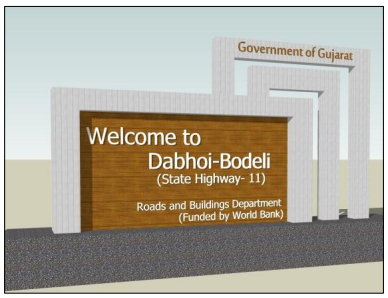

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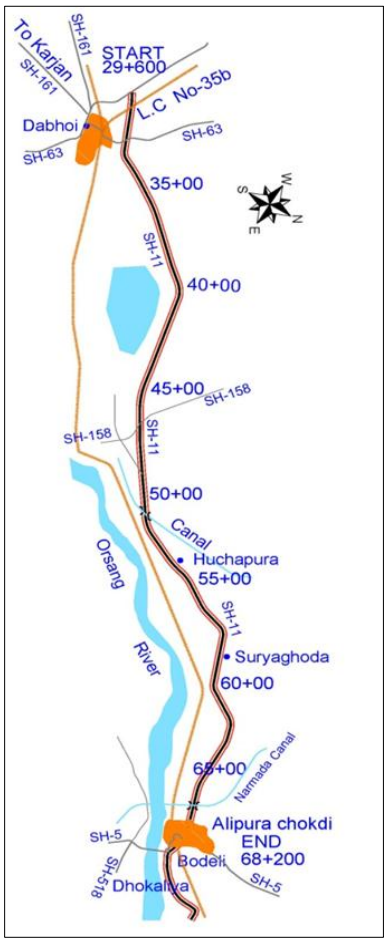
GOVERNMENT OF GUJARAT



Project Preparatory Works Consultancy Services for Gujarat State Highway Project - II

Detailed Project Report

Executive Summary
(DABHOI – BODELI)

January 2013

LEA Associates South Asia Pvt. Ltd.
LEAdership in engineering & planning solutions

EXECUTIVE SUMMARY

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

1. Gujarat is one of the versatile and dynamic states in India. The state has established itself on stronger economic foundation. Over the last decade the name of "Gujarat" has emerged synonymous with progress and vibrancy. Government of Gujarat (GoG) through Roads and Buildings Department (R&BD) is thriving to deliver better than the best road infrastructure for the communities.

2. Gujarat roads, managed by R&BD, are known as one of the best in the country. R&BD is successfully managing its road assets through various flagship programs of GoG, besides multilateral funding and Public Private Participation. The Gujarat State Highway Project – I (GSHP-I) successfully implemented by R&BD, GoG through 2001 to 2007 with the World Bank assistance, has set many bench marks for other states to follow. The state appreciating need of sustenance of its economic growth, endorses that the infrastructure is one of the key and further its enhanced quality is a great value addition.

3. GSHP-I project umbrella before its closure itself rooted efforts towards second highway project for the state. The Updated Strategic Options Study (USOS) for the Core Road Network of the Gujarat State was carried out in 2005-06 to this respect and the same was duly revalidated in 2010. This study has prioritised road sections on strategic parameters to arrive at about 1,600 km road length. R&BD, GoG with in-principal agreement with the World Bank (WB) has finalised project budget as Rs. 2,100 crore. As a pre-requisite for loan appraisal process with the WB, R&BD, GoG selected about 397.9/460 km of road length for project preparatory works.

4. R&BD, GOG has taken a step forward by selecting LEA Associates South Asia Pvt. Ltd. (LASA) as Project Preparatory Works Consultant. Project Preparatory Works Consultancy Services (PPWCS) mandates the consultant for detailed engineering project report preparation along with procurement documents for selected 397.9 km road length.

1.1.1 Project Corridors

5. The corridors are selected by R&BD across the state to have representation of various project interventions like four laning, wide two laning and maintenance. The list of project corridors at a glance is furnished through Table 1.1. The map showing project corridor is provided as Map 1.1.

Table 1.1: List of Project Corridors

Work Type	Sr. No.	Link Name	SH No.	Length (km)
Two Laning / Wide Two Laning	1	Lunawada – Khedapa (Border)	SH-02, SH-152	56.70
	2	Bayad – Lunawada	SH-69,SH-63, VR/MDR	44.56
	3	Dhansura – Meghraj	SH-145	46.65
	4	Gondal – Atkot	SH-01	35.40
	5	Dhandhuka – Dholera	SH-20	27.00
	6	Umreth- Vasad (including	SH-83,SH-188, SH-151	35.45

Work Type	Sr. No.	Link Name	SH No.	Length (km)
		Kapadvanj-Ladvel)		
	7	Dabhoi – Bodeli	SH-11	38.60
Four laning	8	Mehsana-Himmatnagar	SH-55	66.15
Rehabilitation	9	Paliyad-Dhandhuka	SH-001	46.00

Source: As provided in Terms of Reference (ToR)[1]

1.2 BROAD OBJECTIVES AND SCOPE

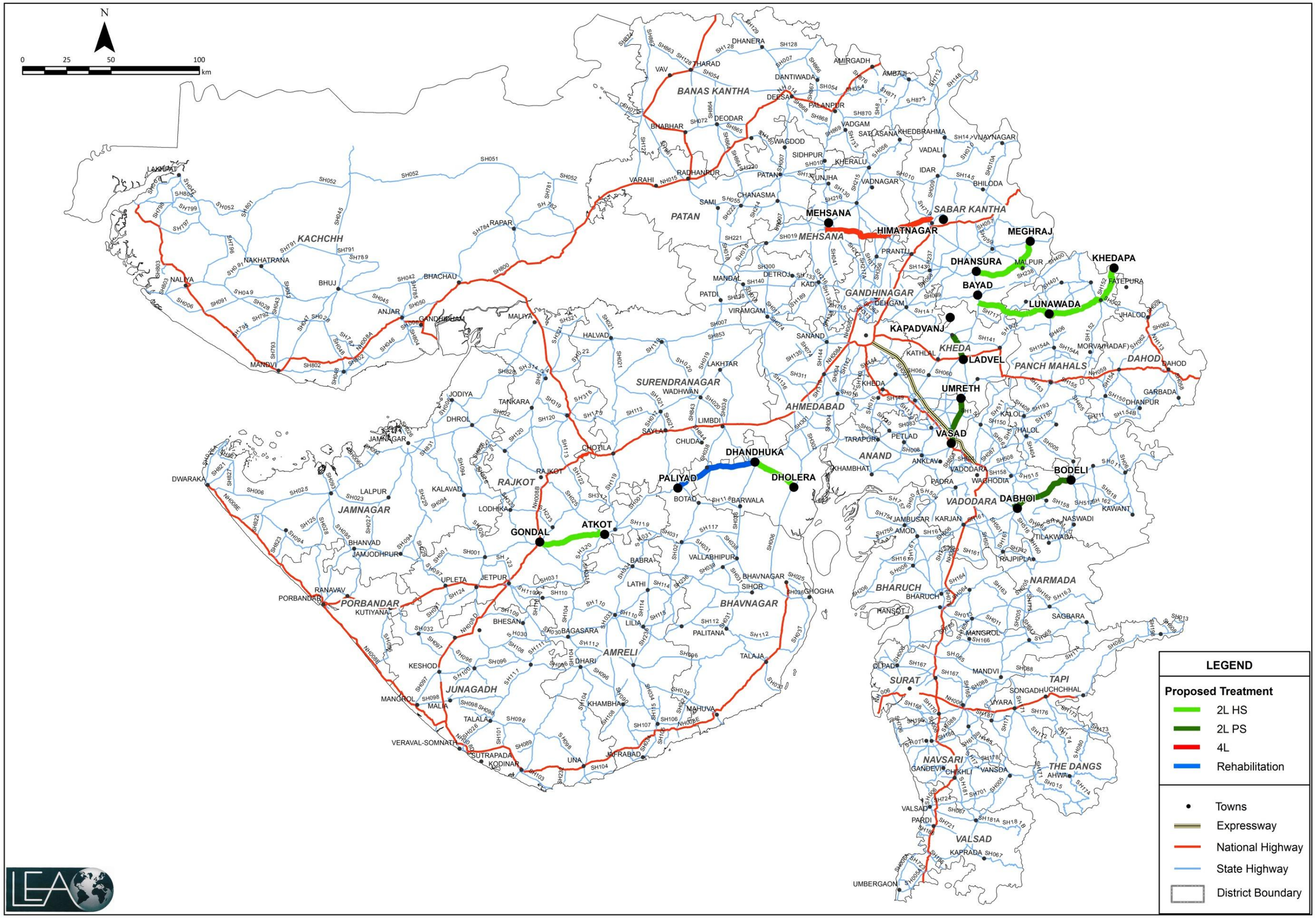
Project Intervention	Total Length (Km)
Widening to Wide 2L	286.9 km
Widening to 4L	66 km
Maintenance/Rehabilitation	45 km
Total length	**397.9 km**

6. The broad objective of the assignment is to have detailed engineering project ready for bidding. It includes economic analysis for each section, integration of road safety audit in final design, implementation and O&M along with Environmental Impact Assessment, Environmental Management Action Plan and Rehabilitation and Resettlement Studies as per World Bank Guidelines.

