5.71%	6.02%	5.4%	23.9%	33.6%	42.4%	

Although the trends are those for the growth in net value addition, we understand that they will not be different from those of the State Domestic Product, as we are talking of growth rates only and not the absolute values. Since agriculture is the major contributor to primary sector and industry to secondary sector, working on the share of each sector, at the regional level income contribution, will not be much off the real scenario.

At the state level, the sectoral contribution to NSDP has been observed to be as given in Table 7-2.

Table 7-2: Sectoral Contribution to State Income (% of total NSDP)

Year	Primary	Secondary	Tertiary
1999	28.1	31.6	40.3
1998	27.7	31.8	40.5
1999	19.8	35.4	44.7
2000	18.3	33.7	48.0
2001	21.5	31.1	47.5
2002	17.0	36.6	46.4
2003	24.0	32.9	43.0

The contribution of the sectors, which has been taken forward from here, along with the sectoral growth as well as the NSDP growth, as assumed for the future is presented in Table 7-3.

Table 7-3: Projected Sectoral Contribution and Growth

Year	NSDP Growth (% pa)	Sectoral Growth (%)				Sectoral Contribution (%)		
		Primary	Secondary	Tertiary	Year	Primary	Secondary	Tertiary
2003-06	10	4.3	12.3	11.2	2003	24.0	32.9	43.1
2006-10	11.5	4.8	13.1	13.0	2203	20.5	35.0	44.5
2010-15	12.0	5.7	13.2	12.9	2010	16.0	37.0	47.0
2015-20	10.5	5.5	11.1	11.2	2015	12.0	39.0	49.0
2020-25	8.0	4.4	8.0	8.6	2020	9.5	40.0	50.5
Overall	10.4				2025	8.0	40.0	52.0

The above presented growth scenario in based on the state level policies and plans. The Eleventh Five Year Plan targets a growth rate of 9.3% for India. It follows from it that Gujarat needs to grow at

a much higher rate to sustain this growth target for the country. Therefore, a growth rate between 11.4% and 12.0% has been taken to cover the 11th Plan Period.

In order to distribute the growth rate across the region, the regional contribution to the state has been projected as follows:

Table 7-4: Regional Contribution to State Income (%)

Region	Contribution to state income		
	1996	2006	2025
North Gujarat	12.0	11.5	10.0
Central Gujarat	39.6	39.6	40.0
South Gujarat	20.6	20.5	20.0
Saurashtra	25.1	25.7	27.3
Kutchh	2.7	2.7	2.7

With all these above inputs, the income growth rates by region and by sector have been estimated as given in Table 7-5.

Table 7-5: Income Growth Rates by Region (%)

Region	Years / Sector	2006-2010	2010-2015	2015-2020	2020-2015	Overall
North Gujarat	Primary	5.85	6.99	6.65	5.3	6.21
	Secondary	11.21	11.32	9.49	6.87	9.63
	Tertiary	12.74	12.64	10.91	8.44	11.09
	Total	10.42	10.99	9.74	7.55	9.63
Central Gujarat	Primary	3.17	3.78	3.6	2.87	3.36
	Secondary	12.97	13.1	10.99	7.95	11.14
	Tertiary	12.69	12.6	10.87	8.41	11.05
	Total	11.7	12.09	10.51	7.97	10.49
South Gujarat	Primary	4.06	4.86	4.62	3.68	4.32
	Secondary	12.96	13.08	10.97	7.94	11.13
	Tertiary	12.52	12.42	10.73	8.29	10.9
	Total	11.42	11.88	10.34	7.8	10.29
Saurashtra	Primary	5.49	6.57	6.24	4.98	5.84
	Secondary	13.85	13.98	11.73	8.48	11.89
	Tertiary	14.01	13.91	12	9.28	12.19
	Total	11.63	12..35	10.95	8.43	10.79
Kutchh	Primary	4.59	5.49	5.22	4.16	4.88
	Secondary	13.67	13.8	11.58	8.38	11.74
	Tertiary	13.09	12.99	11.22	8.67	11.4
	Total	11.35	11.92	10.55	8.14	10.44

7.1.3 Population Projection

The past trend in population growth, by each district has been observed. Region level population growth trends have been estimated. Based on the past growth trends, and the projection made by the census department, the regional level population projections have been made as given in Table 7-6.

Table 7-6: Population Growth by Region

Region / Years	North Gujarat	Central Gujarat	South Gujarat	Saurashtra	Kutchh	Gujarat
2006-2010	1.57	1.78	2.35	1.56	1.99	1.86
2010-2015	1.40	1.59	2.12	1.39	1.77	1.66
2015-2020	1.38	1.56	2.11	1.37	1.73	1.65
2020-2025	1.37	1.55	2.11	1.36	1.71	1.64

7.1.4 Per Capita Income

Having arrived at the income growth rates and population growth rates, the per capita income growth rate by each region and for Gujarat as a whole has been estimated.

Table 7-7: Growth of Percapita Income by Region

Region / Years	North Gujarat	Central Gujarat	South Gujarat	Saurashtra	Kutchh	Gujarat
2006-2010	8.57	9.59	8.66	9.77	8.99	9.44
2010-2015	9.31	10.17	9.35	10.66	9.78	10.16
2015-2020	8.22	8.79	8.04	9.43	8.63	8.72
2020-2025	6.10	6.32	5.58	6.98	6.32	6.27

7.1.5 Assessment of Elasticity Values

The elasticity values derived by region[19] and mode were further taken up to year 2025 based on our judgment. As the grouping of modes in deriving elasticity values was dependent on the past data, by assuming factors for other modes[20], the classificatory mode-wise and period-wise elasticity values by region were evolved. The same are presented in Table 7-8 and Table 7-9, respectively.

Table 7-8: Elasticity by Mode (Grouped Vehicle Type) and by Region

Mode		Cars/Jeeps (3-wheeler)	Buses	Trucks	Motor Cycles
North Gujarat	2006-10	1.15	0.65	1.17	1.7
	2010-15	1.1	0.65	1.1	1.5
	2015-20	1.05	0.6	1.1	1.3
	2020-25	1	0.6	1	1.1
Central Gujarat	2006-10	1.5	0.72	1.17	1.8
	2010-15	1.4	0.72	1.17	1.6
	2015-20	1.3	0.7	1.1	1.4
	2020-25	1.2	0.7	1.1	1.1
South Gujarat	2006-10	1.5	0.9	1	1.8
	2010-15	1.4	0.85	0.9	1.6
	2015-20	1.2	0.75	0.9	1.4
	2020-25	1.1	0.75	0.9	1.1
Saurashtra	2006-10	1.3	0.9	0.81	1
	2010-15	1.2	0.85	0.8	1
	2015-20	1.1	0.75	0.75	1
	2020-25	1	0.75	0.75	1
Kutchh	2006-10	1.15	0.72	1.1	1.2
	2010-15	1.1	0.72	1.1	1.2
	2015-20	1.15	0.8	1.05	1.15
	2020-25	1.15	0.8	1.05	1.15

Table 7-9: Elasticity by each Mode and by Region

Mode	Factor	North Gujarat				Central Gujarat				South Gujarat				Saurashtra				Kutchh			
		2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25
Scooter/Motor Cycle	1.0 of MC/Sc	1.7	1.5	1.3	1.1	1.8	1.6	1.4	1.1	1.8	1.6	1.4	1.1	1	1	1	1	1.2	1.2	1.2	1.2
Auto Rickshaw/ Chakda	0.8 of Car	0.9	0.9	0.8	0.8	1.2	1.1	1	1	1.2	1.1	1	0.9	1	1	0.9	0.8	0.9	0.9	0.9	0.9
Car/Jeep (OT)	0.7 of Car	0.8	0.8	0.7	0.7	1.1	1	0.9	0.8	1.1	1	0.8	0.8	0.9	0.8	0.8	0.7	0.8	0.8	0.8	0.8
Car/Jeep (NT)	1.0 of Car	1.2	1.1	1.1	1	1.5	1.1	1.3	1.2	1.5	1.4	1.2	1.1	1.3	1.2	1.1	1	1.2	1.1	1.2	1.2
Mini Bus	0.7 of Bus	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6
Standard Bus	1.0 of Bus	0.7	0.7	0.6	0.6	0.7	0.7	0.7	0.7	0.9	0.9	0.8	0.8	0.9	0.9	0.8	0.8	0.7	0.7	0.8	0.8
Tempo/LCV	0.8 of Truck	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.9	0.9	0.8	0.8

[19] In the study on the Strategic Options Study, an effort was made to assess elasticity values. R&BD gave access to extensive time series data base. This data provided an opportunity to explore and determine region wise and mode wise elasticity values.

[20] Insight to the growth of registered vehicles by region also formed an input in fixing up the factors.

Mode	Factor	North Gujarat				Central Gujarat				South Gujarat				Saurashtra				Kutchh			
		2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25	2006-10	2010-15	2015-20	2020-25
2-Axle Truck	1.0 of Truck	1.2	1.1	1.1	1	1.2	1.2	1.1	1.1	1	0.9	0.9	0.9	0.8	0.8	0.8	0.8	1.1	1.1	1.1	1.1
3-Axle Truck	1.1 of Truck	1.3	1.2	1.2	1.1	1.3	1.3	1.2	1.2	1.1	1	1	1	0.9	0.9	0.8	0.8	1.2	1.2	1.2	1.2
MAV	1.2 of Truck	1.4	1.3	1.3	1.2	1.4	1.4	1.3	1.3	1.2	1.1	1.1	1.1	1	1	0.9	0.9	1.3	1.3	1.3	1.3
Tractor with Trailor	0.6 of Truck	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.6	0.6
Tractor without Trailor	0.6 of Truck	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.6	0.6
Cycle	0.4 of Car	0.5	0.4	0.4	0.4	0.6	0.5	0.5	0.5	0.6	0.6	0.5	0.4	0.5	0.5	0.4	0.4	0.5	0.4	0.5	0.5
Cycle Rickshaw	0.1 of Car	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Animal Drawn	0.1 of Car	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Others	0.5 of Car	0.6	0.6	0.5	0.5	0.8	0.7	0.6	0.6	0.8	0.7	0.6	0.6	0.7	0.6	0.5	0.5	0.6	0.6	0.6	0.6

7.2 Traffic Forecast

As already mentioned, the forecast of likely traffic levels by each of the homogeneous links falling along the project corridor have been done by using the following three methods:

- Trend Based Method;
- Econometric Method; and
- CAM Method

7.2.1 Trend Based Traffic Forecast

The trend based traffic forecast had been undertaken based on the observations made on the past traffic growth rates. At the time of the Strategic Options Study, a time series data on traffic on various roads across the state were compiled. Using this, past trend in the traffic growth by each of the five regions in the state were then derived. These derived growth rates were then moderated to arrive at the following growth rates of traffic, by region and mode presented in Table 7-10.

Table 7-10: Trend Based Growth Rate by Group of Modes and Region (in percentage)

Regions	Years	Mode			
		Cars/Jeeps, 3-wheeler	Buses	Trucks	Motor Cycles
North Gujarat	2006-10	4	3.6	6.5	6
	2010-15	5	3.5	6.5	5.5
	2015-20	5	3	6	5
	2020-25	5	3	6	5
South Gujarat	2006-10	7	5	5.5	7
	2010-15	7	4.5	6	6
	2015-20	7	4	6	5.5
	2020-25	7	4	6	5
Central Gujarat	2006-10	6	4	6.5	8
	2010-15	6	3.5	6.5	7
	2015-20	6	3	6	6
	2020-25	5	3	6	5
Saurashtra	2006-10	5	5	4.5	3
	2010-15	6	4	5	4
	2015-20	6	3.5	6	4.5
	2020-25	7	3.5	6	5
Kutchchh	2006-10	6	4	6	5
	2010-15	6.5	3.5	6	5
	2015-20	7	3	6	5
	2020-25	7	3	6	5
Gujarat	2006-10	6	4	6.5	6
	2010-15	6	4	6.5	6
	2015-20	6	4	6.5	6
	2020-25	6	4	6	6
India	2006-10	6	4	6.5	6
	2010-15	6	4	6.5	6
	2015-20	6	4	6	6
	2020-25	6	4	6	6

Since the trend based growth rates were derived from the level of traffic observed on various roads, it has been applied similarly, i.e., the traffic on a section of project corridor falling in a certain region, is expected to experience the growth rate as observed in the past in that region. Therefore, for the present study, the growth rates as projected for the regions of Saurashtra and Central Gujarat were extracted for our earlier study, for use herein. These have been given in Table 7-11.

Table 7-11: Trend Based Growth Rates by each Mode[21]

Region / Mode	Central Gujarat							Saurashtra						
	2006-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40	2006-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
Scooter/Motor Cycle	8.0	7.0	6.0	5.0	4.0	4.0	3.0	3.0	4.0	4.5	5.0	4.5	4	4
Auto Rickshaw/ Chakda	4.2	4.2	4.2	3.5	3.5	3.2	3.2	3.5	4.2	4.2	4.9	4.5	4	4
Car/ Jeep (OT)	4.2	4.2	4.2	3.5	3.5	3.2	3.2	3.5	4.2	4.2	4.9	4.5	4	4
Car/ Jeep (NT)	6.0	6.0	6.0	5.0	5.0	4.5	4.5	5.0	6.0	6.0	7.0	6.5	6	5.5
Mini Bus	2.8	2.5	2.1	2.1	2.0	2.0	1.8	3.5	2.8	2.5	2.5	2	2	2
Standard Bus	4.0	3.5	3.0	3.0	2.8	2.8	2.5	5.0	4.0	3.5	3.5	3	2.5	2.5
Tempo/ LCV	5.2	5.2	4.8	4.8	4.4	4.4	4.4	3.6	4.0	4.8	4.8	4.5	4	4
2-Axle Truck	6.5	6.5	6.0	6.0	5.5	5.5	5.5	4.5	5.0	6.0	6.0	5.5	5	5
3-Axle Truck	7.2	7.2	6.6	6.6	6.1	6.1	6.1	5.0	5.5	6.6	6.6	6	5.5	5.5
MAV	7.8	7.8	7.2	7.2	6.6	6.6	6.6	5.4	6.0	7.2	7.2	7	6.5	6
Tractor with Trailer	3.9	3.9	3.6	3.6	3.3	3.3	3.3	0.6	0.6	3.6	3.6	3	3	2.5
Tractor without Trailer	3.9	3.9	3.6	3.6	3.3	3.3	3.3	0.6	0.6	3.6	3.6	3	3	2.5
Cycle	2.4	2.4	2.4	2.0	2.0	1.8	1.8	2.0	2.4	2.4	2.8	2	2	1.5
Cycle Rickshaw	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.5	0.5
Animal Drawn	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.5	0.5
Others	3.0	3.0	3.0	2.5	2.5	2.3	2.3	2.5	3.0	3.0	3.5	3	2.5	2.5

Since km 17, km 42, km 63.2 and km 104 locations fall in Central Gujarat, growth rates of Central Gujarat has been applied on the base year traffic of these two locations. However, for traffic at km 182, which falls in Saurashtra region, the growth rates of Saurashtra region are applied. Based on the above stated growth rates, the forecasted traffic by each of the homogeneous traffic section are given in Table 7-12. The detailed statement on projected traffic has been given in Volume-II (Appendix-7).

Table 7-12: Projected Traffic using Trend Method

Location	Mode	2007	2010	2015	2020	2025	2030	2035	2040
Total Traffic (in Vehicles)									
km 17	Passenger	24564	29168	38241	49290	61236	74632	90119	106649
	Goods	12217	14689	20003	26665	35601	46495	60799	79601
	Total[22]	**37685**	**44824**	**59325**	**77164**	**98167**	**122589**	**152510**	**187986**
km 42	Passenger	6420	7560	9805	12552	15539	18980	22936	27314
	Goods	4709	5674	7752	10366	13882	18179	23836	31289
	Total	**11333**	**13452**	**17803**	**23194**	**29725**	**37495**	**47138**	**59004**
km 63.2	Passenger	5948	7036	9234	12024	15074	18758	22977	27926
	Goods	6167	7487	10355	13996	18937	25024	33097	43809
	Total	**12169**	**14581**	**19653**	**26091**	**34089**	**43870**	**56169**	**71838**
km 104	Passenger	6728	7982	10492	13631	17049	21063	25679	30910
	Goods	6517	7882	10838	14577	19638	25859	34093	45001
	Total	**13625**	**16272**	**21791**	**28728**	**37262**	**47559**	**60470**	**76677**
km 182	Passenger	8190	9297	11852	15159	20128	26226	33510	42329
	Goods	6744	7711	9886	13333	18005	23795	30749	39647
	Total	**15003**	**17081**	**21821**	**28588**	**38244**	**50148**	**64402**	**82135**

[21] Since the growth rates derived in the earlier study were only up to 2025, they have been extended up to 2040 by moderating them for the future years.

[22] . The Total Volume is inclusive of NMT, etc. Here above the passenger and goods traffic reported is exclusive motorized traffic.

Location	Mode	2007	2010	2015	2020	2025	2030	2035	2040
Total Traffic (in PCUs)									
km 17		60376	71643	95052	124091	160849	205116	261517	333151
km 42		21754	25854	34405	45029	58714	75331	96687	124157
km 63.2		25725	30936	42043	56115	74546	97263	126781	165412
km 104		27693	33159	44762	59402	78493	101924	132326	171978
km 182		29262	33519	42929	56913	76325	100352	129242	165647

7.2.2 Econometric Method

Econometric Method is another classical way of forecasting the traffic on highways. IRC suggests, this is followed for forecasting traffic. This method is data hungry if one were to follow the IRC process. Access to exhaustive traffic data of Gujarat on its state roads is used to develop relationships and adopt the same approach. This method draws upon the growth rates derived in the Strategic Options Study of the Core Road Network in Gujarat, based on detailed and exhaustive study of economy and traffic.

In the Econometric method, as already explained, the elasticity values and economy related parameters, by region and mode, were applied to derive the likely traffic growth rates. This method resulted in traffic growth by each region in the state of Gujarat as well as at the all India level, and by each mode over a time frame of 30 years. The growth rates as adopted from the Strategic Options Study have been given at Volume-II (Appendix-7).

Since the growth rates derived reflected the growth of the various sectors within that region, these growth rates were expected to be applied to the trip productions only. The finally arrived at growth rate was the weighted average growth rates across the varying levels of traffic getting produced at different points. The summary on the projected total traffic has been given in Table 7-13. The detailed mode-wise and year-wise traffic has been presented in Volume-II (Appendix-7).

Table 7-13: Projected Traffic using Econometric Method

Location	Mode	2007	2010	2015	2020	2025	2030	2035	2040
Total Traffic (in Vehicles)									
km 17	Passenger	24564	30533	43456	58024	70482	84186	99240	117036
	Goods	12217	15273	22819	32229	41955	54440	70377	91195
	Total[23]	**37685**	**46800**	**67433**	**91567**	**113875**	**140169**	**171274**	**210011**
km 42	Passenger	6420	7889	11059	14621	17732	21229	25168	29853
	Goods	4709	5909	8883	12612	16481	21464	27858	36242
	Total	**11333**	**14023**	**20206**	**27534**	**34542**	**43048**	**53408**	**66505**
km 63.2	Passenger	5948	7339	10371	13814	16924	20568	24830	29962
	Goods	6167	7758	11688	16661	21911	28730	37542	49124
	Total	**12169**	**15155**	**22125**	**30548**	**38915**	**49384**	**62465**	**79185**
km 104	Passenger	6728	8236	11509	15207	18515	22320	26676	31851
	Goods	6517	8157	12200	17275	22600	29488	38392	50093
	Total	**13625**	**16812**	**24201**	**33043**	**41732**	**52474**	**65785**	**82719**
km 182	Passenger	8190	9984	13872	18264	22226	26807	32079	38339
	Goods	6744	8439	12622	17904	23476	30694	40007	52226
	Total	**15003**	**18498**	**26582**	**36269**	**45814**	**57621**	**72217**	**90707**
Total Traffic (in PCUs)									
km 17		60376	74568	108048	148552	188761	239066	302001	383164
km 42		21754	26904	39190	54198	69357	88598	113006	144740
km 63.2		25725	32119	47512	66632	86414	111887	144591	187329
km 104		27693	34331	50282	69958	90210	116161	149484	193049
km 182		29262	36267	53042	73770	95131	122486	157473	203032

[23] . The Total Volume is inclusive of NMT, etc. Here above the passenger and goods traffic reported is exclusive motorized traffic.

The mode-wise final growth rates, as derived by section have been given in Table 7-14.

Table 7-14: Annual Traffic Growth Rates by Section Using Econometric Method (%)

Location/Section	Mode	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
km 17	2-wheeler	9.9%	9.2%	7.1%	4.3%	3.7%	3.2%	3.2%
	Auto/Chakda	5.9%	5.7%	4.6%	3.3%	3.0%	2.7%	2.7%
	Cars -OT	5.7%	5.6%	4.6%	3.2%	2.7%	2.5%	2.5%
	Cars-NT	7.9%	7.7%	6.3%	4.5%	4.4%	4.3%	4.2%
	Bus	3.8%	3.8%	3.2%	2.4%	2.4%	2.4%	2.4%
	LCV	6.0%	6.5%	5.5%	4.1%	3.9%	3.9%	3.9%
	2-Axle	7.8%	8.3%	7.0%	5.2%	5.2%	4.9%	4.9%
	3-Axle	9.2%	9.8%	8.3%	6.2%	6.0%	5.9%	5.9%
	MAV	10.7%	11.2%	9.4%	7.0%	7.0%	7.0%	7.0%
	Tractor	3.5%	4.0%	3.4%	2.6%	2.5%	2.5%	2.5%
km 42	2-wheeler	9.9%	9.2%	7.1%	4.3%	3.7%	3.2%	3.2%
	Auto/Chakda	5.9%	5.7%	4.6%	3.3%	3.0%	2.7%	2.7%
	Cars -OT	5.7%	5.6%	4.6%	3.2%	2.7%	2.5%	2.5%
	Cars-NT	7.9%	7.7%	6.3%	4.5%	4.4%	4.3%	4.2%
	Bus	3.8%	3.8%	3.2%	2.4%	2.4%	2.4%	2.4%
	LCV	6.0%	6.5%	5.5%	4.1%	3.9%	3.9%	3.9%
	2-Axle	7.8%	8.3%	7.0%	5.2%	5.2%	4.9%	4.9%
	3-Axle	9.2%	9.8%	8.3%	6.2%	6.0%	5.9%	5.9%
	MAV	10.7%	11.2%	9.4%	7.0%	7.0%	7.0%	7.0%
	Tractor	3.5%	4.0%	3.4%	2.6%	2.5%	2.5%	2.5%
km 63.2	2-wheeler	9.2%	8.7%	6.9%	4.3%	3.7%	3.3%	3.3%
	Auto/Chakda	5.6%	5.5%	4.5%	3.2%	3.0%	2.7%	2.6%
	Cars -OT	5.6%	5.4%	4.4%	3.1%	2.8%	2.6%	2.5%
	Cars-NT	7.8%	7.7%	6.3%	4.5%	4.3%	4.2%	4.2%
	Bus	4.0%	3.9%	3.2%	2.5%	2.5%	2.5%	2.5%
	LCV	5.8%	6.2%	5.3%	4.0%	3.8%	3.8%	3.8%
	2-Axle	7.6%	8.1%	6.9%	5.2%	5.2%	4.9%	4.9%
	3-Axle	8.6%	9.2%	7.9%	6.0%	5.9%	5.8%	5.8%
	MAV	10.1%	10.7%	9.1%	6.9%	6.9%	6.9%	6.9%
	Tractor	3.6%	3.8%	3.2%	2.5%	2.4%	2.4%	2.4%
km 104	2-wheeler	8.8%	8.4%	6.7%	4.3%	3.8%	3.3%	3.3%
	Auto/Chakda	5.4%	5.3%	4.3%	3.1%	2.9%	2.6%	2.6%
	Cars -OT	5.5%	5.4%	4.4%	3.1%	2.7%	2.5%	2.5%
	Cars-NT	7.4%	7.3%	6.1%	4.4%	4.2%	4.2%	4.1%
	Bus	3.9%	4.1%	3.3%	2.5%	2.5%	2.5%	2.5%
	LCV	5.7%	6.1%	5.2%	4.0%	3.8%	3.7%	3.7%
	2-Axle	7.6%	8.1%	6.8%	5.2%	5.1%	4.9%	4.9%
	3-Axle	8.7%	9.3%	7.9%	6.0%	5.8%	5.8%	5.8%
	MAV	10.1%	10.7%	9.1%	6.9%	6.9%	6.9%	6.9%
	Tractor	3.5%	4.0%	3.1%	2.4%	2.3%	2.3%	2.3%
km 182	2-wheeler	7.9%	7.8%	6.4%	4.3%	3.8%	3.4%	3.3%
	Auto/Chakda	5.6%	5.4%	4.4%	3.1%	2.9%	2.6%	2.6%
	Cars -OT	5.3%	5.2%	4.3%	3.1%	2.8%	2.6%	2.5%
	Cars-NT	7.7%	7.5%	6.2%	4.4%	4.3%	4.2%	4.1%
	Bus	4.0%	4.0%	3.3%	2.5%	2.5%	2.5%	2.5%
	LCV	5.6%	6.1%	5.2%	3.9%	3.8%	3.7%	3.7%
	2-Axle	7.5%	8.0%	6.8%	5.2%	5.1%	4.9%	4.9%
	3-Axle	8.5%	9.1%	7.8%	6.0%	5.8%	5.8%	5.8%
	MAV	10.0%	10.6%	9.1%	6.9%	6.9%	6.9%	6.9%
	Tractor	3.7%	4.3%	3.2%	2.5%	2.4%	2.4%	2.4%

7.2.3 CAM Method

This method takes into account the effect of consumption, production and mobility levels of the population. The procedure followed is as given below:

- The zones attracting and producing high proportion of trips/commodities have been identified and retained separately and the rest have been clubbed together. This has been done by each of the modes. The condensed OD matrices have been given as Volume-II (Appendix-7).
- For passenger vehicles, person trips formed the base for forecast, whereas for the goods' vehicles, it was the quantum of goods getting moved on the project corridor.
- In case of goods vehicles also, commodities which are related to food and textile[24], have been treated as consumption goods, and the rest, like fertilizers, iron-ore, steel, etc have been considered as productions[25].
- The population by zone has also been clubbed in a similar way as those of the condensed O-D matrices.
- Per person trip rates, consumption rates and the production rates, by each zone have been estimated.
- The mobility or trip rate of an individual is always seen to be going up with time. With higher disposable income in hand as well as with increased economic activity, the mobility rates of people are likely to go up. The person trip rate, as estimated for the base year, has been projected at the rate of 60% of the per capita income growth rate. The finally adopted PCI for this purpose is that of the state of Gujarat and is as follows:

	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
PCI Growth Rate	9.44%	9.5%	8.72%	6.27%	6.27%	6.27%	6.27%

- The income growth has been frozen at the rate achieved in the year 2020-25.
- The production and attraction rates have been, similarly, linked to the NSDP and PCI growth rates, respectively, at the state level. Like in case of the PCI growth, the NSDP growth rate adopted for the analysis is as follows:

	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
NSDP Growth Rate	11.47%	11.50%	10.51%	8.02%	8.02%	8.02%	8.02%

- The multiplication with the zonal population resulted in forecasted total trips and quantum of commodities, by each year.
- Using the average occupancy in case of passenger vehicles, vehicular growth rates by each mode and by each zone have been derived. The growth rates have been given at Volume-II (Appendix-7).
- The modal composition in case of goods vehicles will not be the same in future. With technology up-gradation, there is going to be a modal shift from 2-axle to three axle and MAV vehicles. Keeping this in view and also the average payloads, as they are presently and likely to be in future, the mode-wise growth rates, for goods vehicles has been estimated.

[24] Commodity codes from 1 to 3, which includes Fruits and Vegetables, Food Grains and Txtiles

[25] Commodity codes 4 to 11, which includes Iron & Steel, Fertilizers, etc.

	Growth Rate of Vehicles						
	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
LCV	4.6%	3.4%	3.3%	3.0%	3.1%	3.1%	3.2%
2-Axle	4.5%	4.1%	4.0%	3.6%	3.6%	3.7%	3.7%
3-Axle	4.9%	4.9%	4.7%	4.1%	4.2%	4.2%	4.3%
MAV	5.9%	6.0%	5.7%	4.9%	4.9%	4.9%	5.0%
Tractor	4.4%	5.8%	5.7%	3.6%	3.7%	3.7%	3.8%
Other	3.1%	2.9%	2.8%	2.6%	2.6%	2.7%	2.7%

- The passenger vehicle growth rates by mode and by zones have been applied to the trip productions as has been captured through the OD survey at each of the locations.
- For goods vehicles, the annual rate of vehicular growth has been applied at each of the homogeneous link level.

The traffic forecast, by time and mode has been presented in Volume-II (Appendix-7). However, Table 7-15 summarizes the total traffic likely to get realized in the future years.

Table 7-15: Projected Traffic using CAM Method

Location	Mode	2007	2010	2015	2020	2025	2030	2035	2040
Total Traffic (in Vehicles)									
km 17	Passenger	24564	30507	43235	59091	77093	100915	131018	168388
	Goods	12217	14004	17328	21294	25533	30715	37065	44877
	Total[26]	**37685**	**45471**	**61623**	**81555**	**103917**	**133056**	**169658**	**215004**
km 42	Passenger	6420	8015	11431	15657	20554	27079	35308	45460
	Goods	4709	5402	6700	8250	9912	11949	14449	17530
	Total	**11333**	**13634**	**18370**	**24171**	**30758**	**39350**	**50112**	**63382**
km 63.2	Passenger	5948	7595	11134	15475	20813	28105	37326	48630
	Goods	6167	7092	8858	10977	13271	16096	19582	23899
	Total	**12169**	**14744**	**20055**	**26521**	**34160**	**44286**	**57002**	**72632**
km 104	Passenger	6728	8527	12416	17241	23057	30959	41006	53447
	Goods	6517	7493	9360	11605	14014	16980	20637	25166
	Total	**13625**	**16423**	**22221**	**29338**	**37614**	**48538**	**62306**	**79344**
km 182	Passenger	8190	10397	15161	21052	28176	37854	50124	65260
	Goods	6744	7757	9676	11975	14466	17532	21314	25996
	Total	**15003**	**18227**	**24917**	**33116**	**42740**	**55494**	**71557**	**91388**
Total Traffic (in PCUs)									
km 17		60376	71486	94145	121892	152571	191907	241038	301824
km 42		21754	25737	33835	43750	54709	68735	86258	107966
km 63.2		25725	30458	40083	51801	65091	82236	103685	130208
km 104		27693	32665	42839	55284	69230	87178	109660	137542
km 182		29262	34718	45846	59428	74852	94795	119784	150728

The growth rates as finally realized at the section level are as given in Table 7-16.