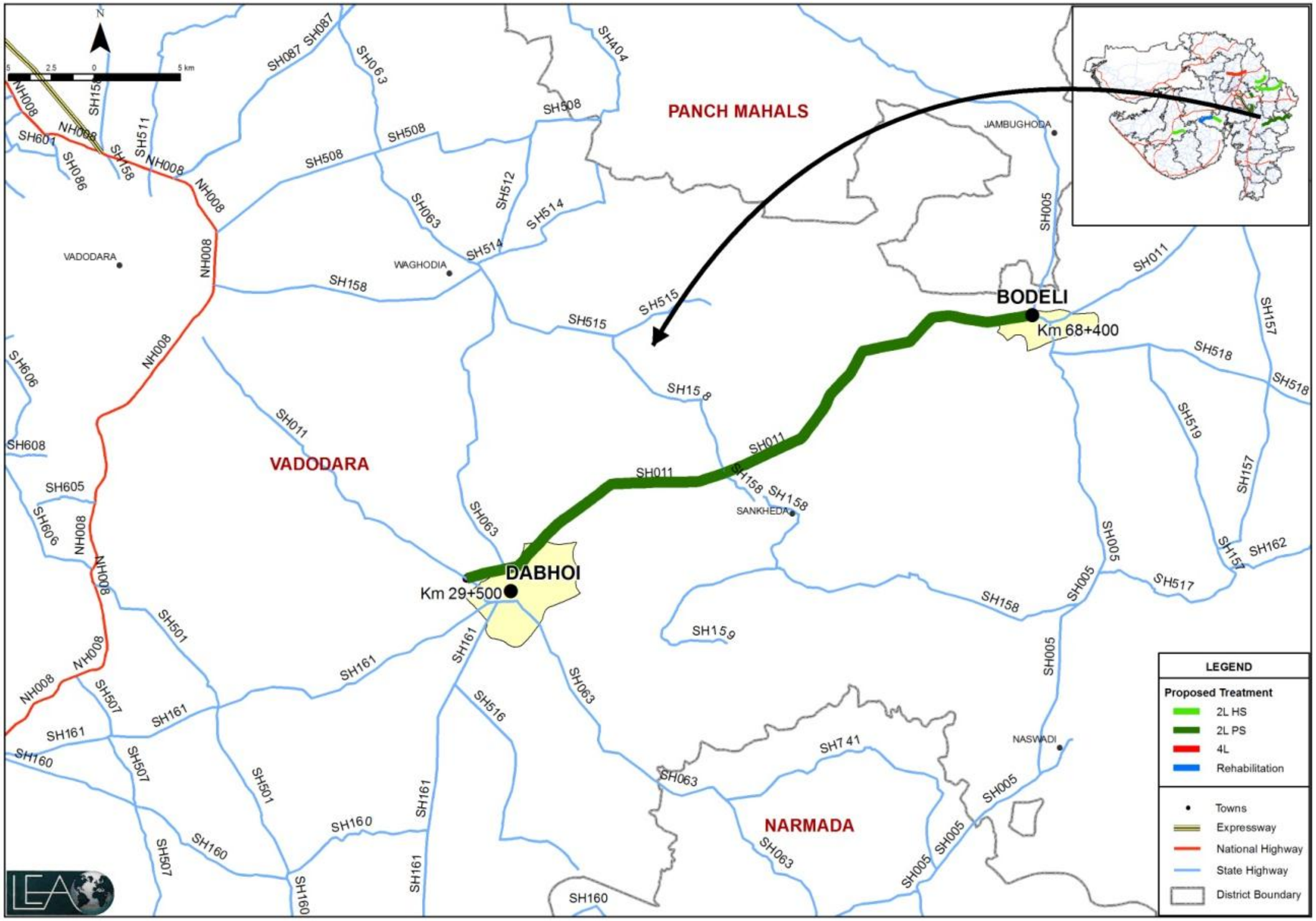
1.3 DETAILED PROJECT REPORT

7. This Executive Summary of DPR pertains to two laning with paved shoulder and hard shoulder for the project corridor Dabhoi-Bodeli. The key map showing project corridor is presented in Map 1.2.

[1] Bodeli-Alirajpur Corridor left out as part of GSHP-II as it is being declared as National Highway



Map 1.1: Project Corridors



Map 1.2: Key Map Showing Project Corridor

2 SOCIO-ECONOMIC PROFILE OF THE CORRIDOR

2.1 DEMOGRAPHIC AND SOCIOECONOMIC PROFILE

8. The chapter presents socioeconomic profile of Dabhoi-Bodeli corridor. The corridor is located in Dabhoi and Sankheda Talukas of Vadodara district covering a total length of nearly 38.6km. Project corridor abuts 27 villages and 1town with a population of 93,124 as per Census 2001. Sankheda taluka through which the corridor traverses is part of Fifth Schedule area .

9. **Population Distribution:** The talukas through which the project corridor traverses comprises a total population of 3.84 lakh in 2011 which was 3.68 lakh during 2001. The population of these talukas grew at an Average Annual Growth Rate (AAGR) of 0.4 percent during the year 2001 to 2011[2].

10. A total 27 census villages and 1 town (Bodeli) abuts the project corridor. The total population of villages and towns abutting corridor is 93,124, which is almost 25 percent to the taluka's population (Census 2001). Settlements seen along the corridor are Vega village, Simalia village and Bodeli town towards the end of the corridor end.

11. The total number of households along project corridor is 18,518. Average Household (HH) size along the project corridor is 5. The average HH size varies from 4.1 in Patna and Bhadrali village to 5.9 in Pansoli village.

12. **Age and Sex Ratio:** The overall population below 6 years age in project corridor taluka's is 11 percent. The average sex ratio[3] for project corridor talukas during 2001 was 930 which increased to 931 during 2011. Average sex ratio for project corridor talukas is lower than the state average.

13. For the project corridor villages, the analysis for sex ratio reveals 921 females per thousand males. Akotadar village is having higher sex ratio of 1054 than other project corridor villages. Similarly, with respect to juvenile sex ratio[4], it was analysed that as against the juvenile sex ratio of 894 for project corridor talukas, the project corridor villages had the lowest sex ratio of 863.

14. **Literacy Rate:** As per the Provisional Census 2011, project corridor taluka's possess literacy rate of 77 percent which was 66 percent during 2001. Male literacy ratio in project corridor taluka is 86 percent as against the female literacy rate of 68 percent in 2011.

[2] Village/ settlement wise analysis for the project corridor has been done based on 2001 Census information. Taluka level analysis is based on 2001 census information and 2011 Provisional census data base information.
[3] Sex Ratio: Number of females per thousand males
[4] Juvenile Sex Ratio is the sex ratio of population in age-group 0-6 years

15. Average literacy rate in project corridor villages as per 2001 was 73 percent, which constitutes 82 percent and 64 percent of male and females literates. Amongst all villages and settlements along corridor, Bodeli town have evinced higher literacy rates i.e. 81 and 83% .

16. **Urban Rural Population:** The project corridor abuts Bodeli town comprising a total population of 10,490 as per census 2001. Urban population in project corridor taluka's during 2001 was 65,442 which increased to 88,269 in 2011 with an AAGR of 7.3 percent.

17. **Occupational Structure:** Total workers according to Census 2001 in project corridor taluka's was 1.72 lakh, this comprises 78 percent workers classified as main workers[5] and rest 22 percent as marginal workers[6]. Taking into account the composition of workers majority of workers are engaged in agricultural activities (48 percent) followed by cultivators (26 %).

18. The total workers in project corridor settlements are 34,142. Worker composition for the villages/settlements along the corridor shows highest share of workers engaged in others sector[7] (58 percent) followed by agricultural sector (27 percent).

19. **WPR:** The Workforce Participation Ratio (WPR) for project corridor taluka's in 2001 was 47 percent. Comparing and analyzing the male and female WPR, it was recorded that the female WPR is merely 33 percent as against male WPR of 59 percent.

20. The average WPR for project corridor settlements is 37 percent which is lower than the taluka's WPR. Male WPR in project corridor settlements is 55 percent as against 17 percent for female WPR.

21. **Schedule Caste and Schedule Tribe Population:** Analysis of social groups for the project corridor has been done on the basis of concentration of Schedule Caste (SC) and Schedule Tribe (ST) population in talukas and project corridor settlements. Sankheda taluka through which the corridor traverses is part of Fifth Schedule Area. Almost 38 percent population of project corridor is tribal populous. Sankheda taluka comprises almost 45percent tribal populous. SC community in project corridor talukas have minimal share of 4 percent.

22. Tribal groups identified in these talukas are predominantly Rathwa, Bhil, Nayak and Ghamit. As per Census 2001, the total SC and ST population for settlements and villages along the corridor accounts for the figure of 28,675 which is nearly 31 percent of total population for settlements along the project corridor. Primarily, the predominant group amongst the social groups is that of ST community i.e.26 percent to the entire SC and ST population of the corridor.

[5] Main workers were those who had worked for the major part of the year preceding the date of enumeration i.e., those who were engaged in any economically productive activity for 183 days (or six months) or more during the year

[6] Marginal workers were those who worked any time at all in the year preceding the enumeration but did not work for a major part of the year, i.e., those who worked for less than 183 days (or six months).

[7] Census Definition of Other Workers: All workers, i.e., those who have been engaged in some economic activity during the last one year, but are not cultivators or agricultural labourers or in Household Industry, are 'Other Workers (OW)'. The type of workers that come under this category of 'OW' include all government servants, municipal employees, teachers, factory workers, plantation workers, those engaged in trade, commerce, business, transport banking, mining, construction, political or social work, priests, entertainment artists, etc. In effect, all those workers other than cultivators or agricultural labourers or household industry workers, are 'Other Workers'

3 CORRIDOR CHARACTERISTICS

3.1 PROJECT CORRIDOR

23. Project corridor is of importance from the perspective of being tribal connectivity and interstate linkage with Madhya Pradesh. Western side linking Vadodara, the central Gujarat region on NH-8 (New NH 48) while on other extreme on eastern side, till Gujarat border Ferkuwa, with Madhya Pradesh is a long connectivity corridor. Dabhoi-Bodeli is bridging link of 39 km is having on one hand Vadodara-Dabhoi while other side it seamlessly connects with Bodeli-Ferkuwa (border with Madhya Pradesh) Alirajpur. Orsang River towards Vadodara. The mining areas located near to Bodeli and towards Chotaudepur. Facilitates interaction of tribal belt of Bodeli-Alirajpur with Vadodara and southern/northern parts of Gujarat.

Table 3.1: Existing Corridor Characteristics

Sr. No.	Components	Details	
1	Corridor Name and SH Number	Dabhoi-Bodeli (SH-011)	
2	District	Vadodara	
3	Sections	Dabhoi-Bodeli (SH-011)	
4	Start Chainage (km)	29+600	
5	End Chainage (km)	68+200	
6	Total Length of Corridor (km)	38.6	
7	Right of Way (m)	30	
8	Carriageway width (m)	7	
9	Intersection/Junction	4	
10	Traffic	km 39+600	km 56+200
		9,450Vehicles (16,309 PCU)	7,145 Vehicles (11,183 PCU)
11	Terrain type	Plain	
12	Soil Classification	Silty Clay	
13	Pavement Condition	Fair to Poor	
14	CD Structures		
	Major Bridge	1	
	Minor Bridge	12	
	Pipe Culvert	40	
	Slab Culvert	5	
	Box Culvert	-	
	Total Number of Structures	58	
15	Riding Quality- IRI (m/km)	2.56-5.61	
16	Existing Crust Thickness	285-670	
17	Soaked CBR	1.6-9.6	
18	Vehicle Damage Factor		

Vehicle Type	VDF
Mini Bus	0.21
LCV	0.49
BUS	0.50
2-Axle Truck	6.82
3-Axle Truck	7.52
M-Axle Truck	4.60

4 TRAFFIC ANALYSIS AND FORECAST

4.1 INTRODUTION

24. Road development projects are meant for achieving multi-objectives while meeting the basic needs of the road user - *Mobility and Accessibility*. Key functionalities and upcoming utilization of the project corridor in years to come is the essential task for which the highway facility needs to be upgraded or improved. All proposed solutions from traffic point of view have appropriately been incorporated with respect to issues related to geometry, environmental and social.

4.2 EXISTING TRAFFIC CHARACTERISTICS

25. The analysis of traffic volume data indicates an ADT of 9,743 vehicles, equivalent to 16,813 PCU, at km 39+600 while 7,366 vehicles, equivalent to 11,529 PCU, are observed at km 56+200. Trucks comprise the maximum share of vehicular traffic of about 41% at km 39+600, and about 33% at km 56+200. Around 5.5 to 7.3% of the total traffic is travelling within peak hour as observed at km 39+600 and km 56+200.

26. Travel desire pattern on the corridor indicates most of the traffic travelling within the state. Vega, Transa near Dabhoi, Sankheda and Alipura in Bodeli are identified as major intersection/junctions at which peak hour volume observed is 2,060, 939, 1,060 and 3,457 respectively. Speed and delay study indicates the existing average speed on the corridor as 36 kmph. The maximum VDF values are observed as 6.57 and 7.52 for 2-axle trucks and 3-axle trucks respectively.

27. The passenger and goods traffic characteristics indicate that most of the trips are made for shorter distances and accordingly shorter durations. The analysis indicates around 35% and 53% of the passenger and goods trips, respectively, to be made daily.

28. The major commodity being carried on the corridor is building materials. Vadodara-Dabhoi (SH-011) is identified as influencing corridor on which an AADT of 19,877 vehicles (28,110 PCU) is observed.

29. The traffic analysis for the corridor and influence area is taken as deep as to study and analyse traffic levels for each homogeneous section of the corridor for present and future conditions. Traffic sections with present and proposed lane configuration as well as traffic levels are tabulated in Table 4.1.

Table 4.1: Homogenous Sections with Details

Sections	Existing Chainage and Length (km)			Present Lane Configuration	Total	PCU
	Start	End	Length			
1	29.6	45.0	15.4	2L	9,450	16,311
2	45.0	68.7	23.7	2L	20,191	26,934

4.3 TRAFFIC FORECAST

30. Traffic forecast is done using both – Trend Based and Econometric Method. In addition, incorporating Client and World Bank view points, appropriate options are worked out. The growth of registration vehicles in state as well as flat 5% growth of vehicles each year is worked out to better ensure the realistic assessment of traffic forecast. Growth rates estimated from Trend Based Method is adopted. The forecasted traffic using Trend Based, Econometric and Flat 5% growth rates are presented in Table 4.2.

Table 4.2: Total Forecasted Traffic

km 39+600							
Year	**2011**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Forecasted Traffic by Econometric Method							
Vehicle	9,450	12,638	18,240	25,580	35,239	48,184	66,430
PCU	16,309	22,051	32,460	47,510	68,727	98,931	1,43,223
Forecasted Traffic by Trend Based Method							
Vehicle	9,450	12,015	15,875	20,521	26,302	31,783	36,122
PCU	16,309	20,740	27,475	36,131	47,340	58,196	66,925
Forecasted Traffic by Flat 5% Growth Rate							
Vehicle	9,450	11,488	14,661	18,712	23,882	30,480	38,901
PCU	16,309	19,824	25,301	32,291	41,213	52,599	67,131
km 56+200							
Year	**2011**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Forecasted Traffic by Econometric Method							
Vehicle	7,145	9,516	13,649	18,902	25,688	34,577	46,942
PCU	11,183	15,043	22,009	31,976	45,940	65,671	94,485
Forecasted Traffic by Trend Based Method							
Vehicle	7,145	9,077	11,962	15,372	19,541	23,465	26,555
PCU	11,183	14,191	18,746	24,543	31,953	39,096	44,820
Forecasted Traffic by Flat 5% Growth Rate							
Vehicle	7,145	8,685	11,085	14,147	18,056	23,044	29,411
PCU	11,183	13,594	17,349	22,143	28,260	36,068	46,033

4.4 IMPROVEMENT OPTION

31. Improvement options are further reconfirmed with concerns related to geometry, safety, land acquisition, environmental and social aspects, before incorporation in the final design of the corridor.

Sections	**Existing Chainage and Length (km)**			**Present Lane Configuration**	**Proposed Lane Configuration**	**Total**	**PCU**
	Start	**End**	**Length**				
1	29.6	45.0	15.4	2L	2L+PS+HS	9,450	16,311
2	45.0	68.7	23.7	2L	2L+PS+HS	20,191	26,934

5 ROAD SAFETY AUDIT

5.1 PROJECT BRIEF

32. Dabhoi-Bodeli is proposed to be improved with better riding quality and enhanced safety. Road Safety Audit addresses identification of safety related deficiencies as well as behavioural safety issues while subsequently recommending countermeasures in approaching towards sustainable design solution. All sections of the project corridor are visited and studied. Review and audit of safety measures of the corridor are followed with the prevailing best practices. With proposed improvement option of two lane with paved shoulder and granular shoulders, the objective of the exercise focuses on abating road accidents and their severity while improving riding quality.

5.2 ACCIDENTS STATISTICS

33. First Information Report (FIR) details relating to the accidents, fatalities and injuries in the project corridor and its immediate influence area are collected and studied. Though such information is recorded by police stations, there is a potential scope of other minor injury and property damage accidents to not have reported. However, efforts are extended in preparing safety improvement options beyond available accident data and the same is incorporated in final improvement proposals. 48 fatalities and 112 injuries reported in a span of 5 years (2007 – 2011). The data indicates most accidents concentrated at Vega Chokdi, Tarsana crossing, Pansoli, Simaliya, Timbi crossing and Bodeli.