Table 7-16: Annual Growth Rates by Mode Using CAM Method (%)

Location/Section	Mode	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
km 17	2-wheeler	7.4%	7.3%	6.8%	5.3%	5.3%	5.3%	5.3%
	Auto/Chakda	5.5%	5.4%	5.0%	4.0%	4.0%	4.0%	4.0%
	Cars -OT	9.2%	8.5%	6.9%	6.5%	6.6%	6.0%	5.4%
	Cars-NT	9.3%	8.5%	7.0%	6.5%	6.6%	6.1%	5.5%
	Bus	6.6%	6.6%	6.2%	4.9%	4.9%	4.9%	4.9%
	LCV	4.6%	3.4%	3.3%	3.0%	3.1%	3.1%	3.2%
	2-Axle	4.5%	4.1%	4.0%	3.6%	3.6%	3.7%	3.7%
	3-Axle	4.9%	4.9%	4.7%	4.1%	4.2%	4.2%	4.3%
	MAV	5.9%	6.0%	5.7%	4.9%	4.9%	4.9%	5.0%
	Tractor	4.4%	5.8%	5.7%	3.6%	3.7%	3.7%	3.8%

[26] . As stated earlier, the Total Volume is inclusive of NMT.

Location/Section	Mode	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
km 42	2-wheeler	7.4%	7.3%	6.8%	5.3%	5.3%	5.3%	5.3%
	Auto/Chakda	5.5%	5.4%	5.0%	4.0%	4.0%	4.0%	4.0%
	Cars -OT	9.2%	8.5%	6.9%	6.5%	6.6%	6.0%	5.4%
	Cars-NT	9.3%	8.5%	7.0%	6.5%	6.6%	6.1%	5.5%
	Bus	6.6%	6.6%	6.2%	4.9%	4.9%	4.9%	4.9%
	LCV	4.6%	3.4%	3.3%	3.0%	3.1%	3.1%	3.2%
	2-Axle	4.5%	4.1%	4.0%	3.6%	3.6%	3.7%	3.7%
	3-Axle	4.9%	4.9%	4.7%	4.1%	4.2%	4.2%	4.3%
	MAV	5.9%	6.0%	5.7%	4.9%	4.9%	4.9%	5.0%
	Tractor	4.4%	5.8%	5.7%	3.6%	3.7%	3.7%	3.8%
km 63.2	2-wheeler	7.6%	7.5%	7.0%	5.5%	5.5%	5.5%	5.5%
	Auto/Chakda	6.4%	5.5%	5.2%	4.2%	4.2%	4.2%	4.2%
	Cars -OT	9.3%	8.6%	7.0%	6.6%	6.7%	6.1%	5.5%
	Cars-NT	9.4%	8.6%	7.1%	6.7%	6.7%	6.2%	5.6%
	Bus	6.7%	6.5%	6.1%	4.8%	4.9%	4.9%	4.9%
	LCV	4.6%	3.4%	3.3%	3.0%	3.1%	3.1%	3.2%
	2-Axle	4.5%	4.1%	4.0%	3.6%	3.6%	3.7%	3.7%
	3-Axle	4.9%	4.9%	4.7%	4.1%	4.2%	4.2%	4.3%
	MAV	5.9%	6.0%	5.7%	4.9%	4.9%	4.9%	5.0%
	Tractor	4.4%	5.8%	5.7%	3.6%	3.7%	3.7%	3.8%
km 104	2-wheeler	7.6%	7.5%	7.0%	5.5%	5.5%	5.5%	5.5%
	Auto/Chakda	5.8%	5.7%	5.3%	4.3%	4.3%	4.3%	4.3%
	Cars -OT	9.4%	8.7%	7.1%	6.7%	6.8%	6.2%	5.7%
	Cars-NT	9.5%	8.7%	7.1%	6.7%	6.8%	6.2%	5.7%
	Bus	6.7%	6.5%	6.1%	4.8%	4.9%	4.9%	4.9%
	LCV	4.6%	3.4%	3.3%	3.0%	3.1%	3.1%	3.2%
	2-Axle	4.5%	4.1%	4.0%	3.6%	3.6%	3.7%	3.7%
	3-Axle	4.9%	4.9%	4.7%	4.1%	4.2%	4.2%	4.3%
	MAV	5.9%	6.0%	5.7%	4.9%	4.9%	4.9%	5.0%
	Tractor	4.4%	5.8%	5.7%	3.6%	3.7%	3.7%	3.8%
km 182	2-wheeler	7.7%	7.6%	7.1%	5.5%	5.6%	5.6%	5.6%
	Auto/Chakda	5.8%	5.6%	5.3%	4.3%	4.3%	4.3%	4.3%
	Cars -OT	9.4%	8.7%	7.2%	6.7%	6.8%	6.3%	5.7%
	Cars-NT	9.4%	8.6%	7.1%	6.6%	6.7%	6.2%	5.6%
	Bus	6.8%	6.6%	6.2%	4.9%	4.9%	4.9%	4.9%
	LCV	4.6%	3.4%	3.3%	3.0%	3.1%	3.1%	3.2%
	2-Axle	4.5%	4.1%	4.0%	3.6%	3.6%	3.7%	3.7%
	3-Axle	4.9%	4.9%	4.7%	4.1%	4.2%	4.2%	4.3%
	MAV	5.9%	6.0%	5.7%	4.9%	4.9%	4.9%	5.0%
	Tractor	4.4%	5.8%	5.7%	3.6%	3.7%	3.7%	3.8%

7.3 Comparison and Adoption of Predicted Traffic Volume

The total traffic derived, using the three alternative methods/approaches of traffic projection have been presented in Table 7-17. This is to enable and compare the three projected traffic levels.

Table 7-17: Comparative Statement of Projected traffic Using Alternative Forecast Methods (in PCUs)

Location	Method	2007	2010	2015	2020	2025	2030	2035	2040
km 17	Trend	60376	71643	95052	124091	160849	205116	261517	333151
	Econometric	60376	74568	108048	148552	188761	239066	302001	383164
	CAM	60376	71486	94145	121892	152571	191907	241038	301824
km 42	Trend	21754	25854	34405	45029	58714	75331	96687	124157
	Econometric	21754	26904	39190	54198	69357	88598	113006	144740
	CAM	21754	25737	33835	43750	54709	68735	86258	107966
km 63.2	Trend	25725	30936	42043	56115	74546	97263	126781	165412
	Econometric	25725	32119	47512	66632	86414	111887	144591	187329
	CAM	25725	30458	40083	51801	65091	82236	103685	130208
km 104	Trend	27693	33159	44762	59402	78493	101924	132326	171978
	Econometric	27693	34331	50282	69958	90210	116161	149484	193049
	CAM	27693	32665	42839	55284	69230	87178	109660	137542
km 182	Trend	29262	33519	42929	56913	76325	100352	129242	165647
	Econometric	29262	36267	53042	73770	95131	122486	157473	203032
	CAM	29262	34718	45846	59428	74852	94795	119784	150728

It has been observed that the consumption and mobility based traffic forecast results in the least traffic growth rates and hence the least traffic levels. Given the levels of uncertainty in economic growth and several other dependencies, and also more importantly since this project is likely to be taken up under the commercial format, it has been felt appropriate to use the lowest traffic levels for further consideration and analysis. Also, since the approach puts an emphasis on the consumption and mobility patterns of the individuals, it is felt that it will reflect a realistic future traffic.

7.4 Tollable Traffic

In order to assess the tollable traffic, the extent of local traffic and the potential divertable traffic has been assessed from the captive zone pairs lying on the corridor. The assessment revealed, that in the base year, the tollable traffic by modes varied from 82% to 93%. Amongst modes, maximum divertable traffic was observed to be of MAVs (18%), followed by 3- Axle Trucks (12%) and 2- Axle Trucks (10%).

The assessed base year tollable traffic levels are not likely to be static and shall vary with time, as users shall respond to multiple changes that are likely to take place with time in transport network and systems development. These changes are anticipated as user shall try to maximise the benefits following the utilitarian concept. Hence, it is our considered view that from base year (2007) to 2040 that is 33 years time period, the tollable traffic level shall change and therefore needs considered view on the same. In this regard, we had assumed that both local and divertable shares shall increase with time.

The view on why local traffic component shall increase on the sections of corridor is because the activity mix and profile along with urbanization along corridor is anticipated to change. In fact with time, it may be more intense.

With regard to divertable traffic our considered view has been that it will increase with time for reasons like - the parallel and competing routes will be upgraded, railways may be developed to cater to high speed passenger and high speed goods corridors. Further to this, if similar trend in aviation sector happens there is hidden potential of diversion on to the same over long period of time.

Given these thoughts and views, the potential divertable and local traffic in case of passenger traffic is assumed to grow as a percent of vehicular traffic, by mode, as under:

- Car – from 10% of 2007 to 40% by 2040; and
- Bus/Minibus – from 10% of 2007 to 25% by 2040.

The potential divertable goods traffic is assumed to grow as a percent of total mode wise traffic as under:

- LCV – from 7% of 2007 to 25% by 2040;
- 2-Axle– from 10% of 2007 to 25% by 2040;
- 3-Axle– from 12% of 2007 to 20% by 2040; and
- MAV – from 18% of 2007 to 22.5% by 2040.

Table 7-18: Potential Tollable Traffic (in %)

Mode	2007	2010	2015	2020	2025	2030	2035	2040
Car	90	85	82.5	75	75	70	65	60
Bus/Mini Bus	90	90	90	85	85	80	80	75
LCV	93	88	85	80	78	78	75	75
2-Axle Truck	90	88	88	85	80	80	80	75
3-Axle Trucks	88	88	88	85	80	80	80	80
MAV	82	82	82	80	80	77.5	77.5	77.5

Box 1: Assessment of Local and Tollable Traffic for km 17

The traffic levels at km 17 was high. It was felt that it may have fair proportion of local traffic; unlike other locations. In consultation with R&BD and GIDB, an additional survey to assess tollable and local traffic was conducted. The assessed local and tollable traffic by mode at km 17 was as given under:

Mode	Local Traffic (%)	Tollable Traffic (%)
Car	30	70
Bus	30	70
Mini Bus	12	88
LCV	24	76
2-Axle Truck	19	81
3-Axle Truck	8	92
MAV	11	89

Base year tollable traffic volume by mode, and by location, has been given in Table 7-19 below.

Table 7-19: Tollable traffic by mode and location in base year

Mode	km 17	km 42	km 63.2	km 104	km 182
Car	5261	2202	3337	3084	3955
Bus	1989	1131	885	837	981
Mini Bus	748	247	57	106	229
LCV	2064	837	756	998	1110
2-Axle Truck	4355	1830	1988	1924	1906
3-Axle Truck	2440	982	2163	1977	2376
MAV	873	356	485	611	536

The growth rate of tollable traffic over years has been presented in Table 7-20.

Table 7-20: Growth Rate of Tollable Traffic

Mode	2007-10	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40
Car	7.2%	7.9%	4.9%	6.5%	5.1%	4.5%	3.8%
Bus	6.7%	6.6%	4.9%	4.9%	3.6%	4.9%	3.6%
Mini Bus	6.5%	6.6%	5.0%	4.9%	3.7%	4.9%	3.6%
LCV	2.7%	2.7%	2.0%	2.5%	3.1%	2.3%	3.2%
2-Axle Trucks	3.7%	4.1%	3.3%	2.3%	3.6%	3.7%	2.4%
3-Axle Trucks	4.9%	4.9%	3.9%	2.8%	4.2%	4.2%	4.3%
MAV	5.9%	6.0%	5.2%	4.9%	4.2%	4.9%	5.0%

8. NEEDS ASSESSMENT

8.1 Access Controlled Facility

Rightly addressing the present needs, the first step towards enhancement of speed and safety on project corridor is to develop this as partially access controlled highway.

Objective	Steps to Achieve Objective	Benefits
Enhanced Speed and Safety by Partially Access Controlled Highway	1. All major intersections and junctions as GRADE SEPARATED structures, normally Flyovers	• Uninterrupted through traffic. • No conflict at intersections/junctions for main highway traffic with local/slow moving and/or non motorized traffic, also cross pedestrian movements.
	2. Service Lanes in Urban/Industrial zone	• Segregation of localized traffic. • Getting rid of on highway/side parking by commercial and passenger vehicles.
	3. Pedestrian/Vehicular Underpasses	• Shall cater for cross pedestrian and/or vehicular movements without affecting speeds on main highway.
	4. Cattle crossing Underpasses	• Safety for road users and animals. Reduction in fatalities considerable.
	5. Other Junctions: At grade improvements	• Improved safety through well designed rotary/junctions.
	6. Crash Barriers all along main highway	• Controlled access, smooth and speedy traffic flow on main highway.
	7. Fencing along ROW on either sides	• First point of access restriction, only at selected points permission of cross movements.

8.2 Capacity Augmentation Needs

The projection of traffic reveals in ascertaining of higher order improvements in terms capacity enhancement of project corridor. Based upon traffic projections the section wise requirement for six laning of project corridor works out as:

				As per LoS B/DSV		As per MCA
Section-I	:	Km 14.5 to Km 35	:	Immediate	:	Immediate
Section-II	:	Km 35 to Km 63	:	Year 2020	:	Year 2027
Section-III	:	Km 63 to Km 104	:	Year 2017	:	Year 2023
Section-IV	:	Km 104to Km 148	:	Year 2015	:	Year 2022
Section-V	:	Km 148 to Km 182.4	:	Year 2014	:	Year 2020

Irrespective of capacities and augmentation plans, service roads have been proposed along the urban/industrial areas from safety point of view and also for enhanced speeds on main highway for through traffic. The total length of service roads along the corridor is given at Table 8-1.

Table 8-1: Length of Service Roads along the Corridor

From km	To km	Length (Km)
14.6	32	17.4
33	35	2.0
55.945	56.93	0.985
59.4	61.74	2.34
102.24	103.165	0.93
147.73	148	0.275
148	148.655	0.655
168.53	171.05	2.525
Total		**27.11**

8.3 Safety Needs

The increase in the number of motor vehicles on the road has created a major social problem- loss of lives through road accidents. The loss of lives and serious economic loss caused by the road accidents demand the attention of society and call for a solution to the problem. A multi- disciplinary approach is needed in understanding the problem and providing solutions. The accident situation in India is much more serious because of the rapid growth of vehicles in past few years and the inadequacy of many of our roads and streets to cope with such traffic combined with ineffective traffic management.

Reducing the number of accidents requires sustained actions on a number of “fronts” covering traditional areas of Engineering and Environment, Enforcement and Emergency services. This multi-fold approach recognizes the fact that traffic accidents are rarely the result of a single cause or factor. The contributory factors in traffic accidents can be broadly categorized into Human Factors, Road and Environment factors and Vehicle Factors.

Based on RSA, a number of recommendations have been made for safety of vehicle movement on the project road.

9. CORRIDOR DEVELOPMENT POTENTIAL AND IMPROVEMENT OPTIONS

The present road is a four lane facility. Very soon it is likely to get congested with the growing traffic. For this purpose, various alternative options have been worked out and discussed in details with the GIDB and R&BD[27]. This section presents the range of alternative potential widening proposals.

9.1 Corridor Development Potential

When R&BD decided to undertake four laning of this particular corridor in 1998 the target was reduced travel time, improved road conditions and continually maintaining the road corridor. Over last four years time span the benefits of saving in travel time has been accrued. Even today compared to earlier travel time of 5 hours from Ahmedabad to Rajkot, one is still able to commute within 3 – 3.5 hours.

Having mentioned the facts, other side is, since the vehicle population is growing, local/side friction is increasing. What it calls for? it calls for enhanced speeds with safety. It is required to segregate local traffic from through, also non-motorised/slow moving vehicles in specific sections from fast moving through traffic.

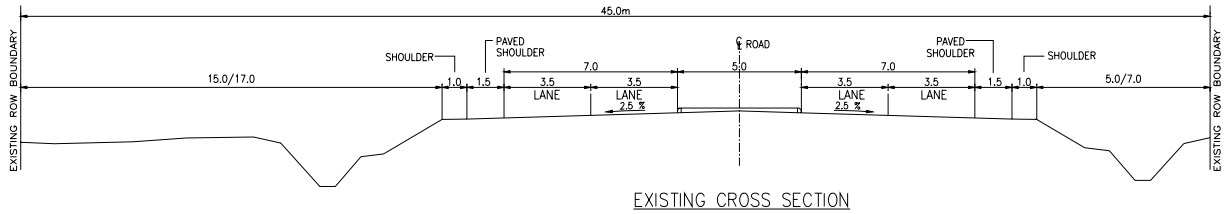
It seems more realistic now to curb local/side friction to provide competitive level of service to road users by enhanced speeds and safety. At this point of time looking at the present corridor environment, it is important having partially access controlled corridor.

Development potential depends firstly upon the corridor specific characteristics. These can be broadly taken as ROW, feasibility of land acquisition, traffic requirements etc. All such project concerns have been given due thought for evolving development options. Ensuing sub-sections deal with corridor specific characteristics which play important role in development of options.

Looking to all such developments the importance of the study corridor getting developed with improved level of service becomes essential. It also needs to be given due importance that national economy is growing stronger and stronger with Gujarat's robust economy sustaining and performing well in recent past. If such is the trend, the immediate need of enhanced speeds and safety cannot be overlooked.

9.1.1 Available Right of Way

The available Right of Way (ROW) for the corridor is 45 m. Representative cross section is shown as under:



EXISTING CROSS SECTION

[27] The discussions and deliberations have been on right from the time the study initiated. Based on those discussions, the six alternate improvement options as worked out were presented in detail in the preliminary feasibility report, along with their costs. Thereafter, it was advised to focus the future work on one option only. In this section, however, the six options, initially developed have been presented in brief, to enable complete appreciation of the project.

It can be seen very well from above representative cross section that:

1. By and large the availability of land within ROW is on left hand side while heading to Rajkot from Ahmedabad with increasing chainage. About 15-17 m land strip is available on LHS from edge of the roadway.
2. The land availability on RHS is about 5-7 m only, from edge of the roadway.
3. The presently available ROW does indicate that either land acquisition or shifting of centre line or even both is the requirement depending upon the development option.
4. Looking to all the above, the open land strip and its width within the ROW carries weight in framing of alternative options.

9.1.2 Proposed ROW, shifting of centre line and land acquisition

Certain obligatory points need to be taken into consideration for proposed ROW and further plan for acquisition of land. Such obligatory points and accordingly the requirements are listed as follows:

Obligatory Points	Requirement
1. Project corridor traverses through GIDC area, having industries set up along the road side from Km 14.5 to Km 35.0.	• Service roads are necessary on both the sides. • Irrespective of widening/up gradation, the road way centre line need to be shifted. • Calls for concentric land acquisition. For 60 m proposed ROW, 7.5 m either side.
2. Urban sections, predominantly exhibits ribbon development and increasing local friction.	• Service roads are necessary on both the sides. • Grade separated facility essential. • Centerline shifting is must.
3. Canal follow closely parallel to RHS end of ROW from Km 46+000 to 49+400.	• Acquisition becomes compulsory only on one side. • Higher order improvement option calls for shifting of centre line.

Proposed ROW and land acquisition proposal goes hand in hand. As a general option having proposed ROW of 60 m all through is one of the options important for future widening requirements. Also in the eventuality of more service road length requirements, acquisition of land strip at present rates shall always be advantageous.

As quoted in Interim Report the ideal 80 m ROW for future and managing it like a corridor is next option for land acquisition.

Urban stretches like Chotila where grade separated facility shall be provided, requires additional land on either side to accommodate local traffic movements, but the social concern may not provide ease of acquiring such land strip. In such cases care needs to be taken in compressing main highway and service road section within the framework of project standards and specifications.

Irrespective of improvement options the centre line necessarily needs to be shifted for GIDC section of Changodar-Bavla and the urban sections.

9.1.3 Traffic Characteristics

Traffic levels on the corridor warrant a six lane over time. It varies by sections. This was established in the earlier chapter. Also a mix of traffic requires that the through traffic be segregated from the local traffic, whether motorised or non-motorised. From safety aspect, there is a need to provide service roads along all settlements, whether urban or industrial.

9.1.4 Structures

Left hand side of the project highway, in general, follows old two lane alignment and Right hand side continues with new alignment of additional two lanes to make old NH8A as four lane divided highway. From structures point of view it has been observed that:

LHS structures are:

1. Built at low level, few of them are submersible during floods.
2. Cross drainage structures and some minor bridges exhibiting widened structures. At places particularly CD works are widened as combination of Pipe and slab.
3. Major structures are also designed only for standard two lane configuration.

At the same time, the structures on RHS are:

1. Newly built.
2. Levels are high considering specific HFL's.
3. New CD works are in good condition.

As far as major bridges and ROB's are concerned, it is always better, to go for six lane structures in advance. In case of minor bridges and CD works, the choice could be from repair/ rehabilitation/ widening to reconstruction, depending upon the condition of the structure.

The proposed schemes for structures have been placed as Volume-II (Appendix-8).

9.1.5 Grade separators

It becomes inevitable to have all the major junctions and intersections as grade separated facilities, when opting for an access controlled corridor. Such facilities can be provided by way of different engineering options like flyovers having open and solid spans, or even by having a continuous flying structure through via duct.

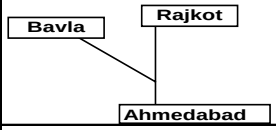
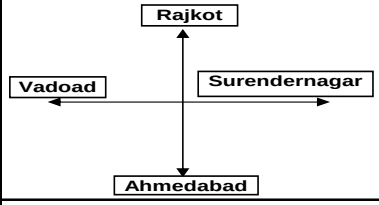
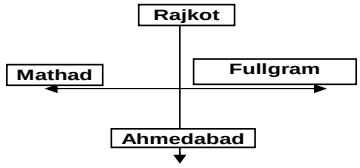
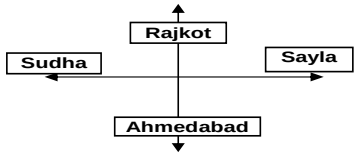
The finalized development plan for grade separators is given in Volume-II (Appendix-8).

9.1.6 Junction improvement

Numbers of minor junctions are seen to be posing serious threats to safety of road users at/near junctions. The traffic conflict, inadequacy of design and lack of signage create chaos at such locations. Considering each junction or minor intersection for grade separated facility may not become a viable proposition. At grade improvement of junctions/intersections with adequate safety measures can also help in achieving desired objectives.

The locations identified for junction improvements are listed in Table 9-1.

Table 9-1: Locations for Junction Improvement

Sr No	Improvement of Junction / Intersection	Type of Junction / Intersection
1	31.800	
2	119.250	
3	130.650	
4	136.800	

9.1.7 Underpasses/Cattle crossings

Main reason of fatalities to human (pedestrians), cattles and road users are because of accidents arising due to cross road movements. Where considerable pedestrian movement is in existence or expected to be in near future, it needs to be attended on priority. Appropriate number of pedestrian underpasses need to be provided near all settlements where cross vehicular movement is taking place. In those sections where considerable interaction of cattle is happening / observed, cattle crossing (underpasses) need to be provided. The proposed locations of such underpasses are listed in Volume-II (Appendix-8).

9.2 Improvement Options and Cost Assessment

Looking at the above stated concerns and potential developments and also based on the meetings with the project steering committee, the following are the potential six options are evolved for further consideration and evaluation:

Option I: 6 lane with service road on both sides in urban/industrial stretches between Km 14.6 to Km 35 with grade separated intersections and few major bridges/ RoB configured to 3 lane and minor bridges/ CD structures configured to 3 lane.

4 lane with service roads in urban/industrial stretches from Km 35 to Km 182.4 with grade separated intersections and all the structures retained as 2 lane.

Option II: 6 lane with service road on both sides in urban/industrial stretches between Km 14.6 to Km 35 with grade separated intersections and few major bridges/ RoB configured to 3 lane and minor bridges/ CD structures configured to 3 lane.

4 lane with service roads in urban/industrial stretches from Km 35 to Km 182.4 with grade separated intersections and all the structures configured to 3 lane.

Option III: 6 lane with service road on both sides in urban/industrial stretches between Km 14.6 to Km 182.4, grade separated intersections and retaining with 3 lane major bridges/ RoB and minor bridges/ CD structures configured to3 lane.

Option IV: 6 lane with service road on both sides in urban/industrial stretches between Km 14.6 to Km 182.4 with grade separated intersections and all structures configured to 6 lane along with a proposal of 60m ROW.

Option V: 6 lane with service road on both sides in urban/industrial stretches between Km 14.6 to Km 182.4 with grade separated intersections and all structures configured to 3 lane along with a proposal of 80m ROW.

Option VI: 4 lane with service road on both sides in urban/industrial stretches between Km 14.6 to Km 182.4 with grade separated intersections and all structures configured to 3 lane along with a proposal of 60m ROW.

The developed options can be summarized as follows:

	Main Carriageway	Service Roads	Grade Separators	Major Bridge/ROB		Minor Bridge/CD Structures
				Old	New	
OPTION-I 6L + 4L Existing ROW 45m: Proposed 60 m	Km 14.5 to Km 35 (6L)	2 lane, either sides for urban/industrial stretches	Flyovers	2L/3L	3L	3L
	Km 35 to Km 182.4 (4L)			2L/3L	3L	2L
OPTION-II 6L + 4L Existing ROW 45m: Proposed 60 m	Km 14.5 to Km 35 (6L)	2 lane, either sides for urban/industrial stretches	Flyovers	2L/3L	3L	3L
	Km 35 to Km 182.4 (4L)			2L/3L	3L	3L
OPTION-III 6L Existing ROW 45m: Proposed 60 m	Km 14.5 to Km 182.4 (6L)	2 lane, either sides for urban/industrial stretches	Flyovers	2L/3L	3L	3L
OPTION-IV 6L Existing ROW 45m: Proposed 60 m	Km 14.5 to Km 182.4 (6L)	2 lane, either sides for urban/industrial stretches	Flyovers	3L	3L	3L
OPTION-V 6L Existing ROW 45m: Proposed 80 m	Km 14.5 to Km 182.4 (6L)	2 lane, either sides for urban/industrial stretches	Flyovers	3L	3L	3L
OPTION-VI 4L Existing ROW 45m: Proposed 60 m	Km 14.5 to Km 182.4 (4L)	2 lane, either sides for urban/industrial stretches	Flyovers	2L	2L	2L

Irrespective of various options, following major heads have been kept common across all the six corridor development options for relative evaluation:

1. Grade Separators	All major Intersections and Junctions
2. Service Roads	Two lane configuration, on either sides for urban/industrial stretches
3. Pavement Design Actual VDF Values Adopted: Mini Bus : 0.58 LCV : 0.87 Std. Bus : 1.27 2-Axle Truck : 8.85 Tandem Axle Truck : 8.10 3-Axle Truck : 10.31 Multi-Axle Truck : 7.44 and Design CBR as 5%.	Pavement Crust: BC : 50 DBM :160 WMM : 250 GSB : 260 Total 720 mm, Sub-grade of 500 mm

9.3 Development Cost

For appreciation of project cost, preliminary cost got worked out, this shall form input to further economic and financial analysis. Option wise major head costing is furnished as follows:

Cost in Crores INR

	Capital Construction Cost	Contingency, Design-Supervision Consultancy	Land Acquisition and Enviro-Social	Total Cost
OPTION-I 6L + 4L Existing ROW 45m: Proposed 60 m	**857.70**	68.62	176.78	**1103.10**
OPTION-II 6L + 4L Existing ROW 45m: Proposed 60 m	**864.39**	69.15	176.78	**1110.32**
OPTION-III 6L Existing ROW 45m: Proposed 60 m	**1252.48**	100.20	177.68	**1530.36**
OPTION-IV 6L Existing ROW 45m: Proposed 60 m	**1302.49**	104.20	177.68	**1584.37**
OPTION-V 6L Existing ROW 45m: Proposed 80 m	**1366.92**	109.35	**411.25**	**1887.53**
OPTION-VI 4L Existing ROW 45m: Proposed 60 m	**775.85**	62.07	177.68	**1015.60**

The selection of development option shall be based upon economic and financial rate of returns. In addition we made assessment with respect potential environmental and social mitigation measures need, which is described in ensuing sections.

10. RATIONALE

10.1 Rationale

Potential Options for project corridor development as noted in earlier chapter are six. The extent of improvement should depend upon the economic benefits or impacts that the improvements proposals will provide to the road users. Therefore economic analysis becomes a key in decision making process, especially when the project to be undertaken is likely to have major societal impacts, like the proposed one. The improvement options need to be seen in the economic context while taking decision.

The investment which is likely to be made for improvement in the proposed project is a major one. In such a scenario, assessing the economic viability of the project, by various potential options, becomes a necessity. The present chapter aims at discussing some of the options from economic perspective. It is based on this from potential six options, the preferred option was selected at rational basis.

10.2 Economic Perspective

10.2.1 Options for Study

Potential six improvement options have been worked out from needs perspective. They present all the range of options. Out of these, the economic analyses[28] have been undertaken for following three options.

Option I : Section 1 six lane; and rest four lane with 60m RoW.

Option III : Full corridor six lane with 60m RoW.

Option VI : Full corridor four lane with 60m RoW, Service Road is there in Section 1 only.

Options III and VI are the extreme cases of full six lane and four lane with improved junctions only. These two options are likely to give us the maximum and minimum benefits which the project implementation is likely to result in. Therefore, economic analysis was done only for these three options.

10.2.2 Economic Perspective of Analysis

The benefits of the implementation schemes have been worked out in terms of savings in vehicles operating costs (VOC) and travel time (VOT). The savings in VOC and VOT, by each option have been given in the Table 10-1.

Table 10-1: Savings in VOC and VOT by Improvement Option (Mill Rs.)

Year	Option I		Option III		Option VI	
	VOC	VOT	VOC	VOT	VOC	VOT
2013	1539	1007	1748	1277	1215	759
2015	1816	1191	2085	1532	1372	891
2020	2419	1654	2861	2218	1703	1180
2025	2604	1928	3194	2732	1879	1390
2030	3332	2176	4716	3477	2342	1747
2035	4490	2827	6748	4385	2986	2372
2040	7272	3301	10837	5665	5437	2713

[28] The results stated and discussed here are those presented in the pre-feasibility report. They have undergone a change then after due to the firming up of the cross-sections and design.

It can be observed that the option with full six-laning gives the maximum benefit to the society. Therefore from the perspective of only the benefits, Option III ranks first to be selected for implementation.

Moving a step forward, when the benefits are compared with the cost of each of the improvement option, the Economic Internal Rate of Return (EIRR), as estimated over 25 and 30 year period are given in Table 10-2 the detailed outputs have been given as at Volume-II (Appendix-12).

Table 10-2: EIRR by Options (%)

	Component of Benefit	Option I		Option III		Option VI	
		25 years	30 years	25 years	30 years	25 years	30 years
EIRR (%)	VOC	17.89	18.47	15.61	16.45	14.66	15.40
	VOC + VOT	27.03	27.21	24.57	24.86	22.84	23.14

The investment in Option III is more as compared to Option I, to the extent that it overtakes the benefits due to the savings in VOC and VOT. As a result, Option I emerges as the best option for implementation from economic perspective.