5.3 SAFETY ISSUES FOR PROJECT CORRIDOR

5.3.1 Carriageway

34. It is observed that carriageway and shoulders are inadequate in width. It is essential to increase the carriageway width in this entire stretch at least up to 10.0 meters + edge strips 0.5 m on either side for improved safety.

5.3.2 Geometric Design

35. During the audit, it is identified that sight distance at sharp curves lack in standards and needs to be improved with geometric design. Curve passing through villages needs proper signage. Appropriate control measures are essential.

5.3.3 Intersections/Junctions

36. There are five major junctions observed on the project corridor. It is observed that considerable habitants gather near these junctions; thereby generating local trips. It is audited that the existing junction design lacks in incorporating local travel behaviour and influence of habitations in proximity, which makes them potential accident prone spots. It is identified that careful attention needs to be given in developing appropriate designs for these junctions. In addition, provision of suitable location of bus stops near junction needs to be considered.

5.3.4 CD Structures

37. The cross drainage works, especially culverts/Canals, are narrow in width and the parapets of the culverts are potential hazards.

5.3.5 Traffic Management and Control Issues

38. It is identified that traffic signs needs to be provided at many places. Existing signages are in a poor condition. It is identified that provision of pavement markings lack at various places on the project corridor.

5.4 IDENTIFIED ISSUES AND SUGGENTIONS

39. Suggestions, recommendation as well as issues identified from safety audit are incorporated into final improvement options which include, but not limited to:

a. Deficient 11 horizontal curves;
b. Identified 58 major/minor intersections (including access roads);
c. Identified 10 highway sections near habitations and;
d. Identified deficient 59 structures.

40. The details of the recommended interventions are presented in Volume III Road Safety Audit.

6 DESIGN OF CORRIDOR

6.1 INTRODUCTION

41. This particular chapter deals with analysis of roadway geometrics, developmental aspects, safety and road furniture requirements, towards providing pleasant and aesthetic highway for road users. This chapter also discusses about pavements, design and rehabilitation proposals of CD structures and bridges.

6.2 TOPOGRAPHIC SURVEYS

42. Topographical survey forms backbone for detailed engineering design. Topographic survey is carried out on the corridor during September 2011 and October 2011, as per the requirements for project preparation. Accuracy of the information collected during the survey has direct bearing on almost all the design activities involved in project preparation. Collection and review of toposheets and available maps/images helped in planning of topographic surveys towards establishing existing geometrics of the road corridor.

43. For the purpose of detailed engineering design, topographical surveys are divided into following activities:

- Setting up benchmarks and control stations to be used during construction;
- Establishment of horizontal control to have unique coordinate systems of Northing and Easting along the project corridor;
- Establishment of vertical control to have the elevation coordinates referenced to nearest GTS stations along the project corridor;
- Collection of Digital Terrain Model (DTM) data containing the existing highway, rivers, streams and other topographical features, to form the basis for the new designs and
- Preparation of base plans containing the entire natural and manmade features like buildings, fences, walls, utilities, trees, temples and other religious structures etc. that would govern the finalisation of horizontal alignment.

6.3 GEOMETRIC DESIGN

44. The highway geometric design deals with road geometrics such as horizontal and vertical alignment, interventions due to social impact, design safety and road furniture details.

45. Highway design has been carried out by considering two aspects:

- **Functional Aspects:** The functional aspects address geometric improvement and visible dimensions of the roadway.
- **Structural Aspects:** The structural aspects deal with designs for pavement, CD structures, bridges and embankments i.e. the ability of the highway to adequately carry and support the vehicle/ wheel loads over the design period.

46. Functional aspects manifested in appropriate horizontal and vertical alignments, sight distance availability, lateral and vertical clearances, intersection treatment, improved design speed, road safety and also cover related facilities.

47. Structural aspects on the other hand calls for detailed evaluation of widening options, concentric or eccentric of the existing road; as dictated by site situations like available ROW, existing utilities, terrain, etc., and importantly the existing structural conditions, both for pavement and CD structures.

6.3.1 IMPROVEMENT OPTION

48. The existing carriageway width of the project corridor is 7.0m, i.e. Two Lane (2L) configuration. Project scope is for widening of existing road from 2L to 2L+PS+HS configuration.

49. The project corridor has right of way of 30m. The improvement option is seen with respect to traffic, safety, speed and mobility. World Bank advises and shared iRAP[8] reports are also taken into consideration.

50. This particular corridor becomes important form traffic, heavy axle loading; it's uncertainty on continuity of growing traffic flow and trees alongside the road. Amongst GSHP-II road sections this is the one project roads carrying high traffic volume. Share of commercial traffic is significant. Along with inter and intra state commercial vehicle movements, the truck traffic due sand mining is major factor influencing flows and serviceability of this corridor.

51. Base year traffic volume itself shows the project road being two lane standard configuration needs immediate up gradation. Looking to immediate and medium term capacity needs the corridor traffic calls for further higher order upgradation. The volume – capacity analysis indicates that the corridor will reach to LOS C in the year 2018 for section - 1 (Section-1: km 29+681.77 to km 45+000); thereby asking for four laning, while Section – 2 (Section-2: km 45+000 to km 68+417.10) reaches to LOS C in the year 2025 (Table 6.1). The emerging traffic scenario and feasibility of improvement option is simulated through Table 6.1.

Table 6.1: Emerging Traffic Scenario and Improvement Needs

Chainage	Traffic/Year	2011	2015	2018	2020	2025
km 29+618.77 to km 56+200.00	Vehicle	9,450	12,015	14,198	15,875	20,521
	PCU	16,309	20,740	24,545	27,475	36,131
	Configuration	2L	2L+PS	4L	4L	4L
	V/C	0.47	0.6	0.71	0.8	1.05
km 56+200.00 to km 68+417.10	Vehicle	7,145	9,077	10707	11,962	15,372
	PCU	11,183	14,191	16755	18,746	24,543
	Configuration	2L	2L+PS	2L+PS	2L+PS	4L
	V/C	0.32	0.41	0.49	0.54	0.71

[8]iRAP: International Road Assessment Programme, Gujarat is also covered under the programme with selected corridors. Findings of IRAP and recommendations at particular stage are shared.

52. This perspective has been discussed with R&BD and looking to uncertainty of sand mining and traffic associated with the same; It is decided to have phased approach. Accordingly project will have consideration of first design period as seven years with full traffic on 2L+PS+HS configuration. R&BD shall look into next phase in advance before reaching the immediate design period of seven years for further interventions.

53. The project corridor is proposed to be widened and strengthened to two lanes with paved shoulder and hard shoulder (2L+PS+HS) in general. But exceptions are there for the stretches with green tunnels (dense tree plantation on both sides) and/or matured dense trees along the project road. In an effort to have improvement, safety and environment on equal footings, compressed cross sections with box cutting type of widening are adopted with safety crash barriers on both the sides. The cross-section depicting placement of existing carriageway and proposed improvement is presented through Figure 6.1.

54. The optimal design is proposed giving priority to save green tunnels, while following design standards with appropriate safety intervention. Therefore, in places, narrow cross-sections, with 11 m and 10 m of formation width is provided instead standard 12.0m of formation width, in order to offer sustainable design solution. The 11 m cross section is of 7 m carriageway with 1.5 m paved shoulder and 0.5m hard shoulder while the 10 m cross section is of 7 m carriageway with 1 m paved shoulder and 0.5m hard shoulder along with provision of safety barriers (W beam crash barrier).

6.3.2 WIDENING SCHEME

55. Existing road is placed concentrically within available ROW of 30m, in general. The condition of existing pavement is fair to poor, with wide cracking at certain locations as described in engineering report of this DPR.

56. The project road is proposed for strengthening except few locations wherein reconstruction is proposed. The concentric option is worked out with consideration of available RoW, least disturbance to green tunnel and other utilities along the project section including social impacts on the project corridor.