10.3 Option for Further Consideration

It is based on above analysis, Option-I i.e. six lane facility upfront in first section and the rest of project corridor as four-lane facility was considered for further work. Given the results and range of benefits, it is felt prudent that staged construction to be incorporated into plan of corridor development. It is this which has formed base for financial analysis.

SECTION D: PRELIMINARY DESIGN AND COST ASSESSMENT

11. THE PROJECT PROPOSAL

11.1 Firmed up Improvement Option

At Preliminary Feasibility Report stage in all six development options were worked out and presented. Later on the same were deliberated with GIDB and R&BD to finalise suitable option for further preliminary designs. The following points were duly considered:

⇒ Present MoA between GoG and MOSRT&H-GoI;

⇒ Traffic levels and capacity augmentation requirements;

⇒ Developments along road corridor;

⇒ Land Acquisition; and,

⇒ Need for partially access controlled corridor.

Accordingly the finalised and adopted improvement proposal was Option-I (widening plan and cross-sections are presented through Figure 11-1 and Figure 11-2 respectively). Preliminary Designs were carried out for this option and provided with Preliminary Design Report (submitted October 2007). Some of the key details of adopted option are presented as under:

- Six laning for initial Urban and Industrial section from km 14.5 to km 35 along with two lane service roads on both side and rest as four lane dual roadway configuration.
- Land acquisition is considered as concentric, looking to the field situation. 7.5 m land strip on either side taken into consideration to extend our 45 m ROW to 60 m. this is applicable for Bavla-Changodar GIDC section along with urban stretches along the corridor. Due to such step shifting of centre line to the extent of 6.5 m is essential.
- From km 35 onwards till km 182.4, carriage way configuration is retained as four lane divided only. In such cases the existing centre line has been retained but in constrained stretches like parallel canal structure in km 46-49, one side land acquisition is taken along with shifting of centre line.
- Overlay for existing pavement section got worked out based on BBD survey results and its analysis.
- For new pavement construction, project specific - mode wise VDF values are adopted and design CBR was considered as 5%.
- Option facilitates road side parallel drain, pedestrian foot path and Cycle track cum dedicated Utility corridor on both sides.
- All grade separators are provided as six lane fly over structures.
- Three major structures recently constructed which are of two lane capacity are kept as same, though all new major bridge/ROB structures are proposed and designed as Six lane.
- CD structures other than repairs/Rehabilitation and widening treatment, they are kept as six lane wide where main highway section is six lane and four lane in next four lane section.

The plan and typical cross sections for the proposed option is as in the Figure 11-1 and Figure 11-2:

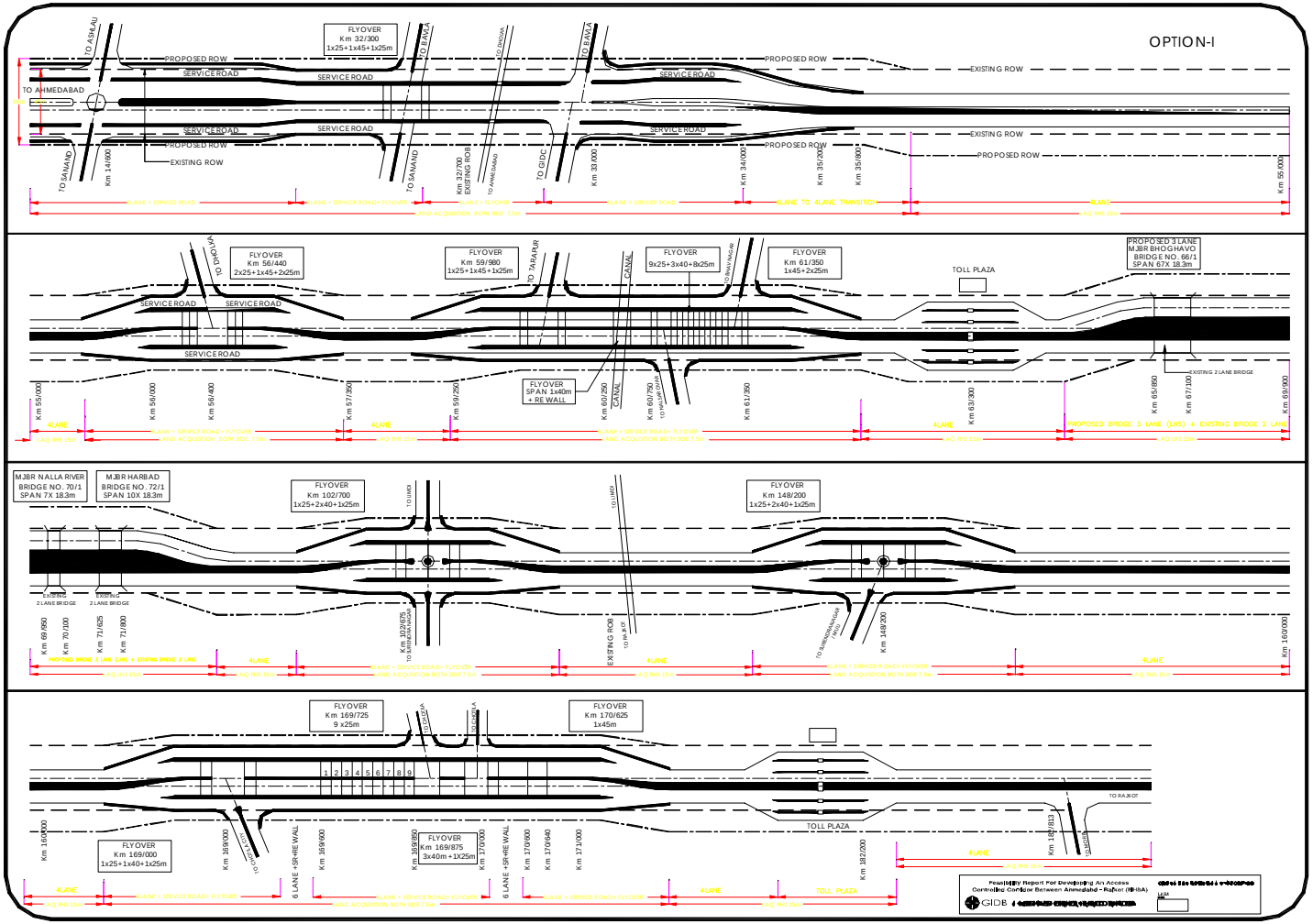
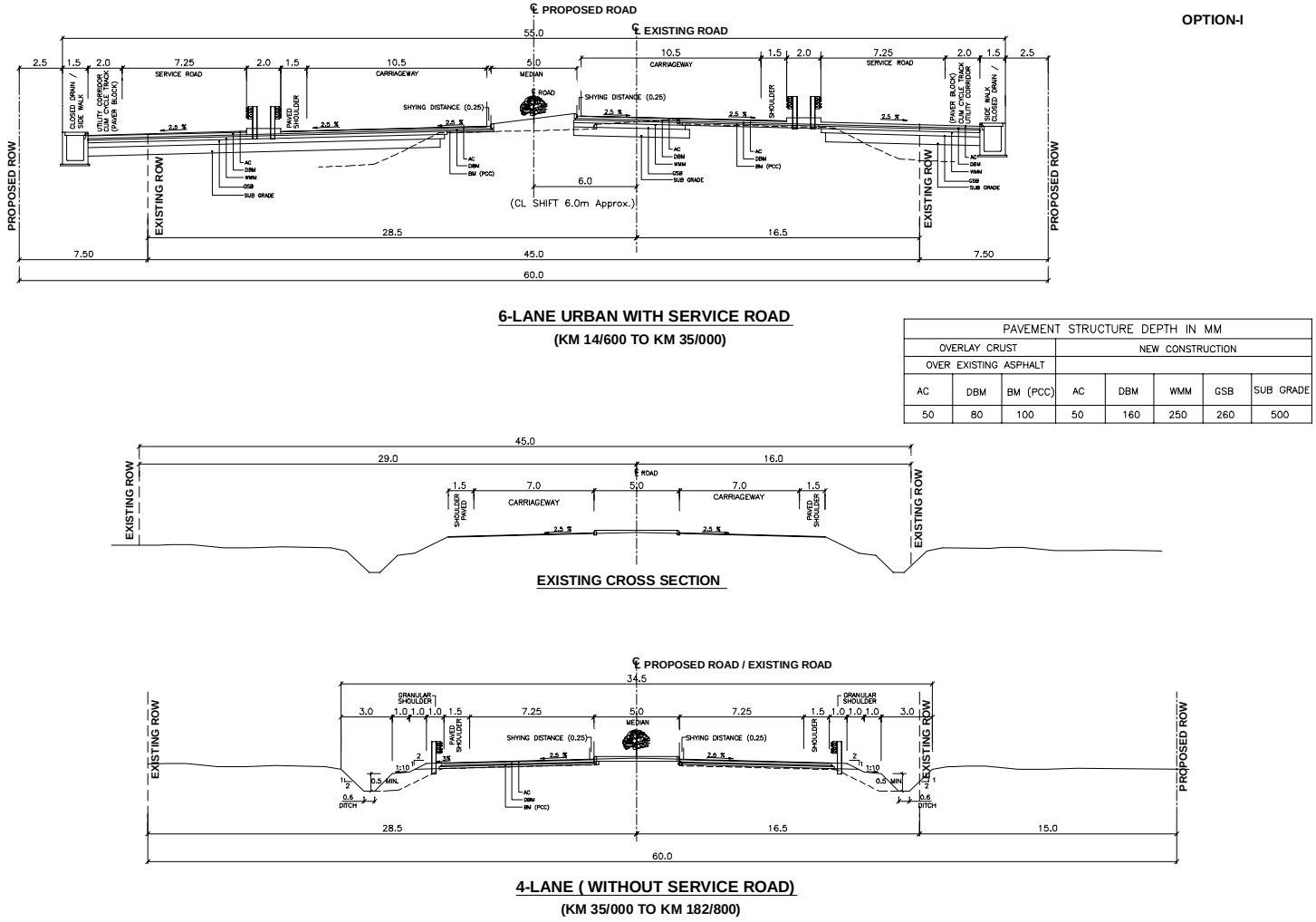


Figure 11-1: Option-I: Plan



PAVEMENT STRUCTURE DEPTH IN MM							
OVERLAY CRUST OVER EXISTING ASPHALT			NEW CONSTRUCTION				
AC	DBM	BM (PCC)	AC	DBM	WMM	GSB	SUB GRADE
50	80	100	50	160	250	260	500

Figure 11-2: Option-I: Typical Cross Sections

11.2 Adopted Design Standards

11.2.1 Geometrics

The geometric design standards adopted for the project are furnished in tabular format for easy and quick reference (Table 11-1).

Table 11-1: Adopted Geometric Design Standards for the Project Corridor

Sl. No.	Description	Standards for Six Lane	Standards for Four Lane
1.	Design speed	100 kmph	100 kmph
2.	ROW	45-100 m as per availability	Generally 45m-60m
3.	Overall width between building lines	80m	80m
4.	Overall width between control lines	150m	150m
5.	Set back between building line & road boundary	3 to 6m	3 to 6m
6.	Roadway Lane width	3.5m	3.5m
	Combined Lane width	10m	–
	Paved shoulder on outer side (Width in rural and urban section)	1.5m	1.5m
	Hard shoulder width on outer side		
	Rural sections	1.5m	2.5m
	Urban and semi-urban sections	1.5m	2.5m
	Cross slope in lanes and paved shoulders	Nil	Nil
	Cross slope in hard shoulders		
	Bituminous concrete surfacing	2.0%	2.0%
	Cement Concrete Surfacing	3.5%	3.5%
7.	Free board	0.6m	0.6m
8.	Edge strip		
	Median side-Rural	0.25m	0.25m
	Median side-Urban	0.25m	0.25m
	iii. Outer side-Urban	0.25m	0.25m
9.	Stopping Sight distance Sight distance shall be in accordance with the intermediate sight criterion preferably but in no case shall be less than the stopping sight distance		
	Desirable (intermediate)	360m	360m
	Minimum (stopping)	180m	180m
10.	Horizontal curvature		
	Requiring no super elevation	3150m	3150m
	Desirable requiring 5% super-elevation for 100 kmph	400m	400m
	Absolute minimum requiring 7% super-elevation for 100 kmph	360m	
11.	Vertical Alignment		
	Minimum distance between PVI	150m	150m
	Minimum length of vertical curve	60m	60m
	Minimum “K” value		
	For – Sag	45	45
	For - Crest	75	75
12.	Gradient		
	Maximum	3.3%	3.3%
	Minimum	0.5%	0.5%
	In cut and kerbed sections		
	On unkerbed sections on embankment	0.05%	0.05%
	On unkerbed sections not on embankment	0.05%	0.05%
13.	Maximum grade change not requiring vertical curve	0.5%	0.5%
14.	Min.vertical clearance to road bridge over road	5 m	5 m
15.	Min. vertical clearance to road bridge over rail	6.75m	6.75m

Sl. No.	Description	Standards for Six Lane	Standards for Four Lane
16.	Superelevation Maximum Desirable	 7% 5% (avoids risk of overturning of vehicles moving at lower speeds)	 7% 5% (avoids risk of overturning of vehicles moving at lower speeds)
17.	Rate of change of superelevation	1 in 150	1 in 150
18.	Side walk	2.0m	2.0m
19.	a) Central Median (raised) Width in rural and urban section Cross slope (as per IRC SP: 50-1999) b) Median besides Service Road Width in urban and semi-urban sections	 1.5 - 4.5m – 0.5-1.5m	 1.5 - 4.5m – 0.5-1.5m
20.	Embankment slope In normal section In high embankment (>3m)	 2H: 1V To be decided based on slop-stability analysis	 2H: 1V To be decided based on slop-stability analysis
21	Interchange Ramp Design speed (kmph) Carriageway Width a) Single lane b) Double lane Paved shoulder a) Inner b) Outer Minimum radius Maximum superelevation Gradient a) Desirable b) Maximum	 65 kmph 4.6m 8.8m 2.3m 1.2m 155m 7% 4% 6%	 65 kmph 4.6m 8.8m 2.3m 1.2m 155m 7% 4% 6%
22	Interchange Loop Ramp Design speed (kmph) Carriageway Width a) Single lane b) Double lane Paved Shoulder a) Inner b) Outer Minimum radius Maximum superelevation Gradient a) Desirable b) Maximum	 50 kmph 4.6m 8.8m 2.5m 1.2m 90m 7% 4% 6%	 50 kmph 4.6m 8.8m 2.5m 1.2m 90m 7% 4% 6%
23	Intersections Length of storage lane (including taper) for right turning Minimum length of acceleration lane Minimum length of deceleration lane Maximum radius for left turn Minimum radius for right turn Width of turning lane (inner radius of 30m) Rate of taper (min)	 160m 120m 90m 30m 15m 5.5m 1 in 15	 160m 120m 90m 30m 15m 5.5m 1 in 15
24	Busbay Min. length of busbay Maximum length of pedestrian guard rail on either side of the busbay	 30m 20m	 30m 20m
25	Truck Layby Min length of layby Min parking length for each vehicle Min parking width for each vehicle Min. width of raised separator between layby and carriageway Rate of taper (min)	 100m 15m 2.75m 3m 1 in 10	 100m 15m 2.75m 3m 1 in 10

Sl. No.	Description	Standards for Six Lane	Standards for Four Lane
26	Toll Plaza		
	Width of lane at toll plaza	3.2m	3.2m
	Width of lane for oversized vehicles	4.5m	4.5m
	Width of islands	2.0m	2.0m
	Rate of taper (min)	1 in 10	1 in 10
	Longitudinal slope at the central portion	0%	0%
	Longitudinal slope at approaches	0.05%	0.05%
	Vertical clearance of canopy over standard lane	5.5m	5.5m
	Vertical clearance of canopy over oversized vehicle lane	-	-
27	Safety barriers		
	Bridge approaches and high embankments	3m and above	3m and above
28	Clearance for Utility Lines		
	Horizontal	As per IRC 32-1969	As per IRC 32-1969
	Street lighting poles		
	a) Roads with raised kerbs	300mm min from edge of kerb	300mm min from edge of kerb
	b) Roads without raised kerbs	1.5m min from edge of carriageway	1.5m min from edge of carriageway
	Overhead power and telecommunication lines	10m min. from edge of roadway	10m min. from edge of roadway
	Vertical	As per IRC 32-1969	As per IRC 32-1969
	Ordinary wires/lines carrying voltage upto and including 110 volts and telecommunication lines	5.5m min.	5.5m min.
	Electric power lines carrying voltage upto and including 650 volts	6.0m min.	6.0m min.
	Electric power lines carrying voltage exceeding 650 volts	6.5m min.	6.5m min.
29	Landscaping		
	C/C spacing between trees parallel to the road	10-15m	10-15m
	Min. distance between kerb and nearest edge of tree trunk	2m	2m
	Maximum height of shrubs in median	1-1.5m	1-1.5m
	Species of trees	Local, indigenous species suitable to high salinity microclimate	Local, indigenous species suitable to high salinity microclimate
	Species of shrubs in median	nerium oleander album, shrubs/plants containing latex	nerium oleander album, shrubs/plants containing latex

11.2.2 Grade Separator, Bridges and CD Structures

The Design Standards and the loading followed are mainly based on the requirements laid down in the latest editions of IRC/ IS Codes of Practices and Standards specifications. Additional technical references are also considered wherever the provisions of IRC/IS codes are found inadequate.

The following IRC/IS codes are adopted for structures design:

IRC: 5-1998	Standard Specifications and Code of Practice for Road Bridges, Section I - General Features of Design (Seventh Revision)
IRC: 6-2000	Standard Specifications and Code of Practice for Road Bridges, Section II - Loads and Stresses (Third Revision)
IRC: 18-2000	Design Criteria for Prestressed Concrete Road Bridges, (Post- Tensioned Concrete)
IRC: 21-2000	Standard Specifications and Code of Practice for Road Bridges, Section III - Cement Concrete (Plain and Reinforced (Second Revision)
IRC: 78-2000	Standard Specifications and code of Practice for Road Bridges, Section VII- Foundations and Substructure (First Revision)

IRC: 83 (Part II)-1987	Standard Specifications and Code of Practice for Road Bridges, Section IX-Bearings, Part II: Elastomeric Bearings.
IRC: 83 (Part III)-2002	Standard Specifications and Code of Practice for Road Bridges, Section IX-Bearings, Part III: POT-PTFE Bearings.
IRC: 89-1997	Guidelines for Design and Construction of River training and Control works for Road Bridges. (First Revision)
IRC: SP: 33-1989	Guidelines on Supplemental measures for Design, Detailing and Durability of Important Bridge Structures. (Second Revision)
IS: 2911 (Part1/Sec2)	Code of Practice for Design and Construction of Pile Foundation for Bored Cast in situ Piles.

MOST Specifications for Road and Bridge Works published by Ministry of Roads Transport & Highways (Roads Wing), Government of India (Latest Edition)

For areas/items not covered in the above specifications, provisions of following standards need to be followed where required:

- Provisions of IS codes of practices
- Relevant provisions of BS codes of practices
- Sound Engineering Practices, Technical Literatures/Papers and provision of relevant codes of other nations.

11.2.3 Pavement Design

Designs for new pavement and overlays shall be dealt in accordance with Indian standards, i.e IRC. The sub-grade shall at least have a 4 day soaked CBR 97% MDD.

Flexible pavement for new carriageways shall be designed in accordance with the guidelines of IRC 37-2001. The structural coefficients of various layers shall be suitably modified to suit the Indian conditions, if required. The flexible pavement of service roads shall also be designed in accordance with IRC 37-2001.

All pavement layers shall be constructed as per the requirements of MOSRT&H specifications. The drainage layer, which is a part of GSB layer, shall be provided extending over the full width of formation to the embankment slope.

The initial design of overlays on the existing carriageway shall be in accordance with IRC 81-1997 using the BBD deflections. The requirement of future overlays shall be linked to the pavement condition as reflected by pavement roughness and the composition and timings shall be based on performance indicators.

12. ROADWAY GEOMETRICS

12.1 Detailing of Items for Design

The geometric design standards are grouped as furnished hereunder (Table 12-1):

Table 12-1: Categorization of Elements for Geometric Design Standards

Category	Design element
Geometric Design	Cross-sectional elements Sight distance Horizontal alignment Vertical alignment Gradients Super elevation

12.2 Horizontal Alignment

The project corridor has been improved as per the adopted design standards. The proposed inner edge lines for the left and the right carriageway are generally following the left and right median edges of the existing formation width. This is for the immediate as well as future improvements, except in the following cases:

i) Geometric deficiencies where realignment has been done

ii) Places where the existing median width has been reduced to minimise land acquisition. Similarly in urban areas, where the existing median width which is approximately 5.0m, has been reduced to 2.0m to minimise land acquisition in addition to shifting of the centreline to fit the required c/s within the available RoW.

The horizontal alignment design has been done using “Softdesk” as per the widening scheme suggested on the base plans. The design standards corresponding to 100 kmph have been adopted for the project corridor. Extensive field checks to verify the feasibility of the proposed alignment have been carried out and suitable modifications to the alignment have been done.

There are about 6 major bridges; 2 Nos. each at 3 locations, 104 minor bridges including 2 RoB’s and 135 culverts. The major bridges at 3 locations are shifted to 20 m on left hand side from the centre of the existing old bridge and accordingly horizontal alignment is fixed. Four minor intersections have been improved. The criterion that governed finalization of the alignment includes:

- Available ROW from the existing Center line
- Geometric improvements
- Bridges requiring reconstruction and necessary shift from existing bridge
- Urban/Industrial areas requiring service roads
- Road-side properties
- Road-side utilities

Horizontal alignment designs have also been carried out for service roads on both sides of the carriageway where ever provided.

12.2.1 Detailing of Horizontal Alignment Design Effort

Conscientious efforts have been made to accommodate improvements within the RoW. It is pertinent to point out that in a project of such magnitude wherein improvement to the existing project corridor not only involves widening, but also provision of highway facilities such as bus bays, truck laybys, service roads, junction improvements both at grade and grade separated, widening of existing structures and construction of new structures, improvement initiatives call for some acquisition of land, which is unavoidable. Retaining walls, toe walls, reduced median widths and alignment shifts are means judiciously adopted to minimise land acquisition requirements.

The widening scheme for the project corridor involves 4 lane configuration with paved shoulders 1.5 m wide or 6 lane configuration with paved shoulders 1.5 m wide. Also finalised treatment options for CD structures viz., repair, rehabilitation and reconstruction as applicable to different stretches of the project corridor are considered in fixation of horizontal alignment. The curves at 10 locations are found deficient. The details of these curves are presented in Table 12-2 below. About 81 existing curves are looked into; out of these 17 curves are completely eliminated, 39 curves are improved out of which 14 are spiral curves and the 25 curves are modified to simple from spiral curve. The details are presented in the Table 12-2 to Table 12-7. All others have been improved to meet design standard requirements.

Table 12-2: Curves with Insufficient Spiral Length

Sl. No.	Station	Radius (m)	Spiral Length (m)	Spiral Length Required(m)
1	60+300	200	40	110
2	108+600	350	60	63
3	109+400	200	80	110
4	134+000	280	75	79
5	158+000	360	60	61
6	173+500	250	50	88
7	174+000	200	75	110
8	178+400	220	85	100
9	178+700	400	25	55
10	179+400	275	15	80

Table 12-3: Eliminated Curves

Sl .No	Curves at Chainage
1	22+753.212
2	23+440.417
3	23+781.162
4	24+226.034
5	25+099.623
6	29+593.204
7	30+541.732
8	43+077.458
9	55+604.242
10	56+281.208
11	59+513.514
12	61+577.869
13	102+845.471
14	103+171.858
15	139+388.155
16	156+209.952
17	177+889.771

Table 12-4: Improved Curves

Sl .No	Curves at chainages	Improved Curve at Chainage
1	37+659.841	37+862.106
2	37+862.633	
3	38+064.700	
4	56+496.350	56+944.615
5	56+793.402	
6	56+998.594	

Sl .No	Curves at chainages	Improved Curve at Chainage
7	57+183.929	
8	60+109.907	60+287.345
9	60+300.616	
10	60+392.979	
11	102+022.148	102+142.079
12	102+211.575	
13	155+800.959	155+946.576
14	155+031.108	
15	158+214.504	158+345.638
16	158+381.792	
17	179+247.489	179+320.500
18	179+405.771	
19	178+178.324	177+920.547
20	178+458.532	178+429.502
21	178+712.136	178+733.835
22	181+765.344	182+027.727
23	181+886.558	
24	182+042.752	
25	182+169.613	

Table 12-5: Improved Spiral Curves

SL. No	Curves at Chainages
1	78+610.204
2	106+483.710
3	108+634.178
4	109+467.874
5	127+001.803
6	133+959.740
7	136+009.293
8	142+159.160
9	145+947.629
10	150+636.063
11	170+656.660
12	173+339.905
13	175+134.449
14	182+398.316

Table 12-6: Improved Spiral Curve to Simple Curve

Sl. No.	SPIRAL	SIMPLE
1	29+019.107	29+020.575
2	36+691.325	36+689.986
3	39+573.099	39+570.937
4	43+872.247	43+865.654
5	50+935.001	50+926.923
6	51+790.331	50+798.526
7	53+326.426	53+324.106
8	58+365.260	58+371.358
9	59+313.621	59+326.335
10	62+322.810	62+321.686
11	75+958.336	75+960.613
12	87+510.001	87+515.941
13	114+621.112	114+620.125
14	138+659.758	138+659.652
15	140+057.877	140+052.815
16	141+228.756	141+224.506
17	151+518.560	151+503.905
18	153+201.751	153+186.184
19	156+389.565	156+373.927
20	156+552.034	156+539.197
21	167+209.175	167+194.328
22	173+959.322	173+887.107
23	179+927.043	179+900.201
24	180+381.860	180+349.620
25	181+325.858	181+296.704

In general, the horizontal alignment design addressed the requirements of 6 laning from km 14/600 to km 35/000 and 4 lane widening (4 lane width with 1.5m paved shoulder and 1m granular

shoulder). There are few locations where it is not possible to provide the design speed of 100 kmph due to lack of land availability to fit the curve, the Table 12-7 below gives the details of locations where design speed cannot adopted.

Table 12-7: Location with Restricted Speed

LHS		RHS	
From	To	From	To
168800	169250	168800	169250
170400	170900	170400	170900
171300	171800	171300	171800
172200	172500	173175	173600
173200	173650	178200	178850
178200	178850	179100	179550
179100	179550	182500	182800
182500	182810		

12.3 Vertical alignment

The profile of the Project Corridor has been finalized on the basis of DTM data collected during the topographic survey. The prime considerations in finalizing the vertical profile have been:

- Match Existing profile at the median edges
- Minimum longitudinal gradient is 0.05%, for longitudinal drainage
- Minimum length of a vertical curve is 60m
- Maximum gradient of 3.3% at major bridge approaches
- Minimum K (rate of change of vertical curvature) value as 75 for the summit curve and 45 for valley curve
- Top of subgrade as 0.6m above HFL at the edge of shoulder.
- Reconstruction/ Rehabilitation schemes for bridges/culverts
- Pavement improvement schemes – overlay, recycling, reconstruction

The grade line has been kept smooth, with mild gradients consistent with the character of the existing road profile and terrain. Local depressions of varying depths in the profile of existing pavement have been eliminated to streamline the profile, with vertical curves at crests and valleys. Rectification of depressions involves the provision of profile corrective courses with various materials so as to conform to the designed profile. This correction will be necessary in addition to correction of camber or cross-fall.

12.3.1 Detailing of Vertical Profile Design Effort

The vertical profile was raised at major junctions wherever grade separation in the form of flyovers has been provided. Separate profiles have been designed for the left and right carriageway. Separate profiles have been designed for service roads (both sides), and drains in the service road stretches (both sides) considering:

(i) Ground level immediately adjacent to the service road

(ii) Optimise the height of the flyovers at the intersection locations with due consideration to the required/stipulated clearances

(iii) Drainage outlets/streams/nalas etc in the vicinity to ensure proper drainage discharge. In the stretches where no project intervention is being done, the finished profile of the road matches with the existing profile.

Highway plans and profile drawings are given as separate Volume-III-B and III-C for LHS and RHS respectively.

13. SOIL AND MATERIAL INVESTIGATIONS

13.1 Introduction

This section describes specifications adopted for the construction materials that required for the Project Corridor and the methodology followed for the identification of different material sources.

The material investigations carried out including existing material sources that are in use, field investigations for identification of new material sources, collection of samples, testing of samples, and identification of suitable material sources and assessment of available quantity of materials for the project corridor.

13.2 Specifications for Required Materials

The physical properties of road construction materials must meet specific minimum requirements in order to provide durability consistent with the design objectives of the project. Most of the specifications for the materials referred in the designs comply by the Ministry of Shipping, Road Transport & Highways (MoSRT&H) specifications (Fourth Revision).

13.3 Methodology for Identification of Material Sources

Review of existing data was carried out initially to assess the construction materials availability in the vicinity of the project roads keeping in view the requirements of material specifications. These reports identify significant geologic features and existing quarries. The data were used for planning the field investigations. The entire material investigation including identification has been carried out in four phases as mentioned in the following paragraphs.

13.3.1 Field Investigation

Based on the review of the existing data and material sources, which are in use, the same have been identified. Many new locations were identified for fill materials like embankment, select sub-grade and shoulder materials with the help of local inquiry and field assessment of material properties. The quarry locations, which are identified, are in use. A rough estimate of available quantity of the fill material from all the identified borrow areas was assessed. A detailed inquiry has also been carried out for the existing quarries to estimate the likely available material from each of these quarries for this project. This includes assessment of remaining quantity in quarries, number of crushers using a particular quarry, capacity and daily output of these crushers and present supply/ demand of the aggregate materials.

13.3.2 Sample Collection

Samples collected from all the identified material sources that are already in use as well as from the new sources for conducting various tests in the laboratory. The samples for fill material are collected in gunny bags not less than 50 kg. The aggregate samples from both quarry and crusher locations are collected not less than 20 kg. The locations of samples to be collected are given in the Volume-II (Appendix-9).

13.3.3 Laboratory Testing

All the samples that collected are tested for their suitability in the construction. The fill materials have been tested for classification, maximum dry density, CBR and free swell Index. The aggregate materials have been tested for grain size analysis, flakiness & elongation, specific gravity, impact and stripping test. The results for all the materials have been summarized and presented Volume-II (Appendix-9).

13.4 Description on Identified Material Sources

The selected material sources and its characteristics are described in this sub-section. As mentioned the availability of the fill material from the selected borrows was assessed. Lead distances were also calculated from these locations to the project corridor for analysing the unit rates for various items of work. The material characteristics of the suitable sources and the availability of material are discussed below.

The general soil type along the corridor is Sand. The summary of test results and the selected material sources are given in Volume-II (Appendix-9).

13.4.1 Fill Materials

The locations for imported fill / embankment material (PI<15%) are identified at almost all places along the corridor. The common soil groups at these locations are Silty Sand with no plasticity (SM) and sandy clays (SC). The maximum dry density (MDD) at optimum moisture content of these samples is more than 1.840 gm/cc. The soaked CBR at 97% MDD varies from 1.81% to 19.05%. Selected sources can be used in select subgrade having design CBR value.

13.4.2 Sub-Base Materials

There are no known natural sub-base material sources with in the permissible lead along the project corridor. The sub-base material may be produced either by blending different materials or by stabilising the local material with lime/cement to produce the required strength.

13.4.3 Aggregates

The aggregate material, which is required for bituminous and not-bituminous courses, is available from two sources, namely Sayala quarry and Morbi quarry. The material from the both quarries is complying with the specifications with the exception of Flakiness and Elongation Indices which can be improved at construction stage by establishing cone crushers.

13.4.4 Other Materials

Sand is available from Bhogavo river bed at Km 65/0.

Bricks are available from Sarkhej, Bavla and Bagodara located along the corridor.

Hume pipes are available from Ahmedabad and Rajkot.

13.5 Comments on Material Specifications

This sub-section highlights some of the particularities of the project road, and the materials likely to be available, to ensure that these are taken account in the finalisation of specifications.

13.5.1 Material for Granular Sub Base (GSB)

As noted, there is no source for Riverbed material for GSB throughout the entire corridor. However, at some places soft rock is available along the corridor that can be used for GSB after adding some crushed stone aggregates etc.

13.6 Crushed Pavement Materials

Crushed aggregates shall be used in the base and surfacing layers. Right on the corridor and near by locations suitable quality rock can usually be found on the project road. The crushed stone produced by the existing crushers is not acceptable (high flakiness index) however. It is therefore essential that the contractors are made aware of this fact, in the prequalification/bidding documentation, and be required to establish crushing facilities capable of producing acceptable aggregate shape. Their facilities should also have the capacity to produce the required quantities of crushed rock materials.

Further, as production of crushed stone will be a critical element on all the projects, with production of pavement materials dictating the rate at which a project progresses, it is likely that materials from existing suppliers will be brought onto the job. Provision should also be made for additional sampling (on the road) so that the site staffs have the ability to reject material, if it found to be unacceptable.

13.7 Miscellaneous Materials and Products

The availability of the miscellaneous materials is given in the Table 13-1.

Table 13-1: Commercially Available Materials

Material	Source
Bitumen	Vadodara
Anti-Stripping Agents	Mumbai, New Delhi and Ahmedabad.
Portland Cement	Locally available in all towns
Reinforcing Steel	Locally available in all major towns
Admixtures, Curing Compounds	Mumbai & Ahmedabad
Bricks	Locally available
Geosynthetics	Mumbai & Ahmedabad

14. PAVEMENT DESIGN

14.1 Introduction

This section covers the evaluation and design of pavements. The rehabilitation/upgrading works includes pavement strengthening, reconstruction, and new construction associated with alignment improvements.

The findings and recommendations presented below are based on the investigations carried out.

14.2 Methodology

The study and subsequent detailed design followed well established steps and procedures, including the following:

- Collection and review of available data;
- Planning of investigations;
- Field investigation;
- Analysis of data and identification of alternatives;
- Pavement crust thickness design; and
- Cost comparisons.

14.3 Data Review

This task included the collection and review of a variety of documents and reports, of relevance to the project, including the following:

Reports

Design Standards for Geometric Design and, Overlay and New Flexible Pavement Design; and

Maps and Other Published Data

Soils Maps;

Water table Data Maps - Gujarat Water Resources Development Corporation; and

Temperature and Rainfall Data - Gujarat Water Resources Development Corporation.

14.4 Data Collection and Investigation

14.4.1 Road Inspections

Road inspections were conduced at various stages during the project, starting with the initial road inspections which were designed to develop a good knowledge of the road and to assist in the preparation of the testing program. This was followed by more detailed inspections, sample collections and even verification of laboratory test results in the field.

14.4.2 Visual Condition and Inventory Surveys

The condition surveys focused on present pavement appreciation and examining road side conditions (fill height, depth of drains, off set to drains, drainage conditions, etc). This included

visual condition survey (covering cracking, rutting, patching, roughness, pavement failures, etc) which was used in the review of pavement investigation data and the development of pavement design proposals.

14.4.3 Deflection Testing

The testing approach was essentially according to IRC 81-1981. The deflection surveys completed in June 2007. The data was recorded for the deflection by Benkelman beam for each 1 kilometre of road. This resulted in 21 lane kilometres of deflection measurement (at 25 metre intervals in each kilometre) which included 165 km of data for the roads covered.

The data recorded at each survey point included D-200mm (was taken to ensure actual initial reading and not engaged in analysis), D0mm (Initial), D2700mm (Intermediate) and D9000mm (Final) and maximum rebound deflection was calculated.

The pavement deflection readings and analysis is attached separately in Volume-II (Appendix-10).

14.4.4 Subgrade Investigations

The testing approach, and the tests actually carried out at each site are followed in accordance with the finalised methodology. The test procedure at each site included the taking of samples (one at subgrade level for laboratory testing) and insitu moisture.

14.4.5 Axle Load Survey

Axle load surveys were carried out in June 2007. These locations were identified following a review of the traffic data detailed in traffic report, in which the traffic distribution characteristics were analysed and the data (sites) grouped into “like” characteristics.

The details considered in pavement design are presented in Volume-II (Appendix-10).

14.4.6 Pavement Materials Investigations

Pavement material investigation focused on the identification and verification of materials that could be used for road construction. This included materials required for road embankment and concrete construction (drainage structures and bridges), as well as those required for pavements.

14.5 Pavement Design

The pavement design process included the design of new pavements, pavement strengthening and widening treatments. The design approach included Indian Standard procedures. The designs were based on a design period of 15 years. It was also assumed that minor crack sealing treatments would be attended as and when required.

14.5.1 Pavement Cross -Section

A key part of all the design approaches is the determination of the likely in-service moisture conditions under the road, as this influences the subgrade strength and therefore the pavement thickness. Important features of the adopted pavement cross-section includes paved shoulders, to minimise water entry, and granular (dense graded or equivalent) shoulders to allow proper serviceable pavement. Standard four lane divided carriage way configuration is adopted, with lane width of 3.5m.

14.5.2 New Pavements, Pavement Reconstruction and Widening

The design of new and to be partly/fully reconstructed pavements (and widening) has been based on the CBR design method as per IRC-37:2001. The adopted design CBR was determined from the test results of samples collected from selected borrow areas (at 4 days soaked on 97% MDD). Traffic in MSA was calculated from 7 days classified traffic volume count survey at different locations on the corridor.

14.5.3 Overlays and Pavement Rehabilitation

Data Analysis

Deflection test results (maximum rebound deflection at each test point) were analysed in a multi stage process which included the determination and application of seasonal factors, the correction for front leg (of the beam) movement, the exclusion of high and low readings and the determination of a characteristics deflection, for each kilometre section.

Overlay Design

The designs were carried out in accordance with the IRC – 81:1997; Guidelines for Strengthening of Flexible Road Pavement Using Benkelman Beam Deflection Technique. As the existing pavement is surfaced with bituminous pavement, bituminous overlay was designed for the entire corridor.

The final selection of thickness was based on costs, construction considerations and the overall structural need. The overlay requirements and proposed Thicknesses are presented in Volume-II (Appendix-10).

Reconstruction

Reconstruction includes removing the existing pavement, prior to reworking the underlying subgrade and the construction of a new pavement that could incorporate the salvaged pavement material (after it had been crushed and screened - where this is economical), as a lower layer in the new pavement. The pavement construction, which is similar to new construction, typically consists of an AC/DBM surfacing/base layer, a WMM base, a granular or stabilised sub-base and a select subgrade.

Also include the reconstruction of the existing shoulder area that will include a structural pavement, which provides for the drainage needs of the total pavement structure. This is catered for by ensuring the base and sub-base layers are constructed, of the same thickness for the full width of the road formation, through to the batter slopes.

14.6 Pavement Structure

14.6.1 Reconstruction, Pavement Widening and New Construction

The pavement structure adopted for the reconstruction of road pavements and shoulders is basically the same in entire corridor, an AC/DBM surfacing/base, a crushed gravel WMM base course layer, a sub-base (various material types) and a select subgrade (various material types). The adoption of this structure was largely influenced by the availability of materials and contractor capability.

14.6.2 Overlays

The pavement structure adopted for the overlays was similar in entire corridor. DBM and BC provided for the overlay and thickness was taken as similar to new construction to maintain structure of the pavement and avoid construction conflict.

14.6.3 Design Traffic

The design traffic is 308 MSA (15 year design life) for both road sections. Table of pavement crust thickness with overlay given in Volume-II (Appendix-10).

14.6.4 Pavement Thickness Requirements

General

The proposed road strengthening/reconstruction requirements could range from medium thickness overlays through to full reconstruction of the existing road, including the removal of the existing pavement and the reworking of the underlying layers. Out of 168 Km 16 Km of left carriageway and 8 Km of the right carriageway, reconstruction is proposed because of the unevenness (and roughness) of the road surface, and poor surface condition.

Proposed Road strengthening and Reconstruction Needs

Table 14-1 provide details of the strengthening and reconstruction and new pavement construction requirements for this road. The preferred treatment at each location is indicated in table.

Table 14-1: Pavement Requirements

Chainagae		Left Lane (UP)		Right Lane (Dn)		New Construction in Widening
From (Km/m)	To (Km/m)	Present Serviceability	Strengthening Requirement	Present Serviceability	Strengthening Requirement	
14.6	15	Very Good	Overlay	Very Poor	Overlay	Yes
15	16	Very Good	Overlay	Very Poor	Overlay	Yes
16	17	Very Good	Overlay	Very Poor	Overlay	Yes
17	18	Very Good	Overlay	Very Poor	Overlay	Yes
18	19	Very Good	Overlay	Very Poor	Overlay	Yes
19	20	Very Good	Overlay	Very Poor	Overlay	Yes
20	21	Very Good	Overlay	Very Poor	Overlay	Yes
21	22	Very Good	Overlay	Very Poor	Overlay	Yes
22	23	Very Good	Overlay	Very Poor	Overlay	Yes
23	24	Very Good	Overlay	Very Poor	Overlay	Yes
24	25	Very Good	Overlay	Very Poor	Overlay	Yes
25	26	Very Good	Overlay	Very Poor	Overlay	Yes
26	27	Very Good	Overlay	Very Poor	Overlay	Yes
27	28	Very Good	Overlay	Very Poor	Overlay	Yes
28	29	Very Good	Overlay	Very Poor	Overlay	Yes
29	30	Very Good	Overlay	Very Poor	Overlay	Yes
30	31	Very Good	Overlay	Very Poor	Overlay	Yes
31	32	Very Good	Overlay	Very Poor	Overlay	Yes
32	33	Very Good	Reconstruction	Very Poor	Overlay	Yes
33	34	Very Good	Reconstruction	Very Poor	Overlay	Yes
34	35	Very Good	Reconstruction	Very Poor	Overlay	Yes
35	36	Very Good	Reconstruction	Very Poor	Overlay	

Chainagae		Left Lane (UP)		Right Lane (Dn)		New Construction in Widening
From (Km/m)	To (Km/m)	Present Serviceability	Strengthening Requirement	Present Serviceability	Strengthening Requirement	
36	37	Very Good	Reconstruction	Very Poor	Overlay	
37	38	Very Good	Overlay	Very Poor	Overlay	
38	39	Very Good	Overlay	Very Poor	Overlay	
39	40	Very Good	Overlay	Very Poor	Overlay	
40	41	Very Good	Overlay	Very Poor	Overlay	
41	42	Very Good	Overlay	Very Poor	Overlay	
42	43	Very Good	Overlay	Very Poor	Overlay	
43	44	Very Good	Overlay	Very Poor	Overlay	
44	45	Very Good	Overlay	Very Poor	Overlay	
45	46	Very Good	Overlay	Very Poor	Overlay	
46	47	Very Good	Overlay	Very Poor	Overlay	
47	48	Very Good	Overlay	Very Poor	Reconstruction	
48	49	Very Good	Overlay	Very Poor	Overlay	
49	50	Very Good	Overlay	Very Poor	Overlay	
50	51	Very Good	Overlay	Very Poor	Overlay	
51	52	Very Good	Overlay	Very Poor	Overlay	
52	53	Very Good	Overlay	Very Poor	Overlay	
53	54	Very Good	Overlay	Very Poor	Overlay	
54	55	Very Good	Overlay	Very Poor	Overlay	
55	56	Very Good	Overlay	Very Poor	Overlay	Yes
56	57	Very Good	Overlay	Very Poor	Overlay	Yes
57	58	Very Good	Overlay	Very Poor	Overlay	
58	59	Very Good	Overlay	Very Poor	Overlay	
59	60	Very Good	Overlay	Very Poor	Overlay	Yes
60	61	Very Good	Reconstruction	Very Poor	Overlay	Yes
61	62	Very Good	Reconstruction	Very Poor	Overlay	Yes
62	63	Very Good	Reconstruction	Very Poor	Reconstruction	
63	64	Very Good	Reconstruction	Very Poor	Overlay	
64	65	Very Good	Overlay	Very Poor	Overlay	
65	66	Very Good	Reconstruction	Very Poor	Overlay	
66	67	Very Good	Overlay	Very Poor	Overlay	
67	68	Very Good	Reconstruction	Very Poor	Overlay	
68	69	Very Good	Overlay	Very Poor	Overlay	
69	70	Very Good	Overlay	Very Poor	Overlay	
70	71	Very Good	Reconstruction	Very Poor	Overlay	
71	72	Very Good	Reconstruction	Very Poor	Overlay	
72	73	Very Good	Overlay	Very Poor	Overlay	
73	74	Very Good	Overlay	Very Poor	Overlay	
74	75	Very Good	Overlay	Very Poor	Overlay	
75	76	Very Good	Overlay	Very Poor	Overlay	
76	77	Very Good	Overlay	Very Poor	Overlay	
77	78	Very Good	Overlay	Very Poor	Overlay	
78	79	Very Good	Overlay	Very Poor	Overlay	
79	80	Very Good	Overlay	Very Poor	Overlay	
80	81	Very Good	Overlay	Very Poor	Overlay	
81	82	Very Good	Overlay	Very Poor	Overlay	
82	83	Very Good	Reconstruction	Very Poor	Overlay	

Chainagae		Left Lane (UP)		Right Lane (Dn)		New Construction in Widening
From (Km/m)	To (Km/m)	Present Serviceability	Strengthening Requirement	Present Serviceability	Strengthening Requirement	
83	84	Very Good	Overlay	Very Poor	Overlay	
84	85	Very Good	Overlay	Very Poor	Overlay	
85	86	Very Good	Reconstruction	Very Poor	Overlay	
86	87	Very Good	Overlay	Very Poor	Overlay	
87	88	Very Good	Overlay	Very Poor	Overlay	
88	89	Very Good	Overlay	Very Poor	Overlay	
89	90	Very Good	Overlay	Very Poor	Overlay	
90	91	Very Good	Overlay	Very Poor	Overlay	
91	92	Very Good	Overlay	Very Poor	Overlay	
92	93	Very Good	Overlay	Very Poor	Overlay	
93	94	Very Good	Overlay	Very Poor	Reconstruction	
94	95	Very Good	Overlay	Very Poor	Reconstruction	
95	96	Very Good	Overlay	Very Poor	Reconstruction	
96	97	Very Good	Overlay	Very Poor	Reconstruction	
97	98	Very Good	Overlay	Very Poor	Overlay	
98	99	Very Good	Overlay	Very Poor	Reconstruction	
99	100	Very Good	Overlay	Very Poor	Overlay	
100	101	Very Good	Overlay	Very Poor	Overlay	
101	102	Very Good	Overlay	Very Poor	Reconstruction	
102	103	Very Good	Overlay	Very Poor	Overlay	Yes
103	104	Very Good	Overlay	Very Poor	Overlay	Yes
104	105	Very Good	Overlay	Very Poor	Overlay	
105	106	Very Good	Overlay	Very Poor	Overlay	
106	107	Very Good	Overlay	Very Poor	Overlay	
107	108	Very Good	Overlay	Very Poor	Overlay	
108	109	Very Good	Overlay	Very Poor	Overlay	
109	110	Very Good	Overlay	Very Poor	Overlay	
110	111	Very Good	Overlay	Very Poor	Overlay	
111	112	Very Good	Overlay	Very Poor	Overlay	
112	113	Very Good	Overlay	Very Poor	Overlay	
113	114	Very Good	Overlay	Very Poor	Overlay	
114	115	Very Good	Overlay	Very Poor	Overlay	
115	116	Very Good	Overlay	Very Poor	Overlay	
116	117	Very Good	Overlay	Very Poor	Overlay	
117	118	Very Good	Overlay	Very Poor	Overlay	
118	119	Very Good	Overlay	Very Poor	Overlay	
119	120	Very Good	Overlay	Very Poor	Overlay	
120	121	Very Good	Overlay	Very Poor	Overlay	
121	122	Very Good	Overlay	Very Poor	Overlay	
122	123	Very Good	Overlay	Very Poor	Overlay	
123	124	Very Good	Overlay	Very Poor	Overlay	
124	125	Very Good	Overlay	Very Poor	Overlay	
125	126	Very Good	Overlay	Very Poor	Overlay	
126	127	Very Good	Overlay	Very Poor	Overlay	
127	128	Very Good	Overlay	Very Poor	Overlay	
128	129	Very Good	Overlay	Very Poor	Overlay	
129	130	Very Good	Overlay	Very Poor	Overlay	

Chainagae		Left Lane (UP)		Right Lane (Dn)		New Construction in Widening
From (Km/m)	To (Km/m)	Present Serviceability	Strengthening Requirement	Present Serviceability	Strengthening Requirement	
130	131	Very Good	Overlay	Very Poor	Overlay	
131	132	Very Good	Reconstruction	Very Poor	Overlay	
132	133	Very Good	Overlay	Very Poor	Overlay	
133	134	Very Good	Overlay	Very Poor	Overlay	
134	135	Very Good	Overlay	Very Poor	Overlay	
135	136	Very Good	Overlay	Very Poor	Overlay	
136	137	Very Good	Overlay	Very Poor	Overlay	
137	138	Very Good	Overlay	Very Poor	Overlay	
138	139	Very Good	Overlay	Very Poor	Overlay	
139	140	Very Good	Overlay	Very Poor	Overlay	
140	141	Very Good	Overlay	Very Poor	Overlay	
141	142	Very Good	Overlay	Very Poor	Overlay	
142	143	Very Good	Overlay	Very Poor	Overlay	
143	144	Very Good	Overlay	Very Poor	Overlay	
144	145	Very Good	Overlay	Very Poor	Overlay	
145	146	Very Good	Overlay	Very Poor	Overlay	
146	147	Very Good	Overlay	Very Poor	Overlay	
147	148	Very Good	Overlay	Very Poor	Overlay	Yes
148	149	Very Good	Overlay	Very Poor	Overlay	Yes
149	150	Very Good	Overlay	Very Poor	Overlay	
150	151	Very Good	Overlay	Very Poor	Overlay	
151	152	Very Good	Overlay	Very Poor	Overlay	
152	153	Very Good	Overlay	Very Poor	Overlay	
153	154	Very Good	Overlay	Very Poor	Overlay	
154	155	Very Good	Overlay	Very Poor	Overlay	
155	156	Very Good	Overlay	Very Poor	Overlay	
156	157	Very Good	Overlay	Very Poor	Overlay	
157	158	Very Good	Overlay	Very Poor	Overlay	
158	159	Very Good	Overlay	Very Poor	Overlay	
159	160	Very Good	Overlay	Very Poor	Overlay	
160	161	Very Good	Overlay	Very Poor	Overlay	
161	162	Very Good	Overlay	Very Poor	Overlay	
162	163	Very Good	Overlay	Very Poor	Overlay	
163	164	Very Good	Overlay	Very Poor	Overlay	
164	165	Very Good	Overlay	Very Poor	Overlay	
165	166	Very Good	Overlay	Very Poor	Overlay	
166	167	Very Good	Overlay	Very Poor	Overlay	
167	168	Very Good	Overlay	Very Poor	Overlay	
168	169	Very Good	Overlay	Very Poor	Overlay	Yes
169	170	Very Good	Overlay	Very Poor	Overlay	Yes
170	171	Very Good	Overlay	Very Poor	Overlay	Yes
171	172	Very Good	Overlay	Very Poor	Overlay	
172	173	Very Good	Overlay	Very Poor	Overlay	
173	174	Very Good	Overlay	Very Poor	Overlay	
174	175	Very Good	Overlay	Very Poor	Overlay	
175	176	Very Good	Overlay	Very Poor	Overlay	
176	177	Very Good	Overlay	Very Poor	Overlay	

Chainagae		Left Lane (UP)		Right Lane (Dn)		New Construction in Widening
From (Km/m)	To (Km/m)	Present Serviceability	Strengthening Requirement	Present Serviceability	Strengthening Requirement	
177	178	Very Good	Overlay	Very Poor	Overlay	
178	179	Very Good	Overlay	Very Poor	Overlay	
179	180	Very Good	Overlay	Very Poor	Overlay	
180	181	Very Good	Overlay	Very Poor	Overlay	
181	182	Very Good	Overlay	Very Poor	Overlay	
182	182.4	Very Good	Overlay	Very Poor	Overlay	

14.7 Road Design and Construction Considerations

14.7.1 General

The present road formation varies in overall width with earthen shoulders of between 1.0 and 2.0 metres. There are also variations in fill height with these ranging between 0.5 and 2.0 metres above the natural surface and up to a further 0.5 metre above the invert of side drains, which flank both sides of the road.

14.7.2 Site Conditions

The available data indicates that the ground conditions, near the road, may be wet in rainy season in areas where the terrain is flat and the adjacent land is irrigated and during a part of the dry season it becomes dry. The side drains will be wet and possibly filled with water, during and immediately after the wet season. The wet ground conditions could affect the widening process.

Poor quality soil, mainly expansive soils, could also slow down construction, when conditions are wet in starting portion of the corridor.

The non plastic or low plasticity soils, found over the sandstone may also be prone to erosion and will need to be protected where water flows are expected (longitudinal drains and culvert outlets). It is worth noting that lined drains are present in a number of locations.

14.7.3 Pavement construction/reconstruction

Pavement reconstruction and shoulder reconstruction (as part of an overlay treatment) will therefore need to include the reworking of the existing subgrade, before the covered with a new pavement and/or imported subgrade material placed to re-profile the road.

Alternatively side tracks could be constructed for the diversion of traffic during construction.

14.7.4 Pavement maintenance

The existing pavement has been resurfaced for significant lengths in the last two years. It is also likely that there would be a need for another resurfacing treatment (some sections) if the construction of this road is delayed. As this is a possibility it is important that the contract documents are clear on the contractor's maintenance responsibilities and the standard of work required.

It is therefore possible that the road surface levels will be different to those surveyed and used in the design.

15. DESIGN OF CD STRUCTURES AND GRADE SEPARATORS

15.1 Introduction

This section of the report gives detailed information on the existing structural condition, widening scheme for the existing structures, rehabilitation scheme and proposals for new construction.

The survey revealed that the project corridor has 245 structures. The Table 15-1 below provides the details about structures on the study corridor.

Table 15-1: Total Number of Structures:

Type of Bridge		Numbers
Major Bridge	2 Nos. each at 3 Locations	6
Minor Bridge	2 Nos. each at 50 Locations	100
RoB	2 at 2 Locations	4
Culverts	At 135 Locations	135
	Total	**245**

15.2 Review of Existing Data

- Available data with department and through authentic sources got collected, reviewed and used to have appropriate Design proposals.

15.3 Design Considerations

15.3.1 Concrete

Grade of concrete in various elements considered is as under for moderate conditions of exposure.:

Type of Structure	Major Bridges/Flyover	Minor Bridges	Culverts
PSC structure	M40 / M45	-	-
RCC structure	M30/ M35	M30	M25
PCC structure	-	M25	M20
PCC levelling course	M15	M15	M15

15.3.2 Reinforcement

The reinforcement shall conform to one of the following specifications:

- High yield strength deformed bars conforming to IS: 1786 – 1979 (Grade Fe 415).
- Mild Steel bars conforming to IS:432 (Part1) - 1966 (Grade Fe 240)

Prestressing Steel and System

a) System: 12T13 / 19T13 multiple strand system of “Freyssinet” or “IS MAL CCL” or equivalent.

b) Cables: 12T13 / 19T13 cables with strands of 12.7 mm nominal dia.

c) High Tensile Steel

- Strands: 12.7mm low relaxation strands conforming to IS 14268 95.
- Area: 98.7mm^2 per strand
- Ultimate Load: 183.71 KN per strands

- Modulus of Elasticity: 1.95 x 10^5 Mpa
- Friction Coefficient: 0.2/radian
- Wobble Coefficient: 0.003/m
- Anchorage Slip: 6mm average
- Loss of force due to relaxation: 2.5% at 0.7 UTS after 1000 hrs.

Structural Steel

Structural steel will conform to IS: 226 with yield stress of 23.6 Kg/cm^2.

Bearings

Depending upon the type of structure, span length of each superstructure and skew angle, either Pot fixed / Pot cum PTFE sliding bearings or elastomeric bearing has been suggested as per design requirement.

Expansion Joints

Three type of expansion joints are suggested for bridge structures:

1. Strip seal type of expansion joint is proposed for PSC box girder, PSC T-girders and RCC T-Girder type superstructures.
2. Filler type expansion joint is proposed for RCC solid slab and box type structures.

Loads and Load Combinations

Dead Loads

The following Unit weights are taken into consideration for designs as per IRC Codes.

- Reinforced Concrete 2.4 t/m^3
- Pre-stressed Concrete 2.5 t/m3
- Plain Concrete 2.2 t/m^3
- Structural Steel 7.85 t/m^3
- Wearing Coat 2.2 t/m^3

Superimposed Dead Loads

- **Wearing Coat:**

Mastic asphalt 25 mm thick over 40mm thick asphaltic concrete layers considered for the wearing coat. The additional superimposed load considered for wearing coat @ 200 Kg/m^2 on the carriageway (future overlay) shall be considered in the design.

- **Crash Barrier:**

The concrete crash barrier with 500 mm width is proposed to be provided adjacent to the carriageway on either side. Loading may be considered as1.6 t/m for both edges.

Carriageway Live Loads

The bridge will be designed for the worst combination of the following live loads on the carriageway:

1. Three lanes of IRC Class A loading.
2. One lane of IRC Class 70R (Wheeled /Tracked) + one lane of IRC Class A loadings.

Longitudinal forces

Following effects shall be considered in the design:

- Braking force as per the provision of clause 214 of IRC: 6
- Distribution of longitudinal forces due to horizontal deformation of bearings/frictional resistance offered to the movement of free bearings as per clause 214.5 of IRC: 6.

Horizontal Forces due to Water Current

Portion of road bridges which may be submerged in running water shall be designed to sustain safely the horizontal pressure due to force of current as per the stipulations of clause 213 of IRC: 6-2000.

Seismic Loading

The bridges are located in seismic Zone - III as per the IRC: 6-2000. Hence seismic force will be considered only for those bridges having an overall length of more than 60.0 m and Span length more than 15 m.

Wind Loading

Structures shall be designed for wind effects as per the clause 212 of IRC: 6-2000.

Load Combination

All members shall be designed to sustain safely the critical combination of various loads and forces that can co-exist. Various load combinations as relevant with increase in permissible stresses considered in the design shall be as per Clause 202 of IRC: 6 and Clause 706 of IRC: 78

Exposure Condition

The project corridor is located in the central and saurashtra region of Gujarat for that the condition of exposure is considered as “Moderate” for the purpose of design.

Cover to Reinforcement

The following concrete covers are proposed to be used for various structural components:

- Foundation : 75mm
- Substructure : 50mm
- Superstructure : 40 mm

Slope and River Protection Works

Proper approach/slope protection will be provided as per IRC 89 and as per national and international practices.

15.4 Rehabilitation Measures

The repair and rehabilitation strategy of structures is divided broadly in two types i.e. 1) Major repair work and 2) General repair work.

I) Major Repair for Bridges

Major repair for bridges includes the following activities:

- Widening / Reconstruction of Existing Substructure in part or full as applicable
- Widening of Existing Super-structure

- Chip-off the Concrete at end 0.5m (minimum) of Deck Slab in full or partial depth at the Engineer's discretion. Repair or Reconstruct the cut portion and provide new Crash Barrier and Drainage Spout.
- Repair of cracks at pier / abutment and their Caps
- Reconstruction of Median Retaining Wall
- Removing of Existing (in damaged areas at the Engineer's discretion) and laying new Wearing Coat with proper cross fall to maintain the drainage
- Providing new stone pitching at embankment slopes with stone masonry steps to provide access to Sub-Structure and River Bed Level
- Remedial measures for protection of scoured riverbed by providing Floor Mattress, etc as required and as directed by the Engineer.
- Cleaning of Existing Expansion Joints and / or providing and fixing New Expansion Joints in entire / partial width of the deck as required and as directed by the Engineer.
- Repair / Reconstruction of Dirt Wall and / or Approach Slab in full / partial width as per site condition at the Engineer's discretion

II) General Repair work for Bridges:

General repair work includes the following activities

- Repair of Honeycombing
- Repair of Spalling of Concrete
- Repair / replacing of Exposed / Corroded Reinforcement at Deck Slab Soffit and / or Girder Bulbs
- Repair of existing Median Walls
- Repair of Wing / Return Walls
- Making up the Depression at Approach Slab by Bituminous Concrete Surfacing as per site condition and as directed by the Engineer
- Installation/ Rectification of Drainage Spouts as per site condition and as directed by the Engineer
- Providing Drip Course at Slab / Deck Edges
- Repair of damaged Stone Pitching and providing stone masonry steps to access sub-structure and riverbed level.
- Repair or Reconstruction of damaged Railing / parapet / crash barrier to match the Existing in part or entire length at the Engineer's discretion.

Repair for culverts

Repair work for Pipe Culverts:

Most of the pipe culverts are observed to have smooth flow conditions, but quite a few numbers are found to be partially choked. Internal diameters of the pipes are large enough to be cleaned to remove the deposition.

The headwalls of the culverts were found to be in good shape, with minor cracks at places. The damaged section of the headwalls needs repairs.

Repair work of Slab culverts:

Detailed visual inspection of the slab culverts revealed that there are some cracks of varying width at the deck, soffit. Also other defects like Spalling, exposed and corroded reinforcement were observed in some cases.

Methodology for General Repair/Rehabilitation recommendations:

Crack repairs

For cracks smaller than 0.3 mm, high thermoset monomers such as 'Monopol' of Krishna Conchem or equivalent are recommended. For cracks between 0.3 mm to 1.0 mm, low viscosity epoxy injections such as 'KP 250/HP 259 'of Krishna Conchem or equivalent is recommended. For the cracks larger than 1 mm, polymer modified cement grout 'Rendroc –RG' of Fosroc Chemical or equivalent can be used.