57. The proposed widening scheme is presented in Table 6.2.

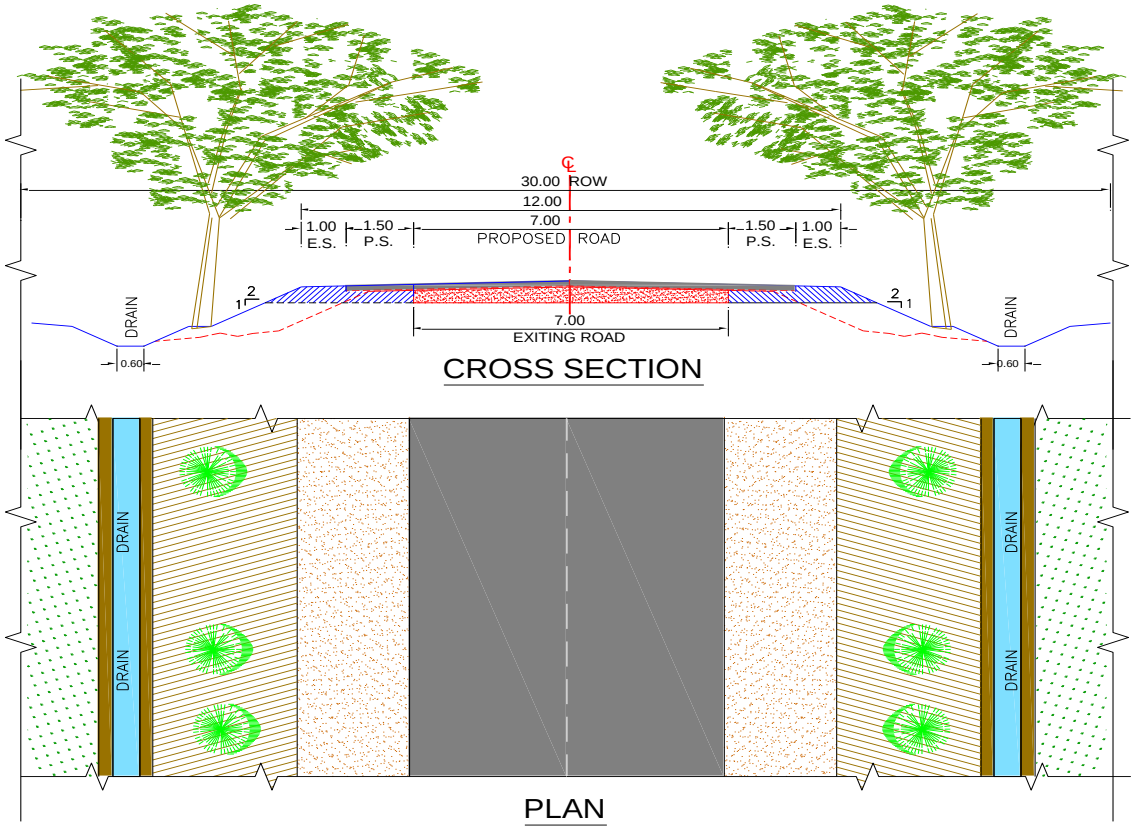


Figure 6.1: Proposed Improvement Option (2L to 2L+PS+HS)

Table 6.2: Proposed Widening Scheme

Start Chainage	End Chainage	Length	Presence of Green Tunnel	Existing Width	Proposed Formation width	Proposed CW+PS	Proposed Paved Shoulder	Proposed Hard shoulder	Remarks
29618.77	29740	121.23	No	7	12	10	1.5	1	Vega Rotary
29740	30510	770	No	7	12	12	1.5	1	RoB (6m service road on both side)
30510	31300	790	No	7	12	10	1.5	1	
31300	32600	1300	No	7	12	10	1.5	1	
32600	32800	200	No	7	17.5	14		1	Junction Improvement
32800	35450	2650	Yes	7	11	10	1.5	0.5	
35450	36000	550	Yes	7	12	10	1.5	1	
36000	38000	2000	No	7	12	10	1.5	1	
38000	45000	7000	No	7	12	10	1.5	1	
45000	45500	500	Yes	7	11	10	1.5	0.5	
45500	46300	800	No	7	12	10	1.5	1	
46300	46600	300	Yes	7	10	9	1	0.5	
46600	46840	240	Yes	7	17.5	14		1	Intersection Improvement
46840	47500	660	No	7	12	10	1.5	1	
47500	50000	2500	Yes	7	10	9	1	0.5	
50000	50700	700	No	7	12	10	1.5	1	
50700	50900	200	Yes	7	11	10	1.5	0.5	
50900	51200	300	No	7	11	10	1.5	0.5	
51200	52800	1600	Yes	7	11	10	1.5	0.5	
52800	54000	1200	No	7	12	10	1.5	1	
54000	56000	2000	Yes	7	11	10	1.5	0.5	
56000	56700	700	No	7	11	10	1.5	0.5	
56700	58300	1600	Yes	7	11	10	1.5	0.5	
58300	59300	1000	No	7	11	10	1.5	0.5	
59300	60300	1000	Yes	7	10	9	1	0.5	

Start Chainage	End Chainage	Length	Presence of Green Tunnel	Existing Width	Proposed Formation width	Proposed CW+PS	Proposed Paved Shoulder	Proposed Hard shoulder	Remarks
60300	60500	200	No	7	11	10	1.5	0.5	
60500	63600	3100	Yes	7	11	10	1.5	0.5	
63600	64000	400	No	7	11	10	1.5	0.5	
64000	65500	1500	No	7	12	10	1.5	1	
65500	66400	900	Yes	7	10	9	1	0.5	
66400	67700	1300	No	7	10	9	1.5	0.5	Canal Approach
67700	67935	235	Yes	7	10	9	1	0.5	
67935	68417.10	482.1	No	14	17.5	14		1	Existing Four Lane

58. The widening scheme of project corridors is provided in Table 6-5.

6.3.3 Design Interventions

1.1.1.1 Speed

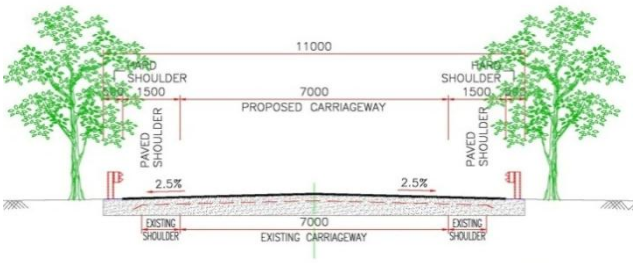
59. The horizontal geometry with speeds less than 65 kmph in rural sections is improved. Largely following the mandate improvements are proposed within available RoW. Efforts are also made to provide safe designs in settlements considering speeds 40-65kmph.

1.1.1.2 Safety

60. The safety is very much incorporated in the design process; interventions include provision of speed humps at exit and entry of settlements, foot paths, improved junction layouts, advanced warning signs, rumble strips, provision of guard rails etc. The safety aspects are discussed in sub-sections 3.4 and 3.5. The detailed interventions on safety are provided through Volume III of this DPR. Intervention on saving of Trees

61. Special efforts have been made to minimize the impact on trees, saving them to the extent possible. On around half of the corridor length, well grownup trees are observed within proposed formation width of 12.0m. Therefore, proposed formation width is reduced to 11.00 to 10.00 m at respective stretch of the corridor along with appropriated safety measures. Widening is proposed to be taken up by box cutting up to formation width 12.0m only, for minimum impact on long standing trees. Also in widening portion, use of motor graders or similar equipment's along with mini rollers are required to be used for lesser impact on standing trees.

Chainage 29+700



Chainage 49+300

Chainage 62+300

1.1.1.3 Social Impact

62. For the sections through settlements specific care has been taken to safe guard cultural properties, existing permanent structures and kiosks towards reducing the social impacts. In total 37 socially impacted structures are identified in the initial stages of design, the same is reduced to 18, most of them are kiosks as described in Volume-V after design interventions coupled with road furniture and safety measures along the project corridor.

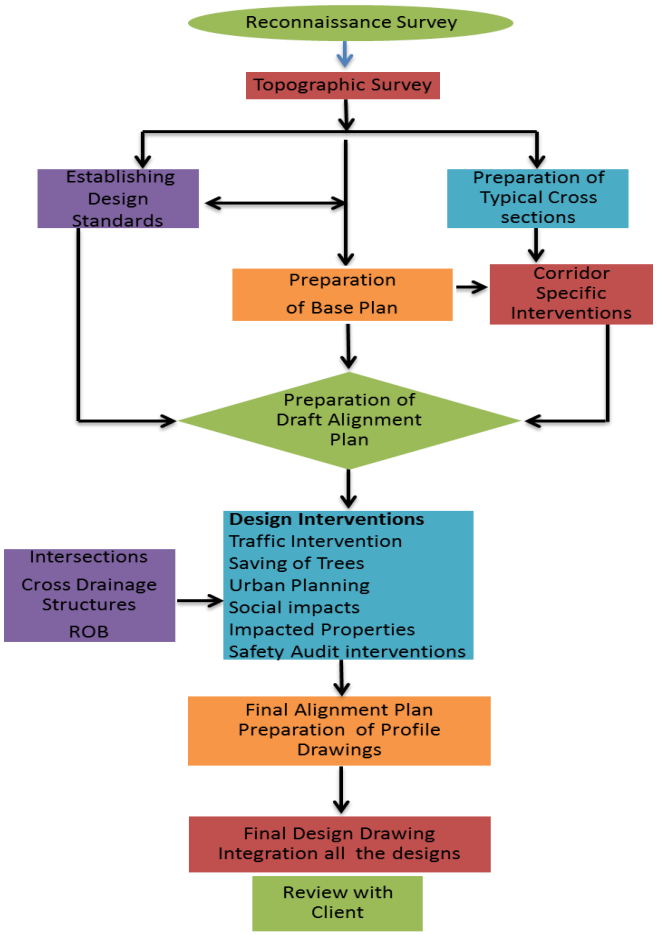


Figure 6.2: Flow Chart Showing Design Interventions

6.3.4 Horizontal Alignment Design

63. Design of the horizontal alignment has been carried out in CIVIL 3D environment as per the finalised widening scheme. Extensive field checks to verify the feasibility of the proposed alignment have been carried out and suitable modifications to the alignment have been effected wherever considered essential to safeguard sensitive elements.