Spalling

Minor distress repair of concrete is considered with anticorrosive polymer modified mortar such as 'Monoband 2000' of Krishna conchem or equivalent.

Concrete bonding agent:

To ensure good bonding between old and new concrete, structural grade epoxy bonding agent is recommended 'Nitobond – FP' of Fosroc chemicals or equivalent.

Coating for old reinforcement bar

Epoxy phenolic based coating is preferred for its better affinity and crust penetrating quality, one coat of EPCO – KP – 100 migratory corrosion barrier followed by a coating of IPNET-RB of 'Krishna Conchem or equivalent.

Repair of Corroded/ Exposed reinforcement

Corroded reinforcement shall to be cleaned by wire brushing/ grit blasting, thereafter ziwerech of FOSROC or equivalent shall be applied before allowing concreting.

15.5 Design and Rehabilitation Requirements

The design and rehabilitation requirement for the grade separators and cross drainage structures with respect to the project corridor is discussed in this sub-section. The inventory survey reveals that some major bridges need to be constructed newly and keeping partially access controlled measures in mind major intersections need to be designed as grade separated in the form of fly over.

15.5.1 Grade Separated facilities at Major Intersection

Based on studies and addressing partially access controlled needs the proposals for grade separated facilities are considered as follows:

1) **At km 32.300:** At this intersection the project corridor intersects with the state highway from Bavla to Sanand. The ROB at Bavla begins just after the intersection. To avoid congestion at this intersection, an obligatory span of 45m and side span of 25 m is proposed retaining the approach of ROB as solid one at same level with RE wall.
2) **At km 56.440:** The state highway leading to Dholka intersects the project corridor due to which an obligatory span of 45 m and two side spans of 25 m and approach ramp with RE wall are proposed.
3) **At Bagodara town:** At this location there are 3 three junctions, one at km 59.980 leading to Tarapur on LHS of the project corridor, second at km 60.750 leading to Nalsarovar on RHS of the project corridor and the third at km 61.340 leading Bhavnagar through Dhanduka on

LHS of the project corridor. Since all the three are closely placed an elevated main carriage way with flyover for 0.85 km alongwith viaduct portion for at garde mobility.

4) **At km 102.700:** At this intersection a SH from Limdi city leading towards Surendranagar intersects the project corridor. A flyover with two side spans of 25 m & two obligatory spans of 40 m with approach ramp as RE wall is proposed.

5) **At km 148.190:** SH leading to Surendranagar/Muli connects the project corridor at this location, to avoid conflicts to the traffic, two side spans of 25 m & two obligatory spans of 40 m with RE approach ramp are proposed.

6) **At km 168.975** - At this junction, an elevated flyover with 0.550 km viaduct is provided over the two intersections one leading to Chotila town and the other to the Chotila temple at chainage 169.950

15.5.2 Bridges and CD Structures

The following structures are proposed to be built as new structures:

1. Bhogavo River Bridge
2. Nalla River Bridge
3. Harbad River Bridge
4. Flyover at km 14.600
5. Flyover/ ROB at km 32.300 & 32.600
6. Flyover at km 56.440
7. Flyover at Bagodara Town
8. Flyover at km 102.700
9. Flyover at km 148.190
10. Flyover at Chotila Town

15.6 Geotechnical Investigation and Findings

The geotechnical investigation involving sub soil exploration by drilling a bore hole at each Major Bridge and even at Flyover was carried out. Location and depth of bore hole is as below.

Table 15-2: Location and depth of bore hole at Bridges

Sr No	Structure No	Name of River	Depth of Bore	Distance
1	66/1	Bhogavo	25	20m from centre of existing low level (LHS) bridge
2	70/1	Nalla	25	20m from centre of existing low level (LHS) bridge
3	72/1	Harbad	25	20m from centre of existing (LHS) bridge

Table 15-3: Location and depth of bore hole at Bridges at flyover

Sr No	Chainage	Depth of Bore	Location
1	32.300	25	NH -8A & Bavla - Sanand Junction
2	56.400	25	NH -8A & Dholka Junction
3	59.980	25	NH -8A & Bhavnagar Junction
4	102.700	25	Nh -8A & Limdi - Surendranagar Junction
5	148.190	25	Nh -8A & Muli / Surendranagar Junction
6	168.975	25	Chotila Town

The soil Investigation report is appended as Volume-II (Appendix-10).

Based on results of the soil investigation and the soil strata, it is considered appropriately to have Well foundation for river bridges, and pile foundations for flyovers.

15.7 Reconstruction and Rehabilitation Alternatives

Reconstruction and rehabilitation of existing bridges and other CD structures depends upon present structural conditions and available width of carriageway. Flyover structures are designed for 6 lane configuration.

For major bridges recommendations for 'reconstruction' has been proposed in few cases where the existing structure is found to be structurally weak, and/or hydraulically inadequate.

Most of the minor bridges and culverts on old carriageway (LHS) have already reached nearly 80% of their design life. Structures showing distress and fatigue and may not remain serviceable for longer period. Hence most of existing structures (LHS) need to be replaced by new structures and widening proposed for structures on RHS.

For Structures the main recommendations can be categorized as :

Major Bridges

There are 3 major bridges (considering both carriageways) on the project corridor. All new bridges (RHS) have 18.30 m span of RCC T-girder type of superstructure, resting on RCC/ PCC substructures, supported by Well foundations. The old (LHS) structures are RCC solid slab, resting on PCC sub-structure, with Well/Open foundation.

The condition of the old bridges in general is poor, as spalling of concrete, exposed and corroded reinforcement, honey combing in deck slab is noted. At many locations the drainage arrangement is deficient and outlets of drainage spouts are seen flushed with the superstructure, and hence are a source for rusting of the reinforcement. In view of the situation, it is proposed that the old bridges are to be reconstructed.

Newly proposed bridge shall be for 3 – lane carriageway facility with one side footpath. To avoid the disturbance in hydrology of river and also the regime, it is proposed to adopt same span arrangement as provided for the bridge on the adjacent lane. The proposal of 18.30 m span arrangement with RCC T- beam and slab is economical. It is proposed to rest over RCC pier with well foundations. The new proposed bridges are at 20 m away from the centre of the existing old bridge.

The proposed overall width of structures will be 13.55 m, i.e. those are recommended for reconstruction. This is applicable for only 3 major bridges. The bridge is designed for 3- lane loading. The configuration is as in the Table 15-4 below

Table 15-4: Recommended Configuration

Details of Bridge	Width (m)
Kerb & Railing	0.55
Footpath	1.5
Shyness left side	0.25
Shyness Right side	0.25
Carriageway	10.5
Crash barrier	0.5
Total Width	13.55

Minor Bridges

The overall width of structures is proposed as 13.75 m designed for 3- lane loading. The detailed configuration is as given in the Table 15-5. The new structures will be constructed at the same location of the existing bridges.

Other structures will be widened to 13.75 m for each carriageway, where two separate bridges are located for different carriageways i.e. in the super structures and as well as in substructure and foundations.

Table 15-5: Proposed Configuration

Details of Bridge	Width (m)
Crash Barrier (LHS)	1.0
Paved Shoulder	1.5
Carriage way	10.5
Shyness	0.25
Crash Barrier (RHS)	0.5
Total Width	**13.75**

ROB

For ROB at km 32/600, on RHS carriageway, the widening to 3 lane capacity would be possible by constructing additional 2 new bridges parallel to existing bridges or dismantling the cantilever portion of deck and provide same size of girder as per existing bridge in the widened portion. For LHS carriageway, due to raised profile, it is required to propose new ROB for 3 lane with one side footpath.

For ROB at km 105/400, looking to the existing carriageway, the widening to 3 lane capacity for both sides would be possible by constructing additional 2 new bridges parallel to existing bridges or dismantling the cantilever portion of deck and provide same size of girder as per existing bridge in the widened portion.

Culverts

The overall width of the culverts is provided for 6- lane configuration. The proposed width will vary from 32.0 m to 45.0 m based on location (Urban or Rural) of structures. This is applicable for new construction as well as widening of existing structures.

Widening of pipe/slab culverts

For the pipe culverts, pipes shall be placed properly in order to maintain the required slope for the free flow of water. In many locations, two separate culverts are located for different carriageway. Hence widening will be up to 14.25m for each carriageway. Stone pitching shall be provided for slope protection and bed protection as per IRC 89.

Where spread type wing walls are present, the same in case of widening shall be dismantled and reconstructed at a new location with PCC and or RCC types.

Grade Separators

To have the partial access control highway, the provision of grade separators at justified locations has been made. The importance has been given to the smooth and safe movement of traffic for crossing the highway with desired turning movement. The provision of service roads has also been made to have the easy movement of local traffic. Obligatory span of 40m/45m has been provided for

the crossing traffic along with the provision of 2 spans of 25m each on either side of the obligatory span to cater the eventuality of increase in traffic in future. To achieve the economy, the provision of reinforced earth walls has been made in the approaches of grade separators. The Reinforced earth wall provision induces the economy in the land acquisition as at most of the places the 6- lane carriageway has been accommodated in about 45 m width of land i.e. a considerable saving in land acquisition and the clearance of utilities and demolition of structures as well.

Pile foundations of 1200 mm dia have been proposed. The depth of pile may vary accordingly to the subsoil parameters. The obligatory span shall be prestressed post tensioned box and other span superstructure shall also be in PSC girder and RCC deck slab system supported over RCC pier/ abutments. The superstructure shall be supported over Elastomeric / POT- PTFE bearings as per requirements. The carriageway on the grade separators has been kept for 3- lane facility with RCC safety barrier.

The overall width of the proposed flyover for each carriageway and the configuration is provided in the Table 15-6.

Table 15-6: Proposed Configuration

Details of Flyover	Width (m)
Crash Barrier (LHS)	0.5
Shyness	0.25
Carriage way	10.5
Shyness	0.25
Crash Barrier (RHS)	0.5
Total Width	**13.75**

Underpass

For pedestrian/ Vehicle crossing, underpasses have been provided at the following chainages.

1) at ch.19.100 km
2) at ch.23.925 km

The width of underpass is 10.5 m (7.50 m + 2 x 1.50 m footpath) and height is 5.50 m.

Cattle Crossing

Cattle crossing have been provided at the following chainages.

1) At ch.90.200 km
2) At ch.123.800 km
3) At ch. 160.800 km

The width of cattle crossing is 4.50 m and height is 3.00 m.

The General Arrangement Drawings (GAD) for each of above locations is provided in Volume-III A of this report.

Rehabilitation Scheme for Existing CD Structures

Repair and rehabilitation work includes widening of minor bridges and general repair work. Widening may be of two types i.e. symmetrical and asymmetrical depending upon the geometry of the road and structural requirement.

Widening of T-Girder Superstructure

T-Girder and Deck Slab:

In case widening of the T-Girder superstructure, the cantilever portion of deck shall be dismantled without damaging the existing reinforcement. New girder having the same dimensions of the existing with same spacing between the girders should be provided. The number of girders provided will depend on the width of widening. The reinforcement provided in the widened portion of deck and the new girder shall be as of that of the existing one. Cross girders shall be extended where existing cross girders are projected beyond longitudinal girder and in case if cross girders cannot be extended beyond longitudinal girder, reinforcement of COG shall be done by drilling holes up to the longitudinal girder.

Footpath

The footpath in the T-Girder structure indicates that the cantilever portion is not designed for vehicle loads. Hence an extra T-Girder has been proposed on the cantilever portion where the footpath on the deck will be removed.

Widening of Solid Slab Superstructure of Minor Bridges

In case of widening of the solid slab superstructure, the edge portion of the slab shall be dismantled without disturbing the existing reinforcement. The same depth and reinforcement as per MOST standards shall be provided for the widened portion.

Widening of Sub-Structure and Foundation of Minor Bridges

The sub-structure and foundation shall be widened with the same size and keeping the same foundation level as per existing.

The details for all the CD structures and grade separators are given in Tabular form in Volume-II (Appendix-10).of this report:

Table-A: Detail Recommendations of Major Bridges.

Table-B: Detail of Proposed Flyover Structures.

Table-C: Detail Recommendations for Minor Bridges.

Table-D: Detail Recommendations for existing ROB

Table-E: Detail Recommendations for Slab/Box/Pipe Culverts

15.8 Hydrological Calculation

Available hydrological data is used for the hydraulic calculations and design of major and minor bridges. Road top level is kept as per highest flood observed in past.

15.9 Design of New Structures

Following structures are proposed to be built as new structures, the specifics for the same are described here under:

1. Bhogavo River Bridge

The new proposed bridge is at 20 m away D/S of the existing old bridge. It is proposed to have 67 spans of 18.30 m in length. To avoid the disturbance of hydrological features of the river and also

the regime, it is proposed to adopt same span arrangement as the existing bridge. A RCC T- beam and slab type superstructure resting over RCC pier with well foundations is proposed. The overall width of structures shall be 13.55 m.

2. Nalla River Bridge

The new proposed bridge is at 20 m away D/S of the existing old bridge. It is proposed to provide 7 spans of 18.30 m in length. To avoid the disturbance of hydrological features of the river and also the regime, it is proposed to adopt same span arrangement as the existing bridge. A RCC T- beam and slab type superstructure resting over RCC pier with well foundations is proposed. The overall width of structures will be 13.55 m.

3. Harbad River Bridge

The new proposed bridge is at 20 m away D/S of the existing old bridge. It is proposed to provide 10 spans of 18.30 m in length. To avoid the disturbance of hydrological features of the river and also the regime, it is proposed to adopt same span arrangement as the existing bridge. A RCC T- beam and slab type superstructure resting over RCC pier with well foundations is proposed. The overall width of structures will be 13.55 m.

Table 15-7: Detailed Proposal

Description	Name of the Bridge		
	Bhogavo River Bridge	Nalla River Bridge	Harbad River Bridge
Proposed width of the Bride (m)	13.55	13.55	13.55
Proposed distance of new bridge from the old bridge (m C/C)	20	20	20
Number of spans	67	7	10
Length of each Span (m)	18.3	18.3	18.3
Span Arrangement	Same as the Exisisting Bridge	Same as the Exisisting Bridge	Same as the Exisisting Bridge

Preliminary Design for stability of well foundation is appended herewith vide Volume-II (Appendix-10).

4. Flyover/ ROB at Km 32.300 & 32.600

It is proposed to provide one obligatory span of 45.00 m (PSC Box) and side span of 25 .00 m (PSC T- Girder) for smooth movement of traffic circulation. Looking at the soil condition, 6 no's of 1.20 m dia bore cast-in-situ pile of 25 m depth is proposed. In the approach portion for the flyover, provision of Reinforced earth wall is proposed.

This flyover is passing from Bavla town and connecting the existing ROB with the provision of footpath through out the stretch. The width of flyover for 3–lane carriageway is 13.55 m.

The ROB on Left side carriageway, a span of 27.20 m length is proposed with PCC Abutment.

5. Flyover at Km 56.440

It is proposed to provide one obligatory span of 45.00 m (PSC Box) and two side spans of 25.00 m (PSC T- Girder) for smooth movement of traffic circulation. Looking at the soil condition, 6 no's of 1.20 m dia bore cast-in-situ pile is proposed In the approach portion for the flyover, provision of Reinforced earth wall is proposed

The width of flyover for 3-lane carriageway is 12.0 m and overall width is 24.50 m.

6. Flyover at Bagodara Town

At this location there are 3 junctions, one at km 59.980 leading to Tarapur on LHS of the project corridor, second at km 60.750 leading to Nalsarovar on RHS of the project corridor and the third at km 61.340 leading Bhavnagar through Dhanduka on LHS of the project corridor. Since all the three intersection are closely located, an elevated main carriage way with flyover for 0.85 km, viaduct portion is proposed.

It is proposed to provide an obligatory span of 45.0 m (PSC Box) and two side spans of 25.0 m (PSC T- Girder) at Tarapur junction. Between Tarapur junction and Nalsarovar Junction a RE wall with 635 m length is proposed. At Nalsarovar Junction, a side span of 25.0 m and an obligatory span of 40.0 m are proposed with 555 m long viaduct portion between Nalsarovar junction and Bhavnagar junction. At Bhavnagar junction an obligatory span of 45.0 m and two side span of 25.0 m are proposed.

Looking to soil condition, 4 no's of 1.20 m dia bore cast-in-situ pile is proposed for 25.00 m side span and 6 no's of 1.20 m dia bore cast-in-situ pile is proposed for 40.00/ 45.00 m obligatory span. In the approach portion for the flyover, provision of Reinforced earth wall is proposed. The width of flyover for 3-lane carriageway is 12.0 m and overall width is 24.50 m.

7. Flyover at Km 102.700

It is proposed to provide two obligatory spans of 40.00 m (PSC Box) and two side spans of 25.00 m (PSC T- Girder) for smooth movement of traffic circulation. Looking to soil condition, 6 no's of 1.20 m dia bore cast-in-situ pile and 20 m length is proposed. In the approach portion for the flyover, provision of Reinforced earth wall is proposed. The width of flyover for 3-lane carriageway is 12.0 m and overall width is 24.50 m.

8. Flyover at Km 148.190

It is proposed to provide two obligatory span of 40.00 m (PSC Box) and two side span of 25 .00 m (PSC T- Girder) for smooth movement of traffic circulation. Looking to soil condition, 6 no's of 1.20 m dia bore cast-in-situ pile and 20 m length is proposed. For Approach portion, provision of Reinforced earth wall is proposed. The width of flyover for 3-lane carriageway is 12.0 m and overall width is 24.50 m.

9. Flyover at Chotila Town

A grade separator is proposed to manoeuvre the through traffic over two 3 armed junction i.e., at km 169.000, 169.950 leading to Chotila town on LHS, the other to temple on LHS respectively and a 4 armed junction at km 170.610. An elevated highway is proposed with viaduct portion of 0.570 km.

An obligatory span of 40.0 m and a side span of 25.0 m are proposed at km.169.000. After this junction 561 m length RE Wall is proposed. Near junction of Chotila temple, 9 spans of 25.0 m+3 spans of 45.0 m and 1 span of 25.0m is provided.

Between ch.169.950 & ch.170.610, RE Wall of 596.0 m length is proposed. At junction 170.610, one obligatory span of 45.0 m and side span of 25.0 m is proposed. The width of flyover for 3-lane carriageway is 12.0 m and overall width is 24.50 m.

16. INITIAL ENVIRONMENTAL ASSESSMENTS

16.1 Introduction

This section on initial environmental assessment has been divided into six major sub-sections. Mainly it covers an initial assessment of likely environmental impacts due to the proposed project, the mitigation measures to be undertaken for addressing the likely adverse environmental impacts and budgetary provisions for environmental mitigation measures along with the institutional framework for the implementation of the environmental management measures. It also includes the clearance requirements from MoEF for the project with draft ToR.

16.2 Environmental Baseline and Assessment of Impacts

Road widening projects have potential positive environmental impacts like reduced air pollution and savings in fuel consumption. However, alongside this, potential adverse impacts are also a reality. The nature and magnitude of such adverse impacts vary based on the intensity of construction works involved, presence and type of sensitive features affected, the type of construction technology used etc.

The project corridor does not pass through any sensitive environmental areas such as Reserve Forests, natural habitats, etc. Also, the proposed widening is limited to an additional 15 m (existing RoW being 45 m) to achieve the proposed RoW of 60 m. No significant environmental impacts are anticipated. The following sections detail out the likely adverse impacts due to the project.

16.2.1 Impact on Physical Environment

a) Meteorology

The microclimate is likely to be modified slightly due to the removal of roadside trees and the addition of increased pavement surface. No significant changes are expected in the macro-climatic setting (precipitation, temperature and wind) of the project corridor. In addition, temporary loss of shade due to the removal of roadside trees will cause discomfort to the slow moving traffic and pedestrians.

b) Physiography and Terrain

The project corridor traverses through a predominantly a plain area. Since no new alignments are proposed, no physiographic changes are likely. Only minor drainage problems at specific locations such as borrow areas are anticipated. Appropriate management measures have been proposed for mitigation of the same. Also, new roadside drains have been designed to drain runoff from road surface as well as adjacent areas.

c) Soil

(i) Loss of Productive Soil

Acquisition of road side agricultural lands for widening will lead to reduction in area of productive lands. About 180 hectares of agricultural land is proposed to be acquired as part of the project. Also if the top soil from such lands is not reused it will lead to loss of the fertile topsoil. Measures for conservation and management of top soil have been discussed as part of the subsequent sections.

(ii) Soil Erosion

The project area is predominantly covered by alluvium sandy loam. The sandy loam region is prone to erosion. All the bridge locations where elevated embankments are required would be more sensitive to the erosion during the construction period. 2 major, 51 minor bridges and 135 culverts are located on the corridor. As a part of the road improvement programme, new under passes and flyovers will be provided in urban and rural stretches. Such areas will also be vulnerable to erosion problems.

(iii) Contamination of Soil

The soil contamination due to the spillages of construction materials like bitumen, asphalt, oil & grease, fly ash etc and the unwarranted disposal of construction spoils and debris will adversely affect the fertility level of the soil. This impact occurs at specific locations like storage areas, construction vehicle parking lots, hot mix plants, etc. During the operation stage, soil pollution due to accidental vehicle spills or leaks is likely. Appropriate mitigation measures have therefore, been proposed.

d) Quarries and Borrow Area

The project would require large quantities of soil, sand and aggregates for construction activities. The material will be sourced from the near by borrow areas and stone quarries (Table 16-1). These selected borrow areas are fully barren land and there is no impact on ecological environment due to excavation. After use, these borrow areas shall be rehabilitated according to the management measures discussed in the subsequent sections.

Table 16-1: Details of Selected Borrow Areas

Sample	Location	LHS/ RHS	Lead from NH 8A (Km)	Date of Sampling	Quantity	Contact person
B1	17+000 (Navapura)	RHS	1.5	07/09/07	10000	Dasharathbhai 9904599207
B2	17+000 (Navapura)	RHS	1.5	07/09/07	10000	Dasharathbhai 9904599207
B3	45+500 (Bhyala)	LHS	2.0	07/09/07	33750	Vinubhai Ramjibhai Parmar 9898328199
B4	65+500 (Bagodara Nr. Goghavo Bridge)	LHS	1.5	07/09/07	Plenty	Ghansyam bhai 9376224660 & 9998973768
B5	87+000 (Rano)	RHS	1.0	07/09/07	57800	Ishubhai 9376056564
B6	179+600 (Moti Mordi)	LHS	1.0	08/09/07	Plenty	Vihabhai Vavdiya 9909067527
B7	164+900 (Sanghani)	LHS	1.0	08/09/07	Plenty	Amar Singh Sarpanch 9375932371
B8	141+950 (Nava Sudamada)	RHS	3.0	08/09/07	Plenty	Dhirubhai Sarpanch Sri 9898129272
B9	127+050 (Navi Morvad)	LHS	2.0	08/09/07	Plenty	Bhupatbhai Sarpanch sri 9979999398

Source: Field Survey, LASA, October-November 2007

e) Water Resources

Ground Water Sources

General impacts envisaged by the project on the ground water resources are due to loss of existing water extraction points such as wells and hand pumps. Ground water is at a premium in all talukas since the corridor passes through arid to semi arid parts of the state. Due to lack of major surface water bodies in the vicinity, construction works have to be undertaken with ground water.

Around 4 wells are present within 35 m from the central line of the road on either side of the corridor. These wells are very large and deep and are used for irrigation and domestic purposes. The proposed widening of the project corridor is likely to result in closure of these wells. The details of these affected wells are given in Table 16-2. Also, a tube well is likely to be affected.

Table 16-2: Wells likely to be affected

S.No.	Type of Water Body	Chainage No.	RHS/LHS	Distance from CL
1	Well	39+150	RHS	19.72
2	Well	42+590	LHS	32.11
3	Well	153+580	LHS	29.64
4	Well	153+605	LHS	25.47
5	Tube well	87+950	LHS	33.6

Source: Field Survey, LASA, October-November 2007

Surface Water Sources

The Bhagavo River is the only major surface water source and cuts across the project corridor chainage 66.100 Km. Two ponds are likely to be impacted due to the proposed project. The details of their location are given in Table 16-3. Consultations were done at the location of the pond in order to understand to usage of the pond and the likely impact on the villagers. Both ponds are used for agricultural and domestic purposes and not for drinking. Pollution of the ponds is anticipated during the construction stage. Care has to be taken that construction and labour camps are not located close to these ponds. Silt run off has to be prevented at these ponds by silt fencing. Consultations with the villagers using these ponds were done.

Table 16-3: Ponds Likely To Be Affected

Chainage		Village Name	Land Use		Water Body	Dist. from C/W edge (m)	Length along road (m)	Left/ Right	Perennial/ Non-Perennial
From	To		Left	Right					
22	23	Pilupara	Industrial	Industrial	Pond	20	100	L	NP
61	62	Bagodara	Agricultural	Agricultural	Pond	5	25	L	NP

Source: Field Survey, LASA, October-November 2007

Pond at Pilupara village (chainage 22.400)

Pond near Bagodara village (chainage 61.100)

Consultation at Pond Location

Canal at Km 46 RHS

There are four canal stretches along the entire project corridor. The details of these canal stretches are presented in Table 16-4.

Table 16-4: Canals likely to be affected

From	To	Location	Land use Left	Land use Right	Water Body	Dist. from C/W edge (m)	Length along the road (m)	Left/ Right	Perennial/ Non-Perennial
46	47	Bhansara	Agricultural	Agricultural	Canal	10	100	R	P
47	48	Bhansara	Agricultural	Agricultural	Canal	10	1000	R	P
48	49	Bhansara	Agricultural	Agricultural	Canal	10	1000	R	P
49	50	Bhansara	Agricultural	Agricultural	Canal	10	500	R	P

Source: Field Survey, LASA, October-November 2007

Drainage

There are two major cross drainage channels having major bridges and 51 cross drainage channels that require minor bridges. 135 culverts are present along the entire corridor stretch across minor water channels. Construction of the new structures when the channel is flowing may lead to drainage disruption through, haphazard dumping of the construction materials and wastes. Roadside storage of construction materials too might lead to disruption in longitudinal drainage. Sediment load from road run-off and potential of collision with vehicles are the concerns associated with the construction phase. During the operational phase contamination due to run-off lubricants and exhaust emissions are the likely impacts.

f) Air Quality

The potential impacts on air quality during construction stage are likely due to the fugitive dust and the exhaust gases generated in and around the construction vehicles equipments and materials processing plants such as crushing sites, hot-mix and asphalt plants, etc. which will create dust in the construction area and its vicinity. This will impact the health of the construction workers and dwellers with in the vicinity of the construction activities. These are primarily short-term impacts. The details of sensitive receptors are presented in Table 16-5.

g) Noise Levels

Due to the various construction activities, there will be short term noise impacts in the immediate vicinity of the project corridor. The construction activities will include the excavation for foundations and grading of the site and the construction of structures and facilities. However, it is important to note that construction noise is generally intermittent and depends on the type of operation, location and function of the equipment. The noise produced by vehicles during the operation stage will increase with increasing volumes of traffic on the corridor. Deterioration in the surface conditions of the pavement over a period of time also increases the noise levels. Apart from the dwelling areas the sensitive receptors like educational institutions and hospitals will also be impacted. (Table 16-5)

Table 16-5: Sensitive receptors along the corridor

Name of the School	Direction	Distance from C/W	Chainage
Hospital	LHS	60m	19+100
Trimurti Hospital	RHS	5m	33+200
Gopal Vidyalay	LHS	40 m	35+200
Uma Institute of Fire Technology	LHS	35m	36+900
Govt School	RHS	15m	149+500
Primary School	RHS	17m	165+400

Source: Field Survey, LASA, October-November 2007

Sensitive locations should be specifically monitored twice or thrice a year that include hospitals, educational institutes etc. as per the following air and noise standards. (Table 16-6 and Table 16-7)

Table 16-6: Ambient Air quality Standards (all values in µg/m^3)

S. No.	Parameter	Sensitive	Residential	Industrial
1	SPM	100	200	500
2	RSPM	75	100	150
3	SO2 (Sulpher di-oxide)	30	80	120
4	No2 (oxide of Nitrogen)	30	80	120

Table 16-7: Ambient Noise quality standards

S. No.	Parameter / Category	Standard (Limits in dB(A)	
		Day	Night
1	Silence Zone	50	40
2	Residential Zone	55	45
3	Industrial Zone	75	70
4	Commercial Zone	65	55

16.2.2 Impact on Ecological Environment

a) Forest

There is presence of forest at limited stretches along the corridor. A Protected Forest is present between chainage 175+000 and 177+000 (Table 16-8). The forested stretches along the corridor are part of the afforestation program of the forest department. No trees are likely to be impacted due to the proposed widening.

Table 16-8: Protected Forests along the Project Corridor

S.No.	From Chainage	To Chainage	Side	Length (m)
1	175+000	176+000	RHS	500
2	176+000	177+000	RHS	200

Source: Taluka & village maps of the Corridor and Source: Primary Survey, LASA, 2007

b) Road Side Trees

The trees along the road side will be removed for accommodating the proposed improvements. The number of trees likely to be felled is presented in Table 16-9.

Impacted Trees- Km 35

Table 16-9: Trees likely to be felled

S.No.	Chainage	LHS	RHS
1	15-25	339	10
2	25-35	291	5
3	35-45	424	40
4	45-55	95	0
5	55-65	18	10
6	65-75	0	0
7	75-85	2	0
8	85-95	2	10
9	95-105	30	40

S.No.	Chainage	LHS	RHS
10	105-115	64	34
11	115-125	100	40
12	125-135	27	33
13	135-145	16	30
14	145-155	41	81
15	155-165	69	118
16	165-175	45	78
17	175-182.4	142	52
Total		**1705**	**545**

c) Fauna

There are no major protected wild life sanctuaries within 10km from the project road. The edge of Nalsarovar Lake near Bagodara is located 27 km from the project road. Accidents with cattle are likely to be high at the village areas along the corridor such as Bhayala, Vadod, Sapar, Bagodara etc, due to road widening, increase in the number of vehicles and increased vehicular speeds. Locations for cattle crossings have been proposed at such locations to avoid such accidents. The details of proposed cattle crossing locations are discussed as part of the severance impacts in the chapter on Initial Social Assessment.

16.3 Environmental Mitigation Measures

In order to cause least disturbance to the environment, certain measures have to be taken to counteract the impacts during the design as well as the construction phases of the project. The management measures proposed to mitigate the impacts on various Environmental Components is given in Table 16-10.