64. The project road design chainages are defined as the starting from km 29+681.77 and ending at km 68+417.10, summing up the total length of the corridor to be 38.735 km.

65. Geometric design of project corridor has been conceptualized for a design speed of 80-100 kmph in rural sections and 40-60 kmph in village/urban sections as per the design standards formulated for the project. The project corridor has fair horizontal geometrics with

proper spirals to existing alignment is observed. The detail of such locations having major geometric improvement with spirals is given in Table 6.3.

Table 6.3: Locations of Geometric Deficiency

Chainage (km)	Radius (m)	Existing Speed (kmph)
32+850	275	65
40+000	300	65
57+800	230	65
62+450	180	65

66. Geometric improvement has been carried out, with due consideration of project features, social impact assessment, along with interventions due to green tunnels. Crossroads have been realigned at the junction with main carriageway to reduce the skew angle of the crossing and to ensure the safety. The list of access roads with realignment is provided Volume VIII of this report. The process involved in design intervention is depicted to in the following Figure 6.2.

67. There is no land acquisition required for this corridor as all the geometrical improvements could be done within available ROW. An exercise has been carried out to assess the average journey speed after improvement of project corridor with project interventions as described below, and radius of curves, the Table 6.4 presents design speed on curves, radius and other details. It is observed that on Dabhoi-Bodeli section, out of identified 74 curves 77% are having radius greater than 2000m and 80-100 kmph of design speed, 12% are having radius in between 360-900 and 40-80kmph design speed and seven curves i.e 6% are having radius less than 360m and with design speeds upto 80 kmph.

Table 6.4: Design Speed on Curves, Radius and Number of Curves

Radius	Design Speed	Number of Curves
>2000	80-100	57
	<80	0
900-2000	80-100	1
	65-80	0
360-900	65-80	9
	40-65	0
<360	65-80	5
	40-65	1
	<40	1

Table 6.5:Speed Limit

Sr. No.	Start Chainage (km)	End Chainage (km)	Speed Limit Zone
1	29+539	29+800	30
2	29+800	30+450	60
3	31+200	31+500	30
4	36+000	36+650	40
5	39+300	39+700	40
6	41+700	42+300	30
7	58+200	59+200	30
8	60+800	61+200	40
9	67+400	68+400	30

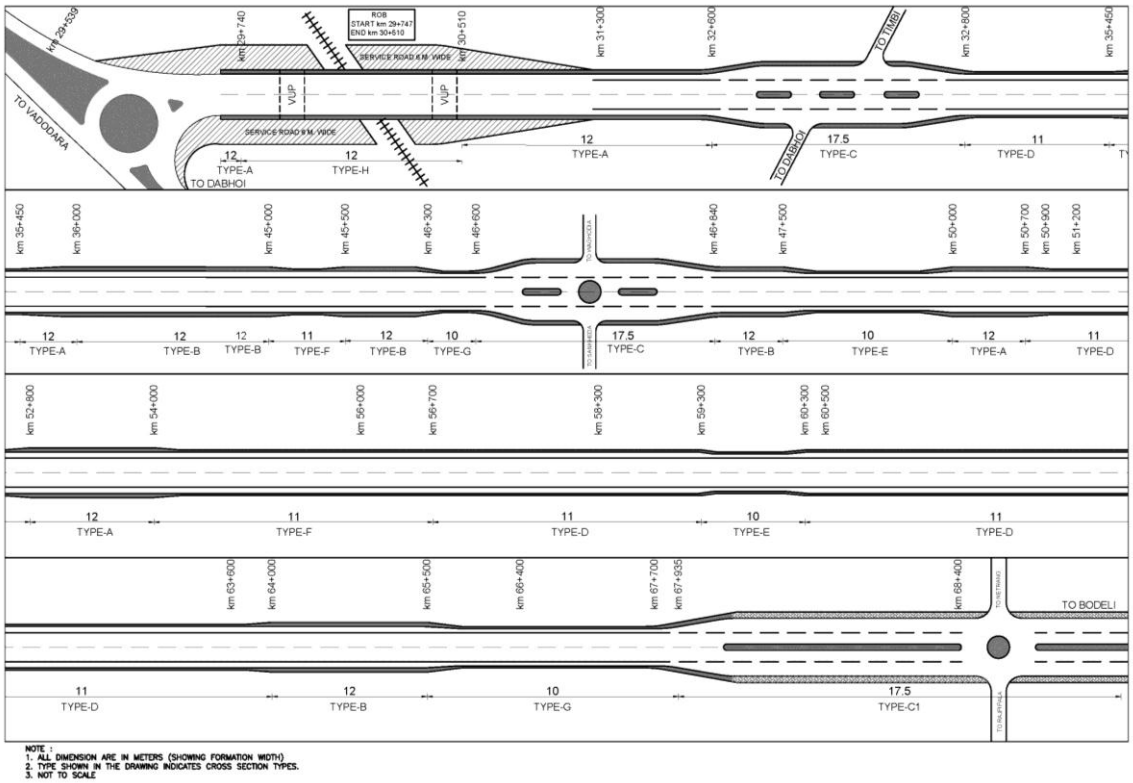


Figure 6.3:Widening Options

6.3.5 Vertical Alignment Design

68. The existing vertical geometry for majority of project road calls for attention. The project road is in place since long, but the proper design of project corridor has probably not taken place in recent times. The existing pavement is under deteriorated condition at places.

69. The design Finished Road Levels (FRL) at the centerline of the roadway is determined from overlay and new pavement design. The pavement design necessitates reconstruction, and overlay in sections as discussed in subsequent chapters.

6.3.6 Side slopes

70. The average embankment height of existing project road is about 0.5-1.0m. The side slopes of highway embankments shall be as flat as possible so that drivers accidentally leaving the roadway have better chances of survival. This has been also recommended in IRC-36, which provides a side slope of 1:4 for low embankment upto1.5m height, although due to limited RoW and accommodating the longitudinal drains the slope is kept as 1:2.0. Where required essential safe guards are proposed.

71. Widening is proposed to be taken up by box cutting up to formation width 12.0m only, for minimum impact on long standing trees. The existing side slopes beyond 12.0m shall be strengthened by alternative methods of compaction like manual compaction and mini rollers, where required.

6.3.7 Road Side Drainage

72. Project corridor is adjoining to agricultural fields, call for attention on drainage. The longitudinal drain is proposed all along the project corridor. The drain width is 0.6m at

bottom and 1.2: 1 side slopes. The drainage analysis along the project road is provided in Volume II of this report. The closed drains along the settlements are proposed to prevent the stagnation of water.

6.3.8 Utility Crossings

73. Utility crossings are proposed at following locations given in Table 6.6 to avoid frequent digging of carriageway.

Table 6.6: Utility Crossing Locations

Sr. No.	Station	Location
1	29+550	Vega Junction
2	29+775	
3	39+500	Simaliya
4	58+300	Suryaghoda
5	58+690	
6	61+075	Harol Village
7	67+400	Bodeli
8	67+900	
9	68+375	

6.4 INTERSECTION/JUNCTION DESIGN

74. At-grade intersections, unless properly designed can be accident-prone and can reduce the overall capacity of the road. The basic requirements for the design of intersections are not only to cater safe movements of road users, but also to provide them full traffic information by way of signs and pavement markings. Simplicity and uniformity is the guiding principles for intersection design. Based upon these principles the at-grade intersections have been categorized as:

1. Major Intersections
2. Minor Intersections
3. Access roads and Cart Tracks

75. The project corridor is having five major junctions, 53 minor junctions/intersections and 3 access roads and cart tracks. The location of intersections along the project corridor with various categories of roads, improvements proposed is detailed in this section and Volume-VIII of this report.

6.4.1 Major Intersections

76. Intersections with category of roads like NH/SH/MDR and having black top surface are presented in Table 6.7.

Table 6.7: Major Intersections/Junctions

Sr. No.	Intersection/ Junction	Type	Chainage (km)	Improvement
1	Dabhoi – Vega Junction	3-arm	29+600	As per MOST standards
2	Tarsana Intersection	4-arm	32+085	As per MOST standards
3	Dabhoi/Lotiya Junction	3-arm	32+700	As per IRC
4	Gola Gamdi Intersection	4-arm	46+725	As per IRC
5	Bodeli Intersection	4-arm	68+417.10	As per IRC

77. The start of the project corridor is near Vega circle bypassing Dabhoi taluka forms a junction (Figure 6.4) with Vadodara-Dabhoi State Highway. At km 46+725, near Gola Gamdi, the project corridor intersects with Waghodia - Sankheda State Highway (Figure 65).