Table 16-10: Mitigation Measures

Sl. No	Activities	Management Measure	Location	Reference
1.0	**PRE-CONSTRUCTION STAGE**			
1.1	*Pre-construction activities by R&B Department*			
1.1.1	Tree Cutting	Trees will be removed from the Corridor of Impact and construction sites before commencement of Construction with prior intimation to the Forest Department. As part of the widening of this section of NH-8A, approx. 2250 nos. of trees will be felled. Three trees will be planted for every tree felling. Forest department will maintain the plantation and R&BD will deposit the money for tree plantation. This disposal will be done immediately to ensure that the traffic movement is not disrupted.	Corridor of Impact	Design MoRTH 201.6 Forest Conservation Act, 1980
1.2.2	Procurement of Machinery			
1.2.2.1	Crushers, Hot-mix Plants & Batching Plants	Specifications of crushers, hot mix plants and batching plants will comply with the requirements of the relevant current emission control legislations.		Contract, MoRTH: 111.1, GoI Air & Noise Standards, OSHA Standards
1.2.2.2	Other Construction Vehicles, Equipment and Machinery	The discharge standards promulgated under the Environment Protection Act, 1986 will be strictly adhered to. All vehicles, equipment and machinery to be procured for construction will conform to the relevant Bureau of Indian Standard (BIS) norms. Noise limits for construction equipments to be procured such as compactors, rollers, front loaders, concrete mixers, cranes (moveable), vibrators and saws will not exceed 75 dB (A), measured at one meter from the edge of the equipment in free field, as specified in the Environment (Protection) Rules, 1986.		Contract, Environment Protection Act, 1986 & MoRTH: 111.1
1.2.3	Identification & Selection of Material Sources			
1.2.3.1	Borrow Areas	Arrangement for locating the source of supply of material for embankment and sub-grade as well as compliance to environmental requirements, as	At all borrow area locations suggested for the project.	MoRTH: 305.2.2.2 Vand Volume-II (Appendix-

Sl. No	Activities	Management Measure	Location	Reference
		applicable, will be the sole responsibility of the contractor. Siting of borrow areas to be as per the Guidelines presented in Volume-II (Appendix-11.1). The contractor will not use any of the locations described here for borrowing (within and upto 1000m either side of Reserve Forest/ Ecologically sensitive areas). Fly ash will be used for the road construction. Locations identified by the contractor shall be reported to the Engineer. Format for reporting shall be as per Form EM3, Volume-II (Appendix-11.4) Planning of haul roads for accessing borrow materials will be undertaken during this stage. The haul roads should be routed to avoid agricultural areas. In addition to testing for the quality of borrow materials by the SC, the environmental personnel of the SC will be required to inspect every borrow area location prior to approval. The criteria for evaluation of borrow areas is presented in Volume-II (Appendix-11.4).		11.2) (results of borrow area samples) Volume-II (Appendix-11.3)
1.2.3.2	Quarries	The Contractor will identify materials from existing licensed quarries with the suitable materials for construction. Apart from approval of the quality of the quarry materials, the Engineer's representative will verify the legal status of the quarry operation, as to whether approval under statutory is obtained. Some of the locations identified during this stage are presented in Volume-II (Appendix-11.5).	All quarries recommended to be used in the project	MoRTH: 111.3 Volume-II (Appendix-11.5)
1.2.3.3	Water	The contractor will source the requirement of water preferentially from surface water bodies, as rivers and tanks in the project area. To avoid disruption/disturbance to other water users, the contractor will extract water from fixed locations. The contractor shall consult the local people before finalizing the locations. Only at locations where surface water sources are not available, the contractor can contemplate extraction of ground water. Consent from the Engineer that no surface water resource is available in the immediate area for the project is a pre-requisite prior to extraction of ground water. The contractor will need to comply with the requirements of the state Ground water department and seek their approval for doing so.	All rivers / surface water bodies that can be used in the project	Contract
1.2.3.4	Sand	The contractor will identify sand quarries with requisite approvals for the extraction of sand for use in the project		
1.2.4	Setting up construction sites			
1.2.4.1	Hot Mix Plants & Batching Plant Location	Hot mix plants and batching plants will be sited sufficiently away from reserve forest, habitation, agricultural operations or industrial establishments. Such plants will be located at least 1000m away from the nearest habitation, preferably in the downwind direction.		Contract MoRTH clause 111.5
2.0	**CONSTRUCTION STAGE**			
2.1.1	Site Clearance			
2.1.1.1	Clearing and Grubbing	Vegetation will be removed from the CoI before the commencement of Construction. All works will be carried out such that the damage or disruption to flora is minimum. Only ground cover / shrubs that impinge directly on the permanent works or necessary temporary works will be removed with prior approval from the Engineer. The contractor, under any circumstances will not damage trees (in addition to those already felled with prior permission from the forest department). Vegetation only with girth of over 30 cm will be considered as trees and shall be removed as per Activity 1.1.2.	Corridor of Impact	Design MoRTH 201 111.15.1, Sub clause 111.15.4
2.1.1.2	Dismantling of Bridgework / Culverts	The culverts will be dismantled carefully and the resulting materials so removed as not to cause damage to the part of the structure retained and other properties and structures nearby. All necessary measures will be taken while working close to cross drainage channels to prevent earthwork, stonework, materials and	At locations were bridge works and culverts are proposed.	MoRTH 202.2

Sl. No	Activities	Management Measure	Location	Reference
		appendage as well as the method of operation from impeding cross-drainage at rivers, streams, water canals and existing irrigation and drainage systems.		
2.1.1.3	Generation of Debris from dismantling of pavement structures	Debris generated due to the dismantling of the existing pavement structure shall be suitably reused in the proposed construction, subject to the suitability of the material and the approval of the Engineer Unutilized debris material shall be suitably disposed off by the contractor; either through filling up of borrow areas created for the project or at pre-designated dump locations, subject to the approval of the Engineer. Debris generated from pile driving or other construction activities shall be disposed such that it does not flow into the surface water bodies or form mud puddles in the area. Disposal sites shall be identified by the contractor as per guidelines provided in Annexure.	Throughout Project Corridor	MoRTH 202.5 MoRTH 517
2.1.1.4	Non-bituminons construction waste disposal	As far as possible construction waste will be utilized in road construction. Location of disposal sites will be finalized prior to completion of the earthworks on any particular section of the road. The Engineer shall approve these disposal sites conforming to the following (a) These are not located within reserve forest areas as indicated in Section 1.2.3.1 (b) The dumping does not impact natural drainage courses (c) No endangered/rare flora is impacted by such dumping. (d) Settlements are located at least 1.0km away from the site. Guidelines for silting of disposal sites are presented in Volume-II (Appendix-11.6).	Dump site locations	Contract MoRTH: 201.4 & 202.5 Section 1.2.3.1
2.1.1.5	Bituminous wastes disposal	The disposal of residual bituminous wastes will be done by the contractor at secure landfill sites, with the requisite approvals for the same from the concerned government agencies.	Throughout Project Corridor	Contract MoRTH: 201.4
2.1.2	Planning Traffic Diversions & Detours	Temporary diversions will be constructed with the approval of the Engineer. Detailed Traffic Control Plans will be prepared and submitted to the Engineer for approval, 5 days prior to commencement of works on any section of road. The traffic control plans shall contain details of temporary diversions, details of arrangements for construction under traffic, details of traffic arrangement after cessation of work each day, safety measures for transport of hazardous material and arrangement of flagmen. Environmental personnel of the Engineer will assess the environmental impacts associated as the loss of vegetation, productive lands and the arrangement for temporary diversion of the land prior to the finalization of diversions and detours. Special consideration will be given to the preparation of the traffic control plan for safety of pedestrians and workers at night. The Contractor will ensure that the diversion/detour is always maintained in running condition, particularly during the monsoon to avoid disruption to traffic flow. He shall inform local community of changes to traffic routes, conditions and pedestrian access arrangements. The temporary traffic detours will be kept free of dust by frequent application of water.	All along the Project Corridor.	MoRTH: 112.1 MoRTH: 112.4 MoRTH:112.2 MoRTH: 112.5
2.1.3	Procurement of Construction Materials			
2.1.3.1	Borrow Areas	No borrow area will be opened without permission of the Engineer Borrow pits will not be dug continuously in a stretch. The location, shape and size of the designated borrow areas will be as approved by the Engineer and in accordance to the IRC recommended practice for borrow pits for road embankments (IRC 10: 1961) The borrowing operations will be carried out as specified in the guidelines for siting and operation of borrow areas. The unpaved surfaces used for the haulage of borrow materials will be maintained dust free by the contractor. Since dust raising is	All along the project corridor, all access roads, sites temporarily acquired & all borrow areas	MoRTH: 305.2.2.2 IRC 10 1961 Volume-II (Appendix-11.1) MoRTH: 111.2, Sub clause 111.15.2

Sl. No	Activities	Management Measure	Location	Reference
		the only impact along the haul roads sprinkling of water will be carried out twice a day along such roads during their period of use.		
2.1.3.2	Stripping, stocking and preservation of top soil	The topsoil from borrow areas, areas of cutting and areas to be permanently covered will be stripped to a depth of 150mm and stored in stockpiles. At least 10% of the temporarily acquired area will be earmarked for storing topsoil. The stockpile will be designed such that the slope does not exceed 1:2 (vertical to horizontal), and the height of the pile is to be restricted to 2m. Stockpiles will not be surcharged or otherwise loaded and multiple handling will be kept to a minimum to ensure that no compaction will occur. The stockpiles will be covered with gunny bags or tarpaulin. It will be ensured by the contractor that the topsoil will not be unnecessarily trafficked either before stripping or when in stockpiles. Such stockpiled topsoil will be returned to cover the disturbed area and cut slopes.	Throughout Project Corridor, where productive land is acquired.	MoRTH: 301.3.2 & MoRTH: 305.3.3 MoRTH: 301.7 & MoRTH: 305.3.9
2.1.3.3	Quarries	The quarry operations will be undertaken within the rules and regulations in force.	All along the project corridor and all haul roads	MoRTH: 111.3
2.1.3.4	Blasting	Except as may be provided in the contract or ordered or authorized by the Engineer, the Contractor will not use explosives. Where the use of explosives is so provided or ordered or authorized, the Contractor will comply with the requirements of the following Sub-Clauses of MoRTH 302 besides the law of the land as applicable. The Contractor will at all times take every possible precaution and will comply with appropriate laws and regulations relating to the import, handling, transportation, storage and use of explosives. The contractor will at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the Engineer. The Contractor will at all times make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whomsoever concerned or affected or likely to be concerned or affected by blasting operations. Blasting will be carried out only with permission of the Engineer. All the statutory laws, regulations, rules etc., pertaining to acquisition, transport, storage, handling and use of explosives will be strictly followed. Blasting will be carried out during fixed hours (preferably during mid-day) or as permitted by the Engineer. The timing should be made known to all the people within 1000m (200m for pre-splitting) from the blasting site in all directions.	All blasting and Pre-splitting Sites.	MoRTH: 302.4
2.1.3.5	Transporting Construction Materials	All vehicles delivering materials to the site will be covered to avoid spillage of materials. All existing highways and roads used by vehicles of the contractor, or any of his sub-contractor or suppliers of materials and similarly roads which are part of the works will be kept clean and clear of all dust/mud or other extraneous materials dropped by such vehicles The unloading of materials at construction sites close to settlements will be restricted to daytime only.	All along the Project corridor and all haul roads	MoRTH: 111.9
2.1.3.6	Water Extraction	Procurement of water is to be carried out as per Section 1.2.3.3 The contractor will minimize wastage of water during construction.	All water bodies recommended to be used in the project	Section 1.2.3.3
2.1.4	Operation of construction equipments and vehicles	All vehicles and equipment used for construction will be fitted with exhaust silencers. During routine servicing operations, the effectiveness of exhaust silencers will be checked and if found to be defective will be replaced. Noise limits for construction equipment used in this project (measured at one metre from the edge of the equipment in free field) such as compactors, rollers, front loaders, concrete mixers, cranes (moveable), vibrators and saws will not exceed 75 dB(A), as specified in the Environment (Protection)	All construction equipments and vehicles	Environment (Protection) Rules, 1986

Sl. No	Activities	Management Measure	Location	Reference
		Rules, 1986 Notwithstanding any other conditions of contract, noise level from any item of plant(s) must comply with the relevant legislation for levels of noise emission. The contractor will ensure that the AAQ concentrations at these construction sites are within the acceptable limits of industrial uses in case of hot mix plants and crushers and residential uses around construction camps. Dust screening vegetation will be planted on the edge of the RoW for screening dust crusher. Monitoring of the exhaust gases and noise levels will be carried out by the agency identified for Environmental Monitoring for the project.		
2.1.5	Material Handling at Site	All workers employed on mixing asphaltic material, cement, lime mortars, concrete etc., will be provided with protective footwear and protective goggles. Workers, who are engaged in welding works, would be provided with welder's protective eye-shields. Workers, engaged in stone breaking activities will be provided with protective goggles and clothing and will be seated at sufficiently safe intervals. The use of any herbicide or other toxic chemical will be strictly in accordance with the manufacturer's instructions. The Engineer will be given at least 6 working days notice of the proposed use of any herbicide or toxic chemical. A register of all herbicides and other toxic chemicals delivered to the site will be kept and maintained up to date by the Contractor. The register will include the trade name, physical properties and characteristics, chemical ingredients, health and safety hazard information, safe handling and storage procedures, and emergency and first aid procedures for the product. No man below the age of 14 years and no woman will be employed on the work of painting with products containing lead in any form. No paint containing lead or lead products will be used except in the form of paste or readymade paint. Face masks will be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint dry rubbed and scrapped.	All construction sites	MoRTH: 111.6 MoRTH: 105 MoRTH: 111.4, Sub clause 111.15.3 IS: 6994 (Part I) – 1973, IS: 14352 – 1996, IS: 2925 - 1984
2.1.6	Precautionary/Safety Measures During Construction	All relevant provisions of the Factories Act, 1948 and the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996 will be adhered to. Adequate safety measures for workers during handling of materials at site (Section 2.1.6) will be taken up. The contractor has to comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress.	All construction sites	Factories Act, 1948 and the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996 Section 2.1.6 MoRTH 105 Sub clause 111.11
2.1.7	Earthworks			
2.1.7.1	Excavations	All excavations will be done in such a manner that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand. The excavations shall conform to the lines, grades, side slopes and levels shown in the drawings or as directed by the engineer. While planning or executing excavation the contractor shall take all adequate precautions against soil erosion, water pollution etc (clause 306) and take appropriate drainage measures to keep the site free of water (clause 311), through use of mulches, grasses, slope drains and other devices. The contractor shall take adequate protective measures to see that excavation operations do not affect or damage adjoining structures and water bodies. For safety precautions guidance may be taken from IS: 3764.	All along the project corridor	MoRTH 301.3.3 MoRTH 304.3.6 IS:3764
	Earth fill	Embankment and other fill areas, unless other wise permitted by the Engineer, be constructed evenly over their full width and the contractor will	Along earth fill areas	MoRTH 305.3.5.3

Sl. No	Activities	Management Measure	Location	Reference
		control and direct movement of construction vehicles and machinery over them		
2.1.7.2	Stripping, stocking and preservation of top soil	Stock piling of top soil as per Section 2.1.3.2 The stockpiles will be located at least 100m from watercourses.	All along the project corridor	Section 2.1.3.2
2.1.7.3	Slope protection and control of erosion	Detailed study is carried out for slope protection.	Hill section of the project corridor.	
2.1.10.4	Drainage requirements at construction sites	In addition to the design requirements, the contractor will take all desired measures as directed by the Engineer to prevent temporary or permanent flooding of the site or any adjacent area.	All along the project corridor	
2.1.7.5	Dust	All earthwork will be protected in a manner acceptable to the Engineer to minimise generation of dust. The contractor will take every precaution to reduce the level of dust along construction sites involving earthworks, by frequent application of water.	All along the project corridor	MoRTH 111.8
2.1.7.6	Contamination of soil	Vehicle/machinery and equipment operation, maintenance and refueling will be carried out in such a fashion that spillage of fuels and lubricants does not contaminate the ground. Oil interceptor will be provided for vehicle parking, wash down and refueling areas within the construction camps. Fuel storage will be in proper bonded areas. All spills and collected petroleum products will be disposed off in accordance with MoEF and SPCB guidelines. Fuel storage and refilling areas will be located at least 1000m from rivers and irrigation ponds or as directed by the Engineer. In all fuel storage and refueling areas, if located on agricultural land or areas supporting vegetation, the topsoil will be stripped, stockpiled and returned after cessation of such storage and refueling activities as per Section 2.1.3.2	All along the project corridor	MoRTH 306 & MoRTH 311 Section 2.1.3.2.
2.1.7.7	Compaction of soil	To minimize soil compaction, construction vehicle, machinery and equipment will move or be stationed in designated area (RoW or CoI, haul roads as applicable) only. The haul roads for construction materials should be routed to avoid agricultural areas	All along the project corridor	Annexuire-A to MoRTH 501
2.1.7.8	Silting, Contamination of Water bodies	Silt fencing will be provided around stockpiles at the construction sites close to water bodies. The fencing needs to be provided prior to commencement of earthworks and continue till the stabilization of the embankment slopes, on the particular sub-section of the road. Construction materials containing fine particles will be stored in an enclosure such that sediment-laden water does not drain into nearby watercourses. All discharge standards promulgated under Environmental Protection Act, 1986, will be adhered to. All liquid wastes generated from the site will be disposed off as acceptable to the Engineer.	Water bodies as detailed out in Volume-II (Appendix-11.7)	Environmental Protection Act, 1986
2.1.7.9	Cutting/Filling of Surface water bodies	Earth works shall be undertaken such that the existing embankments of water bodies are not disturbed. In case of cutting of embankments, the same shall be reconstructed with appropriate slope protection measures and adequate erosion control measures. Filling of surface water bodies will be compensated by digging an equal volume of soil for water storage. Such dug-up soil will be used for spreading as topsoil. Wherever digging is undertaken, the banks will be protected as designed or as approved by the Engineer. The excavation will be carried out in a manner so that the side slopes are no steeper than 1 vertical to 4 horizontal, otherwise slope protection work, as approved by the Engineer will be provided. As far as practicable, and as approved by the Engineer, excavation for replacement of water bodies will be at the closest possible place/location, with respect to the original water	Surface Water bodies whose water storage capacity is affected by the project and whose embankments are being cut	Contract

Sl. No	Activities	Management Measure	Location	Reference
		body or part thereof consumed by filling.		
2.1.8	Sub-Base & Base	The contractor will take all necessary measures/ precautions to ensure that the execution of works and all associated operations are carried out in conformity with statutory and regulatory environmental requirements including those prescribed in Annexure-A to MoRTH 501. The contractor will plan and provide for remedial measures to be implemented in event of occurrence of emergencies such as spillage of oil or bitumen or chemicals. The contractor will provide the Engineer with a statement of measures that he intends to implement in event of such an emergency, which will include a statement of how he intends to adequately train personnel to implement such measures. Adequate safety measures for workers during handling of materials at site (Section 2.1.6) will be taken up. The contractor will take every precaution to reduce the level of dust along construction sites by frequent application of water as per Section 2.1.10.5 Noise levels from all vehicles and equipment used for construction will conform to standards as specified in Section 2.1.5. Construction activities involving equipments with high noise levels will be restricted to the daytime. Transport of materials for construction will be as per Section 2.1.3.5 The contractor will provide for all safety measures during construction as per Section 2.1.7	All along the project corridor	Annexure-A to MoRTH 501 Section 2.1.6 Section 2.1.10.5 Section 2.1.5. Section 2.1.3.5 Section 2.1.7
2.1.9	Surfacing	The contractor will take all necessary means to ensure that works and all associated operations are carried out in conformity with Volume-II Annexure-A to MoRTH 501. All workers employed on mixing asphaltic material etc. will be provided with protective footwear as specified in Section 2.1.6. Noise levels from all vehicles and equipment used for surfacing will conform to standards as specified in Section 2.1.5. Construction activities involving equipments with high noise levels will be restricted to the daytime. Transport of materials for construction will be as per Section 2.1.3.5 The contractor will provide for all safety measures during construction as per Section 2.1.7	All along the project corridor	Annexure-A to MoRTH 501 Section 2.1.6 Section 2.1.5 Section 2.1.3.5 Section 2.1.7
2.1.12	Bridge Works & Culverts	While working across or close to the rivers, the Contractor will not disrupt the flow of water. If for any bridgework, etc., closure of flow is required, the Contractor apart from obtaining the requisite clearances from the PWD (irrigation department) will seek approval of the Engineer. The Engineer will have the right to ask the Contractor to serve notice on the downstream users of water sufficiently in advance. Construction over and close to the non-perennial streams will be undertaken in the dry session. Construction work expected to disrupt users and impacting community water bodies will be taken up after serving notice on the local community. Dry stone pitching for apron and revetment will be provided for bridges and cross drainage structures.	At locations were bridge works and culverts are proposed.	MoRTH 2500
2.1.10	Mitigation Measures for Noise Sensitive Receptors	Provision is made for solid / vegetative noise barrier at locations exceeding operation stage noise levels. Other noise mitigation options shall be explored based on site conditions. The measures shall be taken during construction stage only in case of excessive noise causing disturbance to the sensitive receptors otherwise the measures shall be implemented in operation stage.		Noise Rule 2002
2.1.11	Monitoring Environmental Conditions	The contractor will undertake seasonal monitoring of air, noise quality standards through an approved monitoring agency. The parameters to be monitored, frequency and duration of monitoring as well as the locations to be monitored will be as per the Monitoring Plan.	Monitoring Locations	

Sl. No	Activities	Management Measure	Location	Reference
2.1.12	Protection of Reserve Forest Sections	Dumping of debris shall take place within identified sites only. Erection of signboards as specified by the engineer in the reserve forest section. The contractor shall take responsibility of prohibiting activities like hunting and poaching of faunal species, by the construction workers within this area.	Reserve Forest Sections	Forest Conservation Act, 1980
2.1.12	*Contractor Demobilization*			
2.1.12.1	Clearing of Construction of Camps & Restoration	Contractor to prepare site restoration plans for approval by the Engineer. The plan is to be implemented by the contractor prior to demobi-lization. On completion of the works, all temporary structures will be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the site left clean and tidy, at the Contractor's expense, to the entire satisfaction of the Engineer. Residual topsoil will be distributed on adjoining/proximate barren/rocky areas as identified by the Engineer in a layer of thickness of 75mm - 150mm.	All Construction Workers' Camps	
2.1.12.2	Redevelopment of Borrow Areas	Redevelopment of borrow areas will be taken up in accordance with the plans approved by the Engineer. Guidelines for redevelopment of borrow areas are presented in Volume-II (Appendix-11.8)	At all borrow area locations suggested for the project.	Annexure-8 to MoRTH: 111.2
2.2	**CONSTRUCTION ACTIVITIES BY PIU-ENVIRONMENTAL CELL**			
2.2.1	Tree Plantation and Landscaping	Tree plantation and landscaping shall be implemented through the BOT Concessionaire. Trees felled will be replaced in accordance with the Forest (Conservation) Act, 1980. Detailed Landscape plan is detailed out in preceding chapter.	Entire Project Corridor, as per the tree plantation strategy	
3.0	**OPERATION STAGE ACTIVITIES BY PIU-ENVIRONMENTAL CELL**			
3.1	Monitoring Operational Performance	The PIU will monitor the operational performance of the various mitigation/enhancement measures carried out as a part of the project. The indicators selected for monitoring include the survival rate of trees, water bodies, status of rehabilitation of borrow areas and utility noise barrier at sensitive receptors.		

16.4 Environmental Mitigation Costs

The environmental impacts identified will be addressed through necessary avoidance/ mitigation/ enhancement measures, which will have cost implications on the project. Broad environmental management costs have been worked out for the purposes of preliminary feasibility. Environmental Management Costs already covered under engineering heads are presented in Table 16-11 whereas additional Environmental Management Costs are presented in Table 16-12.

Table 16-11: Environmental Management Measures covered under Engineering Costs

S. No.	Items
1	Dust Suppression During Construction
2	Silt Fencing Around Loose Earth During Monsoon
3	Turfing / Pitching / Seeding & Mulching After Construction
4	Safety - Provision Of Informatory Signs And Speed Humps Near Settlements
5	Bus Bays
6	Safety - Cattle Crossings & Foot Over Bridges
7	Borrow Area Redevelopment
8	Deepening Of Affected Ponds

Table 16-12: Additional Environmental Management Costs (for 60m ROW)

S. No.	Items	Unit	Rate in INR	Quantity	Amount in INR
1	**Mitigation Measures**				
1.1	Water Pollution Prevention - Oil interceptors at vehicle maintenance area	Number	4,000	2	8,000
1.2	Compensation for Tree cutting (Rs 25 to 500 per tree)	Number	500	2250	1125,000
1.3	Prevention of Glare - Plantation in Road Median	Number of shrubs	50	16,000	800,000
1.4	Protection of Median Plantation - Barbed Wire Fencing, height 1.2 m	Length (km)	150,000	80	12,000,000
1.5	Structural Noise Barrier (6 locations)	cu m	2,300	360	828,000
1.6	Forest land acquisition from 175+400 to 176+200, Area (15*800=12000sqm=1.2Ha)	Area (Ha)	650,000	1.2	780,000
1.6	Compensatory afforestration for acquired Forest land	Area (Ha)	250,000	1.2	300,000
2	**Post Environmental Clearance Monitoring during construction**				
2.1	Air Quality near Hot mix plants (2 locations, 3 parameters, 2 times an year, 2 years)	No. of Samples	5,000	24	120,000
2.2	Air Quality at Critical Locations (3 locations, 3 parameters, 3 times an year, 2 years)	No. of Samples	5,000	36	180,000
2.3	Noise Levels at Critical Locations (4 locations, 2 times a year, 2 years)	No. of Samples	4,000	16	64,000
2.4	Surface Water Quality during monsoon (4 locations, 2 years)	No. of Samples	5,000	8	40,000
2.5	Ground Water Quality at plant and camp sites (3 locations, 2 years)	No. of Samples	5,000	6	30,000
2.6	Soil Quality at plant and camp sites(3 locations, 2 years)	No. of Samples	6,000	6	36,000
2.7	Additional Soil Monitoring during Spills (10 locations)	No. of Samples	6,000	10	60,000
	Total				**16,371,000**
	Contingency @ 10%				**1,637,100**
	TOTAL (including contingency costs)				**18,008,100**

16.5 Institutional Framework

Types of institutions responsible for implementation of environmental safeguard measures related to the present project can be divided into two group's viz.,

a) Institutions responsible for provision of environmental and safeguard measures in the present project; and

b) Institutions responsible for grant of clearance with respect to environmental issues arising out of the proposed highway project.

16.5.1 Institutions Responsible For Provision of Safeguard Measures

a) Gujarat Infrastructure Development Board

GIDB acts as a catalyst for infrastructure development in the state. It coordinates between various sector specific departments. The organization aids in project preparation by conducting pre-feasibility and feasibility studies through consultants. It also monitors the progress of projects. At present, the Board covers 22 infrastructure sectors, road sector being one of them.

b) Road and Building Department

The Roads & Buildings Department, Government of Gujarat is in charge of all activities pertaining to planning, construction and maintenance of all categories of roads and all government owned buildings as well as different structures like bridges flyovers etc. in the state of Gujarat. The section of the project corridor is presently under the National Highway division of the R&BD.

16.5.2 Institutions responsible for grant of clearances

Ministry of Environment and Forests (MoEF)

Ministry of Environment and Forests, established in 1985, is the authority responsible for the administration and implementation of GoI's policy with respect to Environmental conservation, management and pollution control. The MoEF is responsible for enforcing regulations in conjunction with various States' Department of Environment and Forests and autonomous organizations under these. The review and approval of EIA pursuant to GoI's legislation[29] and issuing clearances to the projects based on such appraisal lies in the ambit of MoEF.

Central Pollution Control Board (CPCB)

CPCB is a statutory authority under the MoEF in New Delhi with several regional offices. The main responsibilities of CPCB include inter-alia the following:

- Planning and implementing water and air pollution programs;
- Advising the Central Government on water and air pollution programs;
- Setting air and water standards; and
- Co-coordinating with the various State Pollution Control Boards.

The role of CPCB for the present project will be in the advisory capacity (co-ordinating with Gujarat State Pollution Control Board to ensure that the project adheres to the norms and standards set by it).

Gujarat State Pollution Control Board

The Gujarat State Pollution Control Board has the mandate for environmental management at the state level, with emphasis on air and water quality. The board is responsible for:

- Planning and executing state-level air and water initiatives;
- Advising state government departments on air, water and industry issues;
- Establishing standards based on National Minimum Standards;
- Enforcing and monitoring of all the activities within the state under the Air Act, the Water Act, the Water Cess Act and the Environment Protection Act; and
- Issuing No-objection certificates (NOC) for the projects in accordance with the water (Prevention and Control of Pollution) Act of 1974, the Water Cess Act of 1977 and the Air (Prevention and Control of Pollution) Act of 1981.

[29] Environmental Protection Act, 1986, Schedule-I specifies that for the projects falling under the 32 categories

16.6 Draft TOR and Clearance Requirements

The required Government of India (GOI) and State level environmental clearances for implementing the project to be obtained during project preparation are presented in Table 16-13. The contractor shall also obtain the required clearances and NOC from the various agencies like GPCB. GWSSB, PWD etc., for operating his equipments and carrying out construction operations, after mobilization but before construction works start.

Table 16-13: Government of India (GoI) and State Level Environmental Clearances

S. No.	Statutory Authority	Statute under which Clearance is Required	Applicability
1	Ministry of Environment and Forests, Government of India	Environmental Impact Assessment Notification, 14th September, 2006 issued under EP Act, 1986	Environmental Clearance from MoEF[30] is Applicable only if road widening (land acquisition for additional right of way) more than 20m (for any length of road section.
2	Ministry of Environment and Forests, Government of India	Forest Conservation Act, 1980	Forest Clearance from Regional office of MoEF is Applicable

As current project does not involve land acquisition of more than 20 m RoW, environmental clearances and a detailed EMP is not required. However, a draft ToR for procuring consultancy services has been attached in case the preparation of a detailed EMP is considered necessary Volume-II (Appendix-11.9). Also, Form I of the MoEF has been filled and attached as Volume-II (Appendix 11-10) in order to facilitate clearance procedures if required.

[30] Clearance required for road projects have been stated as part of Clause 7 (f) in the MoEF Notification. It states that, "Expansion of National / State Highways greater than 30 km involving additional right of way greater than 20m involving land acquisition". Projects involving road widening (land acquisition for additional right of way) of more than 20m (for any length of road section) require environmental clearance.

17. INITIAL SOCIAL ASSESSMENTS

17.1 Introduction

An initial social assessment has been carried out for the entire project corridor as part of this chapter. The chapter has been divided into eight sections. Section 2 describes the attempts to minimize the extent of social impacts through design interventions. An assessment of the likely social impacts due to the proposed corridor has been carried out as part of section 3. Stakeholder consultations have been an integral part of the assessment of the social issues along the project corridor. These were done at all stages of the project. These consultations and there outcomes have been discussed in section 4. A broad overview of the policy framework has been described in section 5. A resettlement and rehabilitation framework has been discussed in section 6. The section includes an entitlement framework for compensation and assistances to be given to the project affected persons. A broad estimate of the resettlement and rehabilitation budget has been given in section 7. A draft ToR for empanelling of consultants for carrying out a detailed Social Impact Assessment has been given in Section 8, if it is considered necessary by the implementing agency.

17.2 Minimization of Social Impacts

During initial stages of the project, design alternatives were carefully studied. An essential aspect that was looked into was the likely magnitude of social impacts in each of the alternatives. Six options were considered with varying combinations of lane configurations. The options on the basis of proposed RoW can be divided into two categories. These include a) 60 m RoW and b) 80 m RoW. Table 17-1 gives the likely area of land to be acquired. The area to be acquired for 80 m RoW is more than twice that of the land required for 60 m RoW. Significant acquisition of agricultural land would be required in the case of 80m RoW. This would be a major impact as the corridor passes through fertile agricultural lands. In order to minimize these impacts, the proposed RoW was kept to the minimum requirement of 60 m. Also, significant impact reduction is possible on commercial properties.

Table 17-1: Land Acquisition Requirements-60 m and 80 m RoW

Land use	Area to be acquired for 60m ROW (Ha)	Area to be acquired for 80m ROW (Ha)
Industrial	30.6	71.4
Commercial	16.5	38.5
Residential	9	21.0
Agriculture	180	420.0
Barren	16.5	38.5
TOTAL	**252.6**	**589.4**

The proposed project is a partially access controlled corridor. Access control is an important measure for the enhancement of both speed and safety. This however, gives rise to several social impacts such as severance of people from other settlements or from their agricultural lands or from other community facilities. Also, loss of business opportunities is also likely for commercial establishments located along the corridor. In order to minimize such impacts, a partially access controlled corridor has been proposed. A partial access control corridor not only ensures uninterrupted through traffic but also provides for service lanes, cattle crossings, pedestrian underpasses, etc. Table 17-2 gives the social benefits due to the measures adopted as part of the partial access controlled highway.

Table 17-2: Social Benefits- Partial Access Controlled Corridor

Facilities for Partial Access Controlled Corridor	Social Benefits
1. All major intersections and junctions as GRADE SEPARATED structures, normally Flyovers	• Uninterrupted through traffic. • No conflict at intersections/junctions for main highway traffic with local/slow moving and/or non motorized traffic, also cross pedestrian movements.
2. Service Lanes in Urban/Industrial zone	• Segregation of localized traffic. • Getting rid of on highway/side parking by commercial and passenger vehicles.
3. Pedestrian/Vehicular Underpasses	• Shall cater for cross pedestrian and/or vehicular movements without affecting speeds on main highway.
4. Cattle crossing Underpasses	• Safety for road users and animals. Reduction in fatalities considerable.
5. Other Junctions: At grade improvements	• Improved safety through well designed rotary/junctions.
6. Crash Barriers all along main highway	• Controlled access, smooth and speedy traffic flow on main highway.
7. Fencing along ROW on either sides	• First point of access restriction, only at selected points permission of cross movements.

17.3 Assessment of Impacts

The proposed project involves land acquisition of 252.6 hectares (Table 7.3). The widening options however, vary along the corridor. From Km 14.600 to 35.000 Km, six laning has been proposed. The rest of the corridor would have a four lane corridor. However, the acquisition would be done for an RoW of 60 m for future widening. The likely social impacts have therefore, been assessed for the proposed 60 m for the entire corridor. The following paragraphs discuss each of the likely social impacts.

17.3.1 Land Acquisition

As discussed above, the proposed RoW of 60m along the project corridor entails an acquisition of 252.6 ha. Table 17-3 gives the break up of the land to be acquired according to the existing usage. The maximum proportion of land to be acquired is agricultural land. However, only a minor strip of land is proposed to be acquired along the entire corridor. The next major component of land to be acquired is industrial land followed by commercial land. The proportion of residential land acquisition is very less and only mainly partial acquisition (explained in detail in subsequent sections). No major relocation is therefore, anticipated.

Table 17-3: Land Acquisition Requirements-60 m

S.No.	Type of Land	Area (sqm)	Area (Hectare)
1	Agriculture	1800000	180
2	Barren	165000	16.5
3	Commercial	165000	16.5
4	Industrial	306000	30.6
5	Residential	90000	9
	Total	**2526000**	**252.6**

Agricultural Areas- Along Project Corridor

17.3.2 Impacts on Structures

Both private structures (including Industrial, Commercial, and Commercial cum Residential buildings) as well as community structures (including public utilities, public and semi public assets are being impacted due to the proposed acquisition. A total of 501 structures are being impacted along the corridor. The most significant impact is that of commercial properties (Table 17-4).

The impacted structures have been further classified according to the extent of impacts into partial (less than 40% of the structure impacted) and fully impacted structures. More than 60% of the total structures impacted have only partial impacts. Small commercial establishments located along the corridor are likely to suffer impacts. In the case of industries, the compound walls, sheds and guard rooms are the major impacts. Fencing along agricultural lands is also likely to be impacted.

Table 17-4: Structures Impacted By Magnitude

Type of Structure	Partially Impacted	Fully Impacted	Total Impacted Structures
Residence	21	11	32
Commercial	107	71	178
Cultural	10	30	40
Industries	74	0	74
Public utilities	58	54	112
Public\semi-public	8	2	10
Agricultural fencing	24	31	55
Total	**302**	**199**	**501**

Of the total impacted structures, several structures are encroachers or squatters on the existing RoW (Table 17-5). A classification of these has thus been made for category of structure. Commercial and residential encroachments are primarily extensions into the existing RoW. Several squatters can be seen on the existing RoW. The commercial establishments are primarily kiosks. Several shrines are also present along the existing Row. These are described in detail in the subsequent sections. Industrial encroachments are primarily extended compound walls, or gates or sheds.

Table 17-5: Impacted Structures by Ownership

	Encroacher	Squatter	Title holders	Total Affected
Residence	3	0	29	32
Commercial	44	65	69	178
Cultural	5	30	5	40
Industries	21	0	53	74
Public utilities	0	0	112	112
Public\semi-public	0	0	10	10
Agricultural fencing	18	0	37	55
Total	**91**	**95**	**315**	**501**

KM 23 LHS- Commercial Structures

17.3.3 Project Affected Households

The total number of households likely to be impacted is 265 that include residential, commercial and agricultural households (Table 17-6). Since the industries are mainly large scale industries along the project corridor and they have only minor impacts, they have not been taken as project affected households.

Table 17-6: Project Affected Households

Type of Impact	Project Affected Households
Residence	32
Commercial	178
Agricultural fencing	55
Total	**265**

Km 41- Impacted Residential Structure

Impacted Residential Structure

17.3.4 Impacts on Livelihood

Livelihood impacts i.e., loss of livelihood is primarily felt by the commercial households (178 households). Also, there are several kiosks on the project corridor. No major livelihood impacts are expected in the case of agricultural households. Most of the households stand to lose between 7-15 m width strips of land. However, in order to ensure that households who are marginalized or have been left with an unviable piece of agricultural land, budgetary provisions have been made (refer section on resettlement and rehabilitation budget).

Km 168- LHS- At Chotila: Kiosks

17.3.5 Cultural Properties

Along the project corridor 30 cultural structures are fully impacted and 10 are partially impacted. Several of these are small shrines located within the existing RoW. Some have encroached into the existing RoW. Only 5 properties are on private lands (Table 17-5). Community consultations have been done for all these five properties and for some of the smaller shrines. These are described in detail in Section 17.5.

Km 42.6 RHS- Temple

Km 33.95 RHS- Shrine

7.3.5. Impacts due to shifting of utilities

Several utilities like water pipelines, gas pipelines, optical fibre cables and electrical lines are located close to the right of way (Table 17-7). These need to be shifted away from the corridor if the road is to be widened. Similarly road side services like bus stops shelters will have to be shifted from their present locations. However, as part of the construction, such utilities shall be replaced.

Table 17-7: Public Utilities Impacted

Type of Impact	L.H.S	R.H.S	Total
Fully	108	37	**145**
Partially	42	55	**97**
Total	**150**	**92**	**242**

17.3.6 Severance Impacts

As the project proposes a partially access controlled highway, impacts due to severance will also be generated. Key severance impacts include:

- Severance of agricultural lands and grazing grounds located on the other side of the residence;
- Impact on livelihood due to severance of commercial properties such as hotels, petrol pumps, etc on account of loss of access.

Such impacts are difficult to quantify. However, these are likely to cause severe social impacts and require appropriate mitigation measures. Measures such as underpasses, cattle crossings, grade separators, flyover and ROB's at appropriate locations have been proposed at suitable locations to mitigate such adverse impacts. The locations of these are detailed out in the section on mitigation measures.

Areas of Likely Severance Impacts

17.4 Socio-Economic Profile of Project Affected Households

A sample socio-economic survey of the project affected households was carried out along the project corridor. These include a mix of residential and commercial establishments. The major characteristics of the households include:

- Predominantly small and petty business establishments such as restaurants, repair shops, etc;
- Large proportion belonging to scheduled castes; and
- Primarily daily wage labourers with no fixed wages.

Several other issues related to the socio-economic characteristics have been understood and documented through the stakeholder consultations. These have been discussed in the next section.

17.5 Stakeholder Consultations

Stakeholder consultations were conducted at all stages of the project. The consultations were done in the prior to the design of the project corridor. The primary objective was to understand the social concerns of the community. At this stage, consultations also provided valuable inputs to understanding overall development issues in the adjoining villages/towns of the project corridor. Attempts were then made to formulate social safeguard measures which have been inbuilt into the final design. After the design was made, stakeholder consultations were again done. These were to address specific issues such as relocation of cultural properties and impact on cultural properties. The stakeholders consulted include the following:

- Villagers;
- Panchayat heads;
- Industrial associations and individual industries;
- Commercial establishments;
- Cultural properties– Owners & community people.

17.5.1 Pre-Design Consultations

Pre design stage consultations were held in Urban, Rural and Industrial areas. The locations for community consultations are given in Table 17-8. The issues discussed have been summarized briefly in Table 17-9.

Table 17-8: Locations for Consultations

Chainage No.	Location	Date
42.600	Bayla	6/08/2007
61.4	Bagodara	7/08/2007
88.980	Tokrala	6/08/2007
92	Kataria	6/08/2007
103	Limbdi	6/08/2007
119.4	Vadod	7/08/2007
156.4	Sapar	7/08/2007
170	Chotila	7/08/2007
178	Nanimoldi	7/08/2007
Industries at Changodar.		
17.600	Ankur	9/08/2007
20.900	Jagdish	9/08/2007
22.200	Waterman	9/08/2007

Table 17-9: Issues Discussed

Location	Issues Discussed
Chainage No.: 92 Village: Kataria Taluka: Limbdi District: Ahmedabad Date: 6/08/2007 Venue: Panchayat Office No. of Participants: Male: 6 Female:1	Kataria village is located 1 km away from the project corridor on the right hand side. Agricultural land of the village lies along the corridor and is likely to be impacted. **Land Acquisition and Relocation:** Villagers suggested that since the land lying opposite (to the left of the corridor) is vacant Government land, the alignment should be taken from that side. This shall save their lands. They were not ready to shift their agricultural lands. **Cultural property**: Only one shrine located on the left hand side and not likely to be impacted. The shrine was put in place five years ago. **Other Development Issues:** Access to health and clean drinking water are the major issues.
Chainage No.: 88/980 Village: Tokrala Taluka: Limbdi District: Ahmedabad Date: 6/08/2007 Venue: Panchayat Office No. of Participants: Male: 5 Female:2	50% of the village land (primarily agricultural) falls on the right hand side of the project corridor and is likely to get affected. **Land Acquisition and Options for Compensation**: The villagers expressed that if there land is acquired, then they should be given land for land compensation. The land allotted to them should be within their village and also it should be of the same fertility. At present the land price is Rs. 2.5 lakhs for 1 hectare of agricultural land. For residential areas, the land coast is Rs. 50-60/ sq. m. **Road Safety:** Accidents are caused when cattle cross the road. On an average, around 50-60 animals die in a year. They thus expressed that cattle crossing is required. **Road side drainage:** Water logging due to poor drainage is a problem in the area. Both sides of the road are prone to water logging. This they feel is due to the direction of the canal. **Other Development Issues:** Access to health is the major issue.
Chainage No.: 42/600 Village: Bayla Taluka: Bavla District: Ahmedabad Date: 6/08/2007 Venue: Panchayat Office No. of Participants: Male: 20	The village is located on either side of the road. On the left, there are agricultural lands and on the right, there are residential areas. The major issues include the following: **Road Safety:** Villagers have to cross the National Highway to reach their fields. Also, cattle crossing are a daily feature. Therefore, both pedestrian as well as cattle crossings are required. **Land Acquisition and Options for Compensation**: Majority of the villagers expressed that if their land is acquired, then they should be given land for land compensation. Others felt that if cash compensation is more than the existing land rates, then they would prefer to get cash. The existing rate for agricultural land in the village is Rs. 1 lakhs for 1 hectare of agricultural land. For residential areas, the land coast is Rs. 10/ sq. m. **Cultural Property:** A temple and shrine are located along the road. The temple is around 100-150 years old and has been renovated five years ago. IT is also known as Meldi Mata Mandir and is visited by lot of devotees. The villagers strongly opposed to the shifting of the temple and wanted the alignment of the road be changed and widening of the road be done on the other side. **Relocation:** Villagers said that by and large they would prefer to have constructed dwelling units in the same village for loss of the existing houses. They mentioned that they would also like to have training and other employment opportunities. **Drainage:** The existing culvert is too small. As a result, water does not pass from the right hand side to the left hand side. This leads to water logging in the right hand side and dry areas in the left hand side. The problem is further aggravated during rainy season. **Other Development Issues:** Irrigation of agricultural land is a major problem. Water supply pipelines are prone to leakages and therefore, there is lot of mixing of water. Rice, Cotton and Wheat are the major crops produced in the area. Health and education are areas for concern. Veterinary hospitals are also required. Unemployment is a problem in this area. Girl children are unable to continue education due to lack of public transport facilities. Also, there is problem of pollution due to the presence of gas industry near to the village. **Facilities Required:** Bus stand, Cattle crossing and pedestrian crossovers.

Location	Issues Discussed
Chainage No.: 103 Urban Centre: Limbdi Taluka: Limbdi District: Surendranagar Date: 6/08/2007 Venue: Municipality Office No. of Participants: Male: 5	The commercial establishments are located around 40 m from the National Highway and hence, no adverse impacts are anticipated. **Drainage**: The existing culver is too small and there is water logging. The Ramsagar canal water gets collected on the railway line and also enters the town. **Cultural property:** Swaminarayan temple is located on the crossing and is 7 years old.
Chainage No.: 61.4 Urban Centre: Bagodara Taluka: Bagodara District: Ahmedabad Date: 07/08/2007 Venue: Village Rest House No. of Participants: Male:4	It lies in Dholka taluka of Ahmedabad district. The population of the settlement is 4460. The settlement spreads on both sides of the project corridor. 80% of the settlement consisting mainly of residential and agricultural properties lie on the left hand side of the project corridor and the remaining 20% on the right hand side is agricultural land. Following issues were discussed during the consultation: **Resettlement issues:** Private land is upto 3 to 4 meters from the edge of the road at the left hand side of the village. Stakeholders strongly opposed the idea of relocation of their business area. If relocation is compulsory, they want cash and employment instead of their property. **Drainage Problems:** Drainage problem exists on both sides of the project corridor and as per them widening the existing culvert would solve the problem. Stakeholders expressed willingness to construct the underpass for cattle crossing. **Facilities required:** Nearly 20-25 accidents occur every year therefore; the villagers welcomed the proposal for construction of over bridge and also pedestrian footpath on both sides. Cattle accidents are also frequent so they have suggested for the construction of an underpass for movement of cattle on both sides of the road. **Environmental issues:** The people use bore water for drinking purposes. The water is salty in nature and they are also facing bone problems. Air and Noise pollution exist in close proximity to the project corridor. **Cultural properties:** There is no cultural property along the project corridor. **Social features and issues:** The settlement has 2 primary schools, 1 High school and one Government health centre. For higher studies they go to Dholka.
Chainage No.: 119.4 Village: Vadod Taluka: Wadhwan District: Surendarnagar Date:07 /08/2007 Venue: Village Meeting Point No. of Participants: Male: 7	Vadod is located 1 km away from the project corridor at chainage 119.4 km. The village lies in Wadhavan taluka of Surrendranagar district. The population of the village is 2058. The village area equally falls on both sides of the project corridor. Left hand side of the corridor is covered with residential and agricultural properties and the right hand side has only agricultural area. Following issues were discussed during the consultation: **Resettlement issues**: Mainly agricultural properties lie on both sides of the project corridor. If acquisition of the agricultural land is compulsory then the villagers want money and employment. **Drainage Problems:** Drainage problem occurs during monsoon season along the corridor. Stakeholders have asked for construction of open drainage on both sides of the road. **Facilities required**: Few vehicle accidents and 10-15 cattle accidents occur every year therefore, they have welcomed the proposal to construct an over bridge for controlling the accidents. **Environmental issues:** Presently there are no environmental issues in the village. **Cultural properties:** There is no cultural property along the project corridor. **Social features and issues:** The village has one primary school and one government health centre, for high school studies they go to Limbdi.
Chainage No.: 156.4 Village: Sapar Taluka: Sayla District: Surrendranagar Date:07 /08/2007 Venue: Village Meeting Point No. of Participants: Male: 10	Sapar village is located at chainage 156.4 km on the project corridor. The village lies in Sayla taluka of Surrendranagar district. The population of the village is 1054. The village spreads on both sides of the project corridor. 40% of the village area is on the left hand side which consists of agricultural properties and the 60% area on the right hand side is consists of residential properties. Following issues were discussed during the consultation: **Resettlement issues:** Stakeholders strongly opposed the idea of relocation of their residential and cultural property. If relocation is compulsory for residential area, they want cash and employment instead of their property. **Drainage Problems:** There is no drainage problem in the village along the project corridor. **Facilities required:** 20-25 cattle accidents have been occurring every year, so they have welcomed the proposal to construct an under pass for controlling the accidents and for easy movement of tractors to reach the agricultural fields on the other side. **Environmental issues**: The water available is potable and good for drinking. Recently drinking water facility has been developed by WASMO. The village has proper electricity facility. The people living adjacent to the corridor face noise and air pollution. **Cultural properties:** Two temples lie adjacent to the road with in the ROW, but the stakeholders have opposed to their relocation. **Social features and issues:** The village has one primary and one high school but there are no health centres.
Chainage No.: 170 km Urban Centre: Chotila Taluka: Chotila	Chotila is located at chainage 170 km on the project corridor. It is a taluka headquarter of Surendranagar district. The population of the urban area is 36880. Chotila is famous for Chamunda mata temple and is thus an important destination for pilgrims. **Resettlement issues:** There are privately owned commercial properties on both sides of the project

Location	Issues Discussed
District: Surrendranagar Date: 07/08/2007 Venue: Municipality Office No. of Participants: Male:5 Female:1	corridor up to a distance of 40m from the edge. **Drainage problem:** There are no drainage problems along the project corridor. **Facilities required:** Stakeholders put forward their requirement of pedestrian footpath and parking facility for vehicles as there is a heavy rush of pilgrims during festival seasons. Construction of an underpass for cattle crossing was also suggested by them. **Cultural properties:** There are no cultural properties along the project corridor. **Social features and issues:** Chotila has a high school and two government health centers, but there is no college for higher studies.
Chainage No.: 178 km Village: Nanimoldi Taluka: Chotila District: Surendranagar Date: 07/08/2007 Venue: Residence of Panchayat member No. of Participants: Male: 4 Female: 1	Nanimoldi is located at chainage 178 km on the project corridor. It lies in Chotila taluka of Surendranagar district. The population of the village is 1193. The village is evenly spread on both sides of the project corridor. The left hand side is totally agricultural and right hand side is fully residential. **Resettlement issues:** Stakeholders strongly opposed the idea of relocation of their residential and agricultural properties. If relocation is compulsory then they want land in place of their property. **Drainage problems:** There is no water logging problem along the corridor. **Facilities required:** Stakeholders have mentioned that the current alignment of the road should be changed the present curves lead to large number of accidents. They also suggested construction of an underpass for cattle crossing. **Environmental issues:** The village has good water treatment facility and 24 hours electricity. People residing along the road face Air and Noise pollution. **Cultural Property issues:** There are two shrines located within the ROW of the corridor. The villagers have opposed to the idea of the relocation of the shrines. **Social features and issues:** The village has a primary school but no high school therefore, for higher studies children go to Chotila. There are no health centres in the village.
Chainage No.: 17/600 Stakeholder: Ankur Protein Industry Ltd. Village: Changodar Taluka: Bavla District: Ahmedabad Date: 09/08/2007 Venue: Industry No. of Participants: 1	Ankur protein Industry is a large scale production unit. It is located on Left Hand Side of the project corridor. It supplies its goods to various parts of Gujarat, Maharashtra and Rajasthan. The NH 8 is frequently used by them for transportion of goods within and outside Gujarat. **Properties Impacted:** Watchman Room and compound wall. **Resettlement issues:** They preferred monetary compensation if good amount of money was offered or else government should reconstruct their compound wall. **Facilities Required:** If NH 8 is being converted to Expressway then, they prefer to have a service road and an under pass. They also welcomed the suggestion of making the NH partially controlled highway.
Chainage No.: 20/900 Stakeholder: Jagdish Aluminium Private Limited Village: Changodar Taluka: Bavla District: Ahmedabad Date: 09/08/2007 Venue: Industry No. of Participants: 1	Jagdish Aluminum is a small scale business industry. It is located on the Left Hand Side of the project corridor. The unit is involved in production and processing of aluminum sheets. It supplies its goods to Mumbai, Delhi, and other parts of India. They use NH 8A for transportation of their goods. **Properties Impacted:** 9 workers living room & 1 watchmen room. **Resettlement issues:** The chairman preferred monetary compensation for construction of Compound wall. While they also require land at near by place for relocation of workers living room. If land is provided at a faraway place then they would prefer cash compensation for the land acquired for widening. The cash compensation should be according to existing land rate of Industrial area. Current rate pre Yard is 3000/- Rs. which may vary from time to time. **Facilities Required:** If NH is converted to Access Controlled Expressway then a service lane along with an underpass/over bridge should be constructed.
Chainage No.: 22/200 Stakeholder: Waterman Village: Changodar Taluka: Bavla District: Ahmedabad Date: 09/08/2007 Venue: Industry No. of Participants: 1	Waterman is a small scale industrial unit. It is located on Right Hand Side of the project corridor. It supplies water pumps all over India. They use NH 8A a frequently to transport their goods. **Properties Impacted:** Compound Wall and Security Room. **Resettlement issues:** The Managing Director preferred monetary compensation for the land acquired according to prevalent market rates and FSI clearance. **Facilities Required:** If NH is converted to Access Controlled Expressway then facilities required would be: • Proper Drainage System. • Service Lane. • Parking Area near to Factory. • Over bridge. • Proper water supply.

17.5.2 Post – Design Consultations

The Post design consultations were held in commercial, residential and at cultural property locations. Table 17-10 gives the locations of consultations. The consultations at each of these locations have been detailed out in the following paragraphs.

Table 17-10: Locations for Consultations

Chainage No.	Location	Date
17.600	Changodar	20/11/2007
23.000	Checharvadi	20/11/2007
28.700	Motoda	20/11/2007
33.900	Bavala	20/11/2007
33.950	Bavala	20/11/2007
34.100	Bavala	
41.800	Kerala	21/11/2007
156.600	Sapar	22/11/2007

i. Cultural Property Locations

The community consultations at the cultural property locations included an assessment of the existing status of the structure in terms of size, age of structure, ownership status, etc. The discussion with the villagers primarily focused on identification of the relocation option from the villagers. Most of the villagers have agreed on the relocation of the structure with the exception of two structures as they feel that these are of religious importance. Most other affected cultural properties are only small shrines.

ii. Commercial Property

Consultation was conducted at one location where a large number of commercial structures are likely to be impacted. They preferred relocation of shops instead of monetary compensation. The details of the consultations is given in Table 17-11.

Table 17-11: Consultation with Commercial Property

Chainage (km)	Direction	Type of Construction	Number	Ownership Status of Property	Distance from existing CW (m)	Land ownership
23.000	L.H.S	Brick	24	Private	15	Private
	All shops are given on rent. Owner of all shops is Mr.R.G.Vaghalai. Impact Category: To be relocated ❖ Relocation has been agreed in the consultation held with owner of shops on 21-11-07. Relocation option: ❖ Can be shifted out of the proposed ROW. ❖ Prefer land at commercial area or near by place instead of monetary Compensation. Contact Person: R.G.Vaghalai. Mob. No. 9924200476					

iii. Residential Area

The residential households impacted due to the project have expressed that they would like to relocate within the village if they are given land for land compensation. In case of monetary compensation, they wanted replacement cost of the structure and assets. The details of the consultation are given in Table 17-12.

Table 17-12: Consultation with Residential Property Dwellers

Chainage (km)	Direction	Type of Construction	Number	Ownership Status of Property	Distance from existing CW (m)	Land ownership
41.800	R.H.S	Brick / Concrete	3	Private	6 - 7	Private

There are two residential and one cattle shed which would be fully impacted. People living in these houses belong to vulnerable caste (i.e SC).
Relocation has been agreed in the consultation held with the dwellers on 21-11-07.

Relocation option:
- ❖ Can be shifted out of the proposed ROW.
- ❖ Prefer land in village of the same value.
- ❖ Compensation should be given at the replacement cost of the house.
- ❖ They still felt that if possible, alignment option can be changed.

iv. Industries

Consultations at industrial establishments were primarily to inform the stakeholders about the project and the likely impacts. Since most of the impacts in industrial areas are confined to loss of compound wall, sheds of watchman, etc, they were agreeable to monetary compensation for the replacement of the same.

Ankur Industries

Water man Industries

17.6 Policy and Legal Framework

17.6.1 Provisions in Land Acquisition Act, 1984

The Act provides a framework for facilitating land acquisition within the Country. This Act enables the State to acquire private lands for public purposes. The Act ensures that no person is deprived of land except under the Act and entitles Affected Persons to a hearing before acquisition. The main elements of the Act are given in Table 17-13.

Table 17-13: Land Acquisition Act

Section	Aspect	Provision
Section 4	Notification of land	• Notification of land identified for the purpose of public welfare. • Objections must be made within 50 days to the DC (highest administrative officer of the concerned district. • No further sales or transfers are allowed.
Section 6	Intention to acquire land	• DC is directed to take steps for the acquisition, and the land is placed under Section 9. Interested parties are then invited to state their interest in the land and the price.
Section 11	Enquiry and award by Collector.	• DC shall make an award within one year of the date of publication of the declarations. Otherwise, the acquisition proceedings shall lapse.

Section	Aspect	Provision
Section 12	Award of Collector when to be final.	• Award shall be filed in the Collector's office and shall, except as hereinafter provided, be final and conclusive evidence, as between the Collector and the persons interested, whether they have respectively appeared before the Collector or not, of the true area and value of the land, and the appointment of the compensation among the persons interested.
Section 18	Reference to Court.	• In case of disagreement on the price awarded, within 6 weeks of the award the parties (under Section 18) can request the DC to refer the matter to the Courts to make a final ruling on the amount of compensation. • Compensation for land and improvements (such as houses, wells, trees, etc.) is paid in cash by the project authorities to the State government, which in turn compensates landowners. • The price to be paid for the acquisition of agricultural land is based on sale prices recorded in the District Registrar's office averaged over the three years preceding notification under Section 4. The compensation is paid after the area is acquired, actual payment by the State taking about two or three years. An additional 30 percent is added to the award as well as an escalation of 12 percent per year from the date of notification to the final placement under Section 9. For delayed payments, after placement under Section 9, an additional 9 percent per annum is paid for the first year and 15 percent for subsequent years.

Source: Land Acquisition Act, 1894 (Amended in1984).

17.6.2 Provisions in National Policy on Resettlement and Rehabilitation for Project Affected Families, 2007

The policy is applicable to projects that are likely to physically displace 400 families or more en masse in plain areas and 200 families or more en masse in hilly areas, DDP blocks, areas mentioned in Schedule V and Schedule VI of the Constitution of India. The objectives of the Policy are:

- To minimize displacement and to promote as far as possible, non-displacing or least displacing alternatives;
- To ensure adequate rehabilitation package and expeditious implementation of the rehabilitation process with the active participation of displaced persons;
- To ensure that special care is taken for protecting the rights of, and ensuring affirmative state action for weaker segments of society, especially members of SCs and STs and to create obligations on the state for their treatment with concern and sensitivity;
- To provide a better standard of living to displaced families;
- To integrate rehabilitation concerns into the development planning and implementation process; and
- Where displacement is on account of land acquisition, to facilitate harmonious relationship between the requiring body and displaced persons through mutual cooperation.

17.7 Resettlement and Rehabilitation Framework

17.7.1 Mitigation Measures

The mitigation measures for addressal of social impacts essentially relate to three measures including a) modifications in design, b) relocation of public utilities and cultural properties, and c) compensation for loss of private assets.

a) Design Measures

As described in the previous sections, some design interventions have been proposed for the mitigation of impacts due to severance. These include provision of underpasses and cattle crossings. Table 17-14 gives the chainages at which these are located. The locations were identified after on site observations of community behaviour, suggestions of local people and traffic volumes.

Table 17-14: Proposed Measures

Chainage	Proposed Measure
Km 19.10	Under pass
Km 23.9	Under pass
Km 24.9	Under pass
Km 49.425	Cattle Crossing
Km 90.20	Cattle Crossing
Km 123.8	Cattle Crossing
Km 160.18	Cattle Crossing

b) Relocation of Public utilities and cultural properties

Relocation has been agreed upon during stakeholder consultations for mitigation of impact on the public utilities and cultural properties.

c) Compensation for Loss of Private Assets and Livelihood

Compensation and assistances shall be provided for the loss of assets and livelihood to the project affected households and persons. The framework for compensation and assistance has been discussed in the subsequent section.

17.7.2 Compensation and Entitlement Framework

In order to compensate for the loss of assets and livelihood, an entitlement framework has been worked. The framework is in line with the measures adopted as part of the Gujarat State Highways Project by the Roads and Buildings Department. The monetary values have however been updated to the current price levels. The entitlement framework is given in Volume-II (Appendix-11.3).

17.8 Resettlement and Rehabilitation Budget

Volume-II (Appendix-11) gives a broad estimate of the budget for resettlement and rehabilitation worked out as per the entitlement framework. Both compensation and assistances have been accounted for.

17.9 Draft TOR for Social Impact Assessment

The proposed project does not at present cause significant social impacts. However, a Draft ToR has been attached as Volume-II (Appendix-11.4) for carrying out detailed Social Impact Assessment if required.

18. PROJECT COSTING

For appreciation of project cost, preliminary cost got worked out, this shall form input to further economic and financial analysis. Option wise major head costing is furnished as follows:

Cost in Crores INR

	Capital Construction Cost	Contingency, Design-Supervision Consultancy	Land Acquisition and Enviro-Social	Total Cost
OPTION-I 6L + 4L Existing ROW 45m: Proposed 60 m	**855.73**	68.46	175.18	**1100.97**

The selection of development option shall be based upon economic and financial rate of returns. In addition we made assessment with respect potential environmental and social mitigation measures need, which is described in ensuing sections.