The junction design is based on type designs for T junction on NH/SH as per MOST specifications. Detailed junction design is provided through Volume VIII.

6.4.2 Minor Junctions

78. The project section Dabhoi-Bodeli is having 53 the junctions with category of roads like MDR ODR and VR. Type-2 is for approach road having carriageway width less than 5m. 52 junction types are of Type – II while the one is of Type-I. Design details of these intersections are provided in Volume VIII – Drawings.

6.5 WAYSIDE AMENITIES AND SAFETY ASPECTS

6.5.1 Pedestrian Safety

79. Pedestrian crossing across the roads is normally major cause for the accidents.. To reduce the speed and subsequently to increase the pedestrian safety rumble strips are proposed at major intersections/junctions and at entry and exit of settlements.

80. **Rumble strips** are provided at 29 locations on project corridor

81. **Pedestrian Crossings:** Raised pedestrians crossings are provided at 22 locations on project corridor

82. **Foot Path:** is provided at 19 locations summing upto a length of 3.56 km alongside the project corridor on both sides

6.5.2 Crash Barrier

83. The crash barrier are provided at sharp curves, approaches to canals and green tunnels along with signage's to provide safety for vehicles at such locations. The locations of guard rails are given in volume II Part-1 summing to a length of 39.1km on both sides. The crash barrier are provided with W-metal beam type barrier, the details of the same are provided in design drawings.

6.5.3 Bus Shelter

84. There are existing bus stops along project corridor. Generally these stops are associated with a settlement area or an intersection/junction with a crossroad. It is proposed to provide bus stops and bus bays in both directions at these locations. The details of bus shelter and bus bay locations along the project corridor are given in Volume II Part-1. The typical design of bus shelter is provided in Figure 6.4. Bus Shelters and bus bays are provided at 42 locations

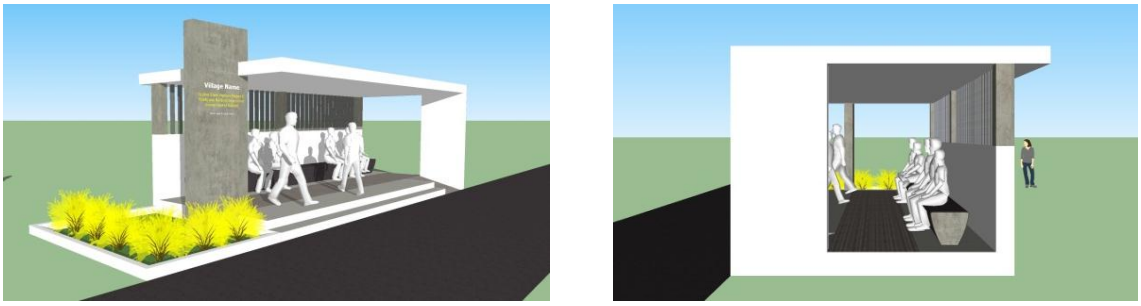


Figure 6.4: Typical Design of Bus-Shelter

6.5.4 Truck Parking

85. During site visit, it is observed that near km 46+465, provision of truck parking would facilitate truck drivers. Appropriately, truck parking is proposed at km 46+465; details of which are provided in Volume VIII of this report.

6.5.5 Integration of Way Side Facilities

86. The integration of bus shelter, foot path and pedestrian crossing is done and the typical plan is depicted in Figure 6.5.

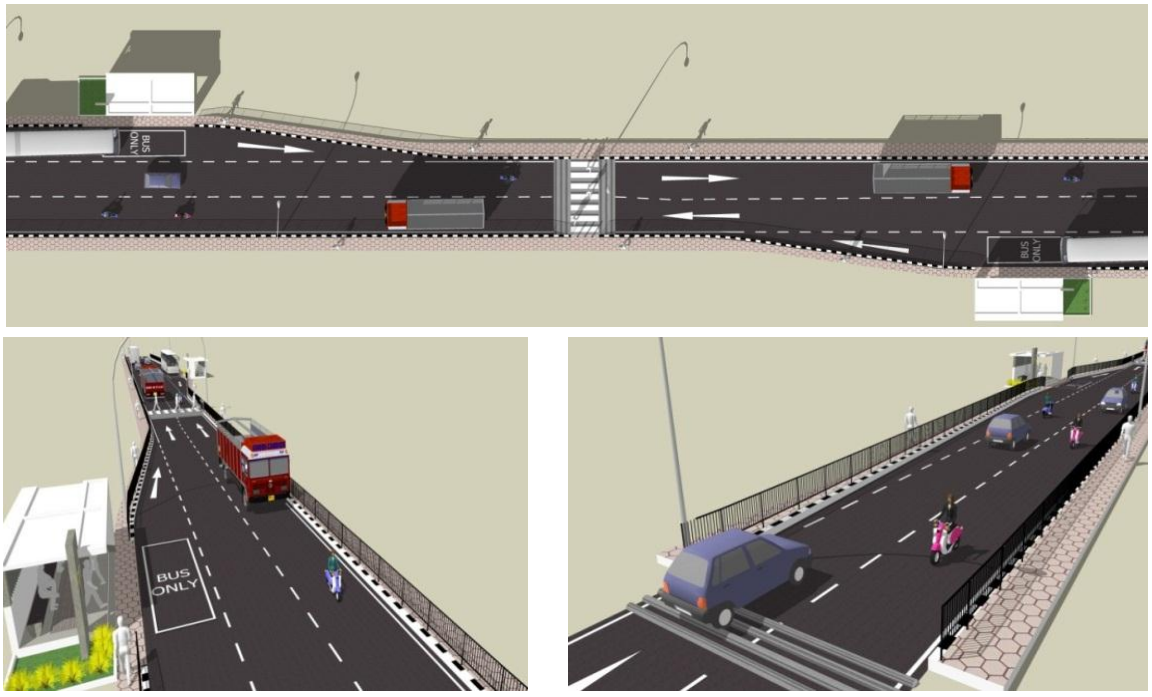


Figure 6.5: Integration of Wayside Facilities

6.5.6 Information on Infrastructure Development

87. The entry and exit point is treated with welcome signage's with due information regarding the project corridors. The same is shown up in Figure 6.6. The detailing is provided in Volume VIII of this report. These signs are provided at two locations near entry and exit of project sections.

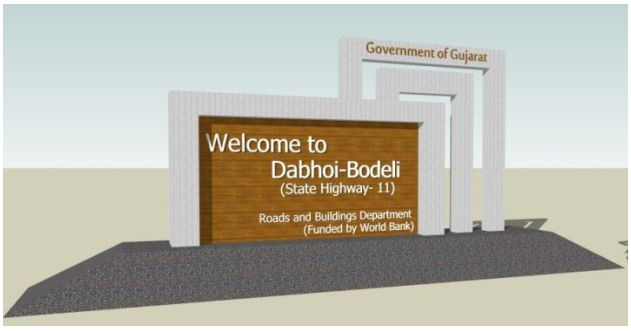


Figure 6.6: Typical View of Welcome Sign

6.6 PAVEMENT DESIGN

6.6.1 General

88. Pavement design forms an integral part of highway design. Pavement performance under prevailing and projected traffic and environmental conditions is considered to be crucial as it has an implication on the economic returns from the project. Present section of the report deals with pavement design and strengthening of the existing pavement crust.

Detailed description of pavement evaluation and pavement design has been included in Volume-II under pavement design chapter.

6.7 DESIGN LIFE OF PAVEMENT

89. In order to determine design life of pavement it is imperative to critically review the traffic forecast data and capacity augmentation planning for the project corridor. According to traffic data the repetitions of million standard axels for dual lane and four lanes during the design life of 7, 10 and 15 years are:

Design life in year's	mesa For Two Lane	mesa For Four Lanes
7	75	40.3
10	112.7	60.2
15	191.3	100.8

90. The traffic volume projection indicates that by the year 2018, four laning of this corridor will be inevitable to cater for the enhanced traffic volume. Since the four laning of the corridor is due in near future therefore adopting 10 year design life for bituminous works under this project would be uneconomical. It is expected that under the purview of four laning scheme the existing road will be retained as one of the dual lane CW and other dual lane CW will be provided as new lane, which will be located eccentric to the existing carriageway. With this concept under consideration it is imperative to strengthen the existing pavement for design life of bituminous courses (overlay and reconstruction) as 7 years and 20 years for granular base and sub courses required for reconstruction of pavement. The existing carriageway may be further strengthened (if required) during execution of four laning project. Based on this concept the design of the overlay and bituminous courses for reconstruction of pavement has been carried out to determine the requirement for a forecast period of 7-year's traffic demand. Thickness requirements for granular base and sub base courses needed for reconstruction of pavement has been determined for a forecast period of 20 years.