ABSTRACT OF COST FOR THE CORRIDOR (NH8A - AHMEDABAD - RAJKOT) Option - 1

S.No.	Section	Chainage	Total Length	Cost in Crores												
				Highway Construction	Structures	Miscellaneous Works	Utility Shifting	Drip Irrigation	Total Cost	3% Contingencies	5% Design, Supervision and Agency Charges	Section Wise Total	Land Acquisition	Environmental Cost	Cultural Properties	Overall Total
1	Section - 1	Km 14+500 to Km 35+000	20.5	143.35	26.45	9.94	0.18	0.21	180.12	5.40	9.01	194.53	126.09			
2	Section - 2	Km 35+000 to 62+000	27	84.17	96.31	1.62	0.18	0.27	182.55	5.48	9.13	197.16	20.87			
3	Section - 3	Km 62+000 to Km 104+000	42	104.52	70.40	2.20	0.18	0.42	177.72	5.33	8.89	191.93	9.56			
4	Section - 4	Km 104+000 to Km 148+000	44	109.12	27.07	1.88	0.14	0.44	138.65	4.16	6.93	149.74	5.53			
5	Section - 5	Km 148+000 to Km 182+400	34.4	93.69	73.13	9.35	0.18	0.34	176.69	5.30	8.83	190.83	13.13			
		Total	**167.9**	**534.85**	**293.36**	**24.99**	**0.85**	**1.68**	**855.73**	**25.67**	**42.79**	**924.19**	**175.18**	**1.50**	**0.10**	**1100.97**

SECTION E: PROJECT VIABILITY ANLYSIS AND WAY FORWARD

19. ECONOMIC ANALYSIS

19.1 Rationale

The proposed road widening/ improvement work is being contemplated. The extent of improvement, however, should depend upon the economic benefits or impacts that the improvement proposal will provide for the users. Therefore economic analysis becomes a key in decision making process, especially when the project to be undertaken is likely to have major societal impacts, like the proposed one. The improvement options need to be seen in the economic context while taking decision. For this the economic analysis has been undertaken for the project, both by each package[31] as well as for the corridor as a whole.

19.2 Economic Perspective of Analysis

The benefits of the road improvement/upgradation has been worked out in terms of savings in vehicle operating costs (VOC) and travel time (VOT)[32]. The inputs which have gone into the estimation of the same have been given at Volume-II (Appendix-12). The savings to the society in terms of VOC and VOT are given in Table 19-1. 'With' and 'without' project approach has been followed for the assessment of benefits.

Table 19-1: Savings in VOC and VOT for Corridor (Mill Rs)

Year	VOC	VOT
2013	1394	884
2015	1570	1038
2020	2134	1475
2025	2634	1952
2030	2995	2392
2035	3789	2866
2040	6904	3349

The benefits are primarily due to the reduced congestion and increased speeds, which is made possible by segregation of local traffic from long distance traffic, as well as by providing grade separation at the intersections.

19.3 Results of Economic Analysis

The economic viability of the project[33] has been assessed by each of the project packages as well as for the corridor as a whole. The results of the economic analysis are presented in Table 19-2. Detailed outputs of the same are given as Volume-II (Appendix-12).

[31] The project has been broken into two packages for financial analysis. This phenomenon has been explained in the chapter on Financial analysis. However, the Package I is from km14.5 to km 61.4 and Package II is from km 61.4 to km182.4.

[32] The assessment of the benefits and economic viability has been undertaken following the IRC SP-30 approach and equations.

[33] The economic analysis undertaken is for the finally selected option. While undertaking financial analysis, one of the options considered is the staged six-lane, i.e. the project road goes for widening to six lane in the year 2021. Economic analysis has not been repeated for this case. This is with the understanding that since Option-III, which is a full six lane improvement option, is

Table 19-2: EIRR and NPV by Packages

Indicator	Component of Benefit	Package I		Package II		Full Corridor	
		25 years	30 years	25 years	30 years	25 years	30 years
EIRR (%)	Without time savings	11.42	12.26	19.58	20.09	15.74	16.41
	With time savings	18.86	19.19	28.70	28.88	23.91	24.19
NPV (Mill Rs)	Without time savings	-ve	108	3153	3950	2957	4070
	With time savings	2910	3367	8093	9411	11015	12790

The sensitivity analysis has been undertaken to assess the sensitivity of the project viability with respect to the major parameters like cost and benefit.

Table 19-3: EIRR under Sensitivity Analysis (in % for 30 years)

Case	Package I		Package II		Full Corridor	
	Without time savings	With time savings	Without time savings	With time savings	Without time savings	With time savings
Base Case	12.26	19.19	20.09	28.88	16.41	24.19
15% Cost Increase	10.85	17.24	18.10	26.09	14.73	21.85
15% Benefit Reduction	10.61	16.92	17.77	25.66	14.45	21.48
15% Cost Increase and 15% Benefit Reduction	9.31	15.15	15.99	23.19	12.93	19.39

The project is justified for implementation even in the worst case of sensitivity analysis if the savings in travel time are taken into consideration.

economically viable, and Option-I, which is the selected option, is also viable, then the staged widening will also be economically justified for implementation.

20. FINANCIAL ANALYSIS

20.1 Background and Options for Study

The present NH-8A was earlier a state highway, which was a two lane facility. The corridor was a very important one for the state as it connected two very important regions, Central and Saurashtra, with the rest of the state as well as the country. These regions were to emerge as the development centers of the state over time, resulting in high traffic levels. If proper infrastructure was not kept in place to facilitate development of the regions, which was so very important for the state economy, the development was likely to get constricted. This was very well realized by the GoG . Therefore, a move was made on the part of the state to get this corridor declared as a National Highway, so that it could be better maintained. However, as otherwise expected by the state, this corridor did not get enough attention of the center and was left unattended as a 2 lane facility only. Then GoG, took up the task of getting the NH-8A widened to 4 lane in 2003, from Bagodara to Rajkot. The GoG, at its own instance, has been mandated by GoI to undertake this work and recover the investment through tolling of the facility. The toll rates were fixed then, and the concession period was kept at a maximum of 20 years, which is expected to get over in 2018. A Memorandum of Agreement (MoA) has been signed between the two governments, according to which the improvement works on this corridor cannot be taken up under the BOT scheme. GoG, represented by the R&BD, took a loan from HUDCO which is likely to get fully repaid by December 2009. R&BD desires to undertake further improvement works on the project corridor.

Since a section of the project corridor is under the MOA, and the rest is still with the MoSRT&H, the financial analysis has been undertaken for scenarios and cases which would aid in arriving at certain alternatives for implementing the project. A detailed analysis has been undertaken by each of the identified project package [34]–

- Package I: from km 14.4 to km 61.4 – the ownership and responsibility of maintaining the road stretch lies with the Centre.
- Package II: from km 61.4 to km 182.4 – the responsibility of maintaining this stretch of road is presently with the GoG, vide the MOA, which is to be effective till 2018.
- Full corridor: as an option for study, the analysis has been undertaken for the whole corridor as one package. This has been done to aid the decision making process.

For each of the above stated packages, the following analysis has been undertaken:

- o As per the present MOA: the financial analysis has been undertaken based on the conditions laid down in the MOA. Since the GoG shall be investing in acquiring the land and relocation of the facilities along the corridor, that cost is also expected to be recovered as per the MOA. The toll rates used are the ones which are being applied presently;
- o As per the MCA prepared by Planning Commission for the National Highways: Since the project corridor is NH, the possibility of implementing the corridor improvement has been examined on the basis of the document prepared for the purpose by the Planning Commission.

[34] Detailed discussions and deliberations of the GoG and the Centre is anticipated at this stage, therefore an exhaustive financial analysis has been undertaken. This is likely to help in understanding all possible scenarios for discussions and decisions.

20.2 Tolling Strategy

Tolling strategy for the project corridor has been worked out based on the project packaging. It has been decided by R&BD to implement the project as two packages, one which is already under the MOA with the centre and the other from km14.500 to km61.400. Therefore the viability study has been undertaken with the assumption of two packages:

- Package I : from km 14.500 to km 61.400
- Package II : from km 61.400 to km 182.400

Location of toll plaza on these packages, which are contemplated to be implemented under commercial/BOT format, is very critical. In order to maximize the realisable toll revenue, toll collection is undertaken only at those locations where higher levels of tollable traffic is likely to be intercepted.

It has been observed that presently there are two toll booths, one each at km 63 and 182. Since setting up of tollable stations means major investment, an attempt has been made to retain the existing toll plazas. With all these considerations, two new toll plazas have been proposed at kms 20.200 and 41.600, retaining the ones at km 63 and 182, along the project corridor. Figure 20-1 shows the locations of toll plaza.

The tolling of vehicles crossing any of the toll plazas is expected to be in the following way:

- The vehicle crossing toll plaza at km 20.200 or 41.600, is expected to pay for the use of half the length of Package I
- Vehicles getting intercepted at km 63 or 182, are expected to pay toll for half the length of Package II – km 61.400 to 182.400.

As per the norms of the MoSRT&H, distance between two toll plazas need to be maintained at a minimum of 60 to 80 km. However, if the Ministry norm is to be followed in this case, there would be substantial loss in toll revenues. Figure 20-1 explains this in details. This figure is based on the turning movement surveys, conducted at Bhavnagar and Bagodara junctions.

There are four major junctions between the two toll plazas. Vehicles leaving the project corridor via one of these turnings or coming on to the corridor through one of the junctions, will pay toll only at one of the plazas. Therefore, if one of the two toll plazas at km 40 or km 63 are eliminated, then there is going to be a revenue loss, more so since the two toll plazas fall on two different packages[35]. Therefore there is a need to set up two toll plazas within the proximity of about 20 km.

[35] At a later date government may decide to collect the tolls from the road users of this corridor at one point only. However, this would be possible only if a device is worked out for sharing the revenues appropriately.

20.3 Assumptions for Analysis

The financial analysis of the above mentioned options have been undertaken with the following assumptions:

Parameters	Under present MOA	New MCA for NHs
Rate of Interest	10% p.a.	12% p.a.
Loan Repayment Period	2 years moratorium + 10 years repayment	2 years moratorium + 10 years repayment
Rate of Inflation	5% p.a.	5% p.a.
Upfront Fee and other Financing Charges	1.5% of loan amount	1.5% of loan amount
Insurance premium	0.7% of capital investment	0.7% of capital investment
Toll Rates	As per present tolls being collected on corridor (121km) in Rs/trip: Cars/Jeep 40 LCV/Mini Bus 75 Bus/Truck 150 3-Axle/MAV 168	As per MoRTH toll rates
Toll Escalation	25% after every 5 years	As per existing MCA[36] and revised escalation formula[37]
Traffic Growth Rate	Realistic	As per MCA – 2% pa till opening of facility and 5% pa thereafter
Project cost	Construction cost + land acquisition cost	Construction cost without land acquisition cast

20.4 Cost of Project

The cost of the project has been assessed after undertaking the preliminary design. The package-wise total project cost, as derived, has been given in Table 20-1.

Table 20-1: Total Project Cost by Package (Mill Rs)

Components	Package I	Package II	Full Corridor
Civil Construction Cost	3707.70	4799.00	8506.70
Contingency (10%)	370.77	479.90	850.66
Construction Supervision (3%)	122.35	158.37	280.66
Inflation During Construction	883.42	1143.44	2026.84
Interest During Construction	429.41	555.79	985.19
Pre-operative Expenses	69.61	90.1	159.72
Insurance Premium	73.89	95.63	169.52
Total Project Cost	**5657.15**	**7322.23**	**12979.25**

In case the analysis has been undertaken following the present MOA norms and conditions, the cost of the project includes the land acquisition, social as well as the utility shifting costs:

- Package I : Rs 5185.37 mill
- Package II : Rs 5097.44 mill
- Full Corridor : Rs 10282.81 mill

[36] 40% of the WPI to be the escalation factor for tolls every year.

[37] The base year toll fee is to be escalated at the rate of inflation plus 3% of base year toll rate till COD.Thereafter, for 15 years from the first year of revision of toll rate , the applicable rate of escalation is 40% of inflation rate plus 3% of base year toll rate . After 15 years the escalation factor is only 40% of inflation rate.

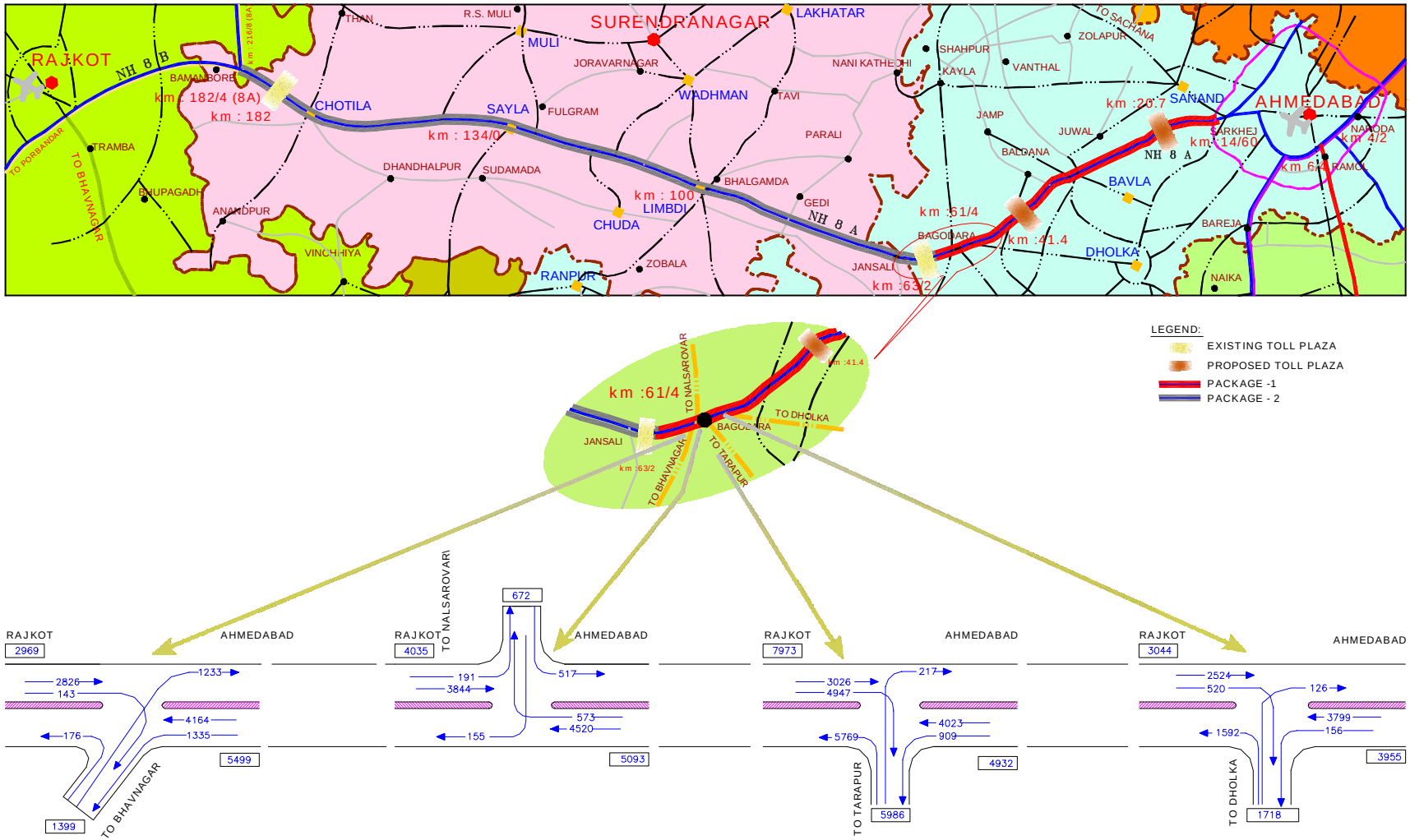


Figure 20-1: Location of Proposed & Existing Toll Plazas and Turning Movements

The routine and periodic maintenance cost as considered in the analysis are as follows:

	Four-Lane	Six-Lane
Routine Maintenance (Rs/km)	40,000	66,000
Periodic Maintenance (Rs/km) (every 5th Year)	3,000,000	5,000,000

20.5 Toll Revenues

The tollable traffic as determined has been used to estimate the revenues for the above stated cases. The total revenues under the two cases, i.e. the present by imposed toll rates and the Ministry toll rates, have been observed to be as given in Table 20-2.

Table 20-2: Total Revenue by Package and Toll Strategy (Mill Rs)

Years	Present MOA		Existing Toll Escalation for NHs as per MCA		Revised Toll Escalation for NHs as per MCA	
	Package I	Package II	Package I	Package II	Package I	Package II
2012 (half year)	141	406	296	639	319	702
2015	334	964	707	1604	844	1861
2020	519	1477	1037	2255	1301	2856
2025	793	2235	1448	3166	1891	4147
2030	1222	3418	2020	4436	2658	5849
2035	1885	5264	2811	6298	3739	8234
2039	2742	7619	3757	8270	4937	10832

20.6 Results of Financial Analysis

The analysis as already mentioned, has been undertaken for the three project package options. The results of the analysis, with the above stated inputs and assumptions, are presented in the ensuing sections by each of the project package. Some of the detailed inputs are given Volume-II (Appendix-12).

20.6.1 Package I : km 14.5 to km 61.4

The analysis for this package is undertaken for all the stated options and the results of the same are presented in Table 20-3.

Table 20-3: Results of Package I

Parameters	BOT - Revised Toll escalation			BOT Toll Escalation being followed so far		
Length (km)	47.5		47.5	47.5		47.5
Concession Period	**20 yrs**	**30 yrs**	**20 yrs**	**20 yrs**	**30 yrs**	**20 yrs**
Cost						
Civil Cost	3707.7		3707.7	3707.7		3707.7
10% Contingency	370.77		370.77	370.77		370.77
3% Const Sup	122.35		122.35	122.35		122.35
Inflation During Construction	883.42		883.42	883.42		883.42
Interest During Construction	429.41		429.41	429.41		429.41
Pre-operative Expenses	69.61		69.61	69.61		69.61
Insurance Premium during Construction Period	73.89		73.89	73.89		73.89
TPC	**5657.15**		**5657.15**	**5657.15**		**5657.15**
Loan Repayment Schedule						
Moratorium	2 years		2 years	2 years		2 years
Repayment Period	10 years		10 years	10 years		10 years
Viability Gap Funding						
Mill Rs			763.7			2263
% of TPC			13.50%			40.00%
Equity Support (Mill Rs)			763.7			1131.50
O&M Support (Mill Rs)			-			1131.50
Results						
Pre-tax IRR(%)	14.99%	17.24%	17.03%	11.84%	14.57%	17.13%
Post-Tax IRR(%)	13.98%	15.95%	16.03%	11.13%	13.53%	15.85%
Return on Equity (%)	15.90%	18.43%	19.04%	9.91%	13.94%	20.18%
Average DSCR	1.62		1.89	1.25		1.73
Minimum DSCR	0.86		1.00	0.48		0.61
Pay Back Period	12 yrs 8 mths		11 yrs 9 mths	15 yrs 4 mths		12 yrs 4 mths

In addition to the above stated cases, the analysis under the present MOA was also undertaken. The results of that analysis indicated that if the project road is to be improved by R&BD, then this package is not viable under the present MOA which is applicable on the Package II of the project. However, the results of the two toll escalation cases presented in the Table 20-3 indicate that if the project is implemented under the new MCA, then it can be made attractive with a certain percentage of grant. If the revised toll escalation formula is used for revising annual toll rates, the amount of grant required is only at 13.5% of TPC.

20.6.2 Package II : km 61.4 to km 182.4

The results of analysis as undertaken have been presented in Table 20-4.

Table 20-4: Results of Package II

Parameters	As per Government Present MOA		BOT Toll escalation being followed so far	BOT - Revised Toll escalation	
Length (km)	120.4		120.4	120.4	
Concession Period	**20 yrs**	**30 yrs**	**20 yrs**	**15 yrs**	**20 yrs**
Cost					
Civil Cost	5097.44		4799.00	4799.00	
10% Contingency	509.74		479.90	479.90	
3% Const Sup	168.22		158.37	158.37	
Inflation During Construction	1214.55		1143.44	1143.44	
Interest During Construction	489.26		555.79	555.79	
Pre-operative Expenses	91.88		90.1	90.1	
Insurance Premium during Construction Period	101.58		95.63	95.63	
TPC	**7672.67**		**7322.23**	**7322.23**	
Loan Repayment Schedule					
Moratorium	2 years		2 years	2 years	
Repayment Period	10 years		10 years	10 years	
Viability Gap Funding					
Mill Rs					
% of TPC					
Equity Support (Mill Rs)					
O&M Support (Mill Rs)					
Results					
Pre-tax IRR(%)	13.00%	15.91%	20.18%	21.61%	23.83%
Post-Tax IRR(%)	12.02%	14.66%	18.52%	19.67%	21.83%
Return on Equity (%)	13.70%	17.11%	24.19%	27.66%	29.80%
Average DSCR	1.49		2.14	2.78	
Minimum DSCR	0.68		0.81	1.43	
Pay Back Period	13 yrs 9 mths		9 yrs 10 mths	8 yrs 4 mths	

The returns of Package II are relatively more that Package I. One of the major reasons is the high cost of the latter. If the GoG has to improve the road under the terms and conditions of the same MOA as is effective so far, then also the project can be implemented with fairly good returns flowing to the GoG. However, in this case, the state government will have to invest the equity component. In order to avoid any such investment commitments on the part of the state, the option of taking the BOT route has also been explored. In this, the project turns out to be an attractive venture for the private investor. However, implementing this project on BOT would necessitate six-laning of the project in the year 2021, when the traffic on section 5 would exceed 60,000 PCUs. The other option to six-laning is truncating the concession period to 2023, after three years of the traffic exceeding the capacity of four lane. Both the scenarios have been examined for commercial viability. The

revised toll escalation formula has been considered for the analysis. The results are as given in Table 20-5.

Table 20-5: Results of Package II under Staged 6-Laning (with revised toll escalation formula)

Parameters	Revised Toll Escalation and Rs 1200 mill prepayment	BOT - Revised Toll escalation			
	if Con. Period ends with requirement of 6-Lane ie 2021 plus 2 more years	Staged Construction - 6-laning opening to traffic in 2021[38]			
		No Upfront Payment		With Upfront payment of about Rs 1500 mn	
Length (km)	120.4	120.4		120.4	
Concession Period	**14 Yrs**	**20 yrs**	**25 yrs**	**20 yrs**	**30 yrs**
Loan Repayment Schedule					
Moratorium	2 years	2 years		2 years	
Repayment Period	9 Years	10 years		10 years	
Viability Gap Funding					
Mill Rs					
% of TPC					
Equity Support (Mill Rs)					
O&M Support (Mill Rs)					
Results					
Pre-tax IRR(%)	16.66%	20.30%	21.52%	16.44%	17.96%
Post-Tax IRR(%)	15.41%	18.69%	19.75%	15.29%	16.56%
Return on Equity (%)	20.66%	18.95%	21.06%	11.49%	15.13%
Average DSCR	2.06	1.61		1.2	
Minimum DSCR	1.22	-0.36		-0.27	
Pay Back Period	8 yrs 6 mths	14 yrs 11 mths		16 yrs 7 mths	

A cost of six laning the highway from four lane has been estimated as Rs 3472 mill[39]. The project receivables are healthy and are able to absorb this kind of staged investment, along with an upfront negative grant of Rs 1500 mill with a concession period of 20 years. However, in case the six-laning is not contemplated, then the concession period has been assumed to get truncated in 14 years, ie, 2023. In that case as well, the concessionaire is able to give about Rs 1200 mill upfront as the negative grant to the government.

Taking this route will, however, mean coming out of the present MOA, and getting into some other agreement with the Centre. When the highway stretch falling in the second package was widened, there was a loan taken by HUDCO, by the GoG. Besides this there was an equity contribution to the tune of Rs 1100 mill made by the state. The loan repayment is likely to get over fully by December 2009. Therefore, this is not going to form a hurdle in revising or dissolving the existing MOA. The equity contribution of the state is likely to be recovered in the form of a negative grant from the prospective bidder, as shown in the analysis. The Package II is an attractive project to be taken up for BOT implementation.

[38] The investment for staged construction is assumed from 2018 to 2020, with the six-lane facility opening to traffic in 2021.

[39] All the grade separators have been constructed upfront with the provision of six-lane, hence the cost is mainly for the carriageway widening only.

20.6.3 Full Corridor

In a situation where the existing MOA can be truncated, and a new understanding on the road upgradation can be entered with the Centre, a scenario where the full corridor of 167.9 km can be taken up on BOT for upgrading to a partially access controlled highway, has been examined. The results of the analysis are given in Table 20-6.

Table 20-6: Results of Full Corridor

Parameters	BOT Toll escalation being followed so far		BOT - Revised Toll escalation	
Length (km)	167.9		167.9	
Concession Period	**20 yrs**	**30 yrs**	**15 yrs**	**20 yrs**
Cost				
Civil Cost	8506.6		8506.6	
10% Contingency	850.66		850.66	
3% Const Sup	280.72		280.72	
Inflation During Construction	2026.84		2026.84	
Interest During Construction	985.19		985.19	
Pre-operative Expenses	159.72		159.72	
Insurance Premium during Construction Period	169.52		169.52	
TPC	**12979.25**		**12979.25**	
Loan Repayment Schedule				
Moratorium	2 years		2 years	
Repayment Period	10 years		10 years	
Viability Gap Funding				
Mill Rs				
% of TPC				
Equity Support (Mill Rs)				
O&M Support (Mill Rs)				
Results				
Pre-tax IRR(%)	16.48%	18.44%	17.65%	20.31%
Post-Tax IRR(%)	15.35%	17.05%	12.26%	18.74%
Return on Equity (%)	18.56%	20.54%	21.30%	24.38%
Average DSCR	1.79		2.30	
Minimum DSCR	0.90		1.23	
Pay Back Period	11 yrs 9 mths		9 yrs 7 mths	

The results of the analysis with the two toll escalation formula have been presented in the table. As expected the corridor as a whole emerges to be an attractive investment for the private sector, more so in case of the revised toll escalation formula.

As in case of Package II, commercial viability in the case of staged construction has also been explored.

Table 20-7: Results of Full Corridor under Staged Six-Laning (with revised toll escalation formula)

Parameters	BOT - Revised Toll escalation				
	Staged Construction - 6-laning opening to traffic in 2021				
				With Upfront payment of about Rs 1500 mn	
Length (km)	167.9			167.9	
Concession Period	**15 yrs**	**20 yrs**	**25 yrs**	**20 yrs**	**25 yrs**
Loan Repayment Schedule					
Moratorium	2 years			2 years	
Repayment Period	10 years			10 years	
Viability Gap Funding					
Mill Rs					
% of TPC					
Equity Support (Mill Rs)					
O&M Support (Mill Rs)					
Results					
Pre-tax IRR(%)	14.13%	17.66%	19.06%	15.54%	17.12%
Post-Tax IRR(%)	12.95%	16.57%	17.73%	14.66%	15.94%
Return on Equity (%)	4.80%	16.83%	18.93%	12.75%	15.61%
Average DSCR	1.69			1.33	
Minimum DSCR	0.27			0.23	
Pay Back Period	14 yrs 7 mths			15 yrs 8 mths	

The phased cost which has been assessed for bringing the project facility to a full six lane road, is Rs 4007 mill. The investment has been assumed in the years 2018 to 2020. Full corridor if taken for staged widening is attractive, with the minimum concession period to be between 18 to 20 years, if no upfront grant is asked for. However, if the concession period is taken to 25 years, the project is able to give an upfront negative grant of about Rs 1500 mill.

21. OPTIONS FOR IMPLEMENTATION

The viability analysis, both economic and financial, reveals the following:

- The project is economically viable, hence should be considered for implementation from the society's perspective.
- From financial perspective, the project can be implemented by R&BD, by continuing to toll the facility as they have been in the past[40]. However, since the present MOA of the GoG with the GoI is only upto 2018, for the scope of work as completed in 2003, there could be requirement to
  - Extend the period of MOA with the GoI;
  - Revise the scope of work as defined in the MOA.
- Again from the financial perspective, the project can be implemented through the BOT route. This would necessitate truncation of the present MOA with the GOI. Once this is agreed upon, the option for implementation could be one of the following:
  - The GoG has invested an amount of about Rs 1100 mill towards the equity participation on the road widening works undertaken in the year 1998. Since the project shows the capability, the project could be bid out on the condition of upfront payment of Rs 1500 mill to the GoG. The project should go for staged investment with six-lane facility coming up when the traffic levels reach 60,000 PCUs. The bidding criteria could be grant-positive or negative. The concession period can be kept at 25 years.
  - If Package II is taken up for implementation separately, then Package I can be bid out on BOT with grant/premium as criteria. The Concession period can be kept as 20 years for this.

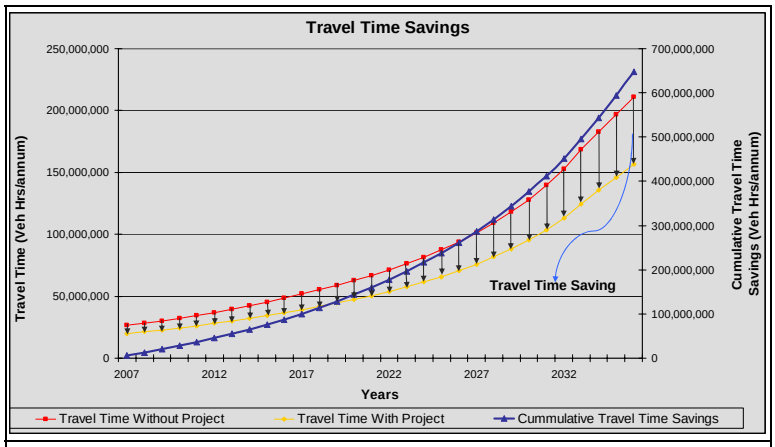


Figure 21-1: Travel Time Savings

- In case of implementation of the project on BOT, the toll escalation formula, as being applied on the state highway VGF projects[41] as well as on the six laning NHs,, should be recommended. This will improve the attractiveness of the project.

The project needs to be planned and implemented. The urgency is the savings in travel time which is precious for the nation as a whole and Gujarat state in particular. The travel time tend to go up from 26 mill vehicle hours in 2008 to about 2010 mill vehicle hours in the year 2035. The savings in travel time, if the project is planned is to the tune of 54 mill vehicle hours.

The dialogue of the state with the centre should get initiated in this direction soon. The effort should be towards truncating the present MOA, and taking up the project on BOT basis for improvement. The GoG as well as the Centre, will get a six-lane facility without investing in the same.

[40] This may be Package II only or the full corridor. Whatever, the case, there would be a need to revise the time and scope of work as mentioned in the MoA.

[41] The formula has been explained in detail in the Volume-II (Appendix-11.- I, Schedule R, of the Planning Commission MCA for State Highways, to be taken up for up-gradation under the VGF scheme.