6.7.1 Criteria for selection of pavement treatment option

91. The selection of treatment types is primarily governed by the structural need of the existing pavement and also influenced by pavement condition of the road.

92. According to Para 6 of IRC: 37-2001 (third revision) draft, the Fatigue life (the number of load repetitions in terms of standard axles that causes fatigue) for bituminous surfacing correspond to development of cracking in 20% of the pavement section. It means that such cracked surface is unacceptable from the point of view of serviceability of the pavement. The bituminous surfacing having cracks in 20% area has outlived its design life therefore pavement is treated as failed section. Further according to para 4.2 of IRC: 81-1997 bituminous surfacing having extensive cracking and/or rutting greater than 20 mm are treated as failed section. Settlement or deformation of the pavement has an adverse effect on the serviceability. Generally settlements and deformation of road pavement are caused on account of poor foundation of road pavement. In this project sections of road pavement sections having settlement & deformations greater than 10% area have been considered as

failed sections. Raveling on bituminous surfacing enhances the roughness value of road pavement which adversely impacts the serviceability, which amounts to reduction in design life.

93. Based on aforesaid principle, the following criteria has been adopted for identification of failed section of bituminous surfacing for this project

- Cracking – sections with cracking exceeding 20% of the area, and/or
- Rutting greater than 20mm and/or
- Settlements of deformations in pavement section in area exceeding 10%

94. The failed sections as identified above will be considered as candidate sections for reconstruction /rehabilitation of the pavement. The pavements of road sections other than failed sections will be considered for strengthening of pavement by providing overlay.

6.7.2 Proposed road strengthening and Reconstruction needs

6.7.2.1 General

95. Based on Pavement condition surveys about 19.417 km of road (Km 36.00 to 48.00, Km 54.00 to 57.00 and Km 64.00 to 68+417) are considered as failed sections, which need reconstruction. Cracking more than 20% exists on all these 19.417 km of road pavement. Extensive raveling coupled with high IRI is noted on these 19.4 km. In view of this these 19.4 km fulfills the criteria as detailed above for failed sections.

96. Distresses on the pavement of rest of the 19.318 kilometers of this corridor (i.e. from km 29+681.77 to 36.000, Km 48.000 to 54.000 and Km 57.00 to 64.00) are not severe however the ride quality is not up to mark. The IRI in most of the cases is more than 3. Though the characteristic deflection is moderate (1.65), the traffic loading is high which, is likely to accelerate the distress development if immediate measures to strengthen the pavement are not initiated at this stage. All these three sections are considered most suitable candidate for strengthening of pavement by providing bituminous overlays on the existing pavement. The strengthening of pavement option envisages that the candidate preventive treatments will focus primarily on medium thick overlay, shape correction, pavement preparatory works, shoulder repairs and drainage.

Table 6.8: Summary of Pavement Condition and Treatment Option

Section from km to km	Length km	Pavement Condition	Proposed Treatment
29.681 to 36.000	06.320	High IRI poor riding quality moderate deflection	Strengthening by overlay
36.000 to 48.000	12.000	Cracking more than 20% coupled with extensive raveling high IRI	Reconstruction
48.000 to 54.000	06.000	High IRI poor riding quality moderate deflection	Strengthening by overlay
54.000 to 57.000	03.000	Cracking more than 20% coupled with extensive raveling high IRI	Reconstruction
57.000to 64.000	07.000	High IRI poor riding quality moderate deflection	Strengthening by overlay
64.000 to 68.417	04.400	Cracking more than 20% coupled with extensive raveling high IRI	Reconstruction
Total	**38.735**		

97. The lane configurations of some of the urban sections of this corridor are proposed as four lanes with divided carriageway. Also the carriageway of this corridor is proposed for widening to standard two lane road with paved shoulders on either side of the pavement. Pavement design for four lane sections and component for widening of Carriageway to standard two-lane and paved shoulder and reconstruction of failed sections is carried out as new pavement design based on the concept of repetitions of million standard axles during the

design life and design CBR of subgrade. The design of new and reconstruction pavement has been done in accordance with IRC Publication No. IRC: 37-2001.

6.7.3 Pavement strengthening (overlay) strategy

98. Pavement strengthening strategy adopted in this project envisages that after attending to the rectification of defects like cracking, potholes, deep depressions, rutting etc. a layer of profile corrective course will be laid over the existing bituminous surface.

99. The requirement of overlay have been deduced from the design curves relating characteristic deflection to the cumulative number of standard axles to be carried over the design life given in IRC 81;1997. The thickness deduced from these is the overlay thickness in terms of bituminous macadam construction. The equivalent overlay thickness in terms of the equivalent overlay thickness in terms of BC/DBM to be provided shall be determined using appropriate equivalency factor given in IRC: 81-1997, which are reproduced below:

1 cm of Bituminous macadam = 1.5 cm of WBM/WMM/BUSG
1 cm of Bituminous macadam = 0.7 cm of DBM/AC/SDC

100. The annual rainfall in project area is >1000 mm and the design traffic (mesa) is more than 100, the proposed wearing and binder course shall be 50 mm BC and DBM of required thickness respectively (Annexure-6 of draft IRC: 37-2001 third revision).

6.7.3.1 Profile Corrective Course (PCC)

101. The cross profile of the existing pavement has either disturbed or inadequate throughout the corridor. A profile corrective course is proposed to bring the road cross section back to proper camber of 2.5% for the sections proposed for strengthening by providing bituminous overlay. The PCC will be laid as an integral part of BM overlay layer. The quantity of BM material for overlay will be increased by 20% to account for leveling requirement.

6.7.3.2 Pavement Preparatory Works

102. The pavement preparatory work includes repair to distressed areas such as crack sealing, full depth repair, pothole repair. The preparatory works will be carried out on the existing pavement surface prior to application of profile corrective course.

6.7.4 Pavement composition

103. Basic design for bituminous course for reconstruction and strengthening requirement of pavements has been carried out for design life of 7 years and 20 years for granular base and sub base courses for reconstruction of pavements.

104. Pavement composition for overlay and reconstruction sections is given in Table 6.9 and Table 6.10 below.

Table 6.9: Pavement Composition for Overlay Sections

Section	Length (km)	DBM overlay (mm)	BC (mm)
km 29.68 to km 36.00	6.40	80	50
km 48.00 to km 54.00	6.00	80	50
km 57.00 to km 64.00	7.00	80	50
Total	**19.318**		

Table 6.10: Pavement Composition for Reconstruction

Section	Length in Km	Reconstruction requirement for design life 7 years for bituminous course (mesa 75) and 20 years (mesa 150+) for granular base and sub bases				
		BC (mm)	DBM (mm)	WMM (mm)	GSB (mm)	Sub grade CBR 6% (mm)
km 36.00 to km 48.00	12	50	50+80	250	260	500
km 54.00 to 57.00	3	50	50+80	250	260	500
km 64.00 to 68.40	4.4	50	50+80	250	260	500
Total	**19.4**					

105. Paved shoulders are to be provided the same pavement composition of main carriageway.

6.8 WIDENING SCHEME

106. The pavement widening scheme is provided in Table 6.11 and Table 6.12. Pavement sections are prepared with respect to type of treatment, varying widths, improvement options and road furniture in line with existing site condition on situation to situation; the same is given in Volume-VIII Part-1.

Table 6.11:Treatment Option

Type	Treatment Option
Type A:	Widening and Overlay; 7.0m carriageway+1.5 paved shoulders+1.0 Hard Shoulder
Type B:	Reconstruction; 7.0m carriageway+1.5 paved shoulders+1.0 Hard Shoulder
Type C:	Reconstruction; Four lane Divided Carriageway for Junction Improvement+ Open Drain
Type C1:	Reconstruction; Four lane Divided Carriageway. R.C.C Closed drain, (Near to Bodeli)
Type D:	Widening and Overlay; 7.0m carriageway+1.5 paved shoulders+0.5 Hard Shoulder
Type E:	Widening and Overlay; 7.0m carriageway+1.0 paved shoulders+0.5 Hard Shoulder
Type F:	Reconstruction; 7.0m carriageway+1.5 paved shoulders+0.5 Hard Shoulder
Type G:	Reconstruction; 7.0m carriageway+1.0 paved shoulders+0.5 Hard Shoulder
Type H:	New Construction, Approach to RoB+Service Road

Table 6.12:Widening Schedule

Start Chainage	End Chainage	Length	Cross-Section Type	Existing Width	Proposed Formation width	Proposed Paved Shoulder	Proposed Hard shoulder	Remarks
29681.77	29740	58.23	A	7	12	1.5	1	Vega Rotary
29740	30510	770	H	7	12	1.5	1	RoB (6m service road on both side)
30510	31300	790	A	7	12	1.5	1	
31300	32600	1300	A	7	12	1.5	1	
32600	32800	200	C	7	17.5		1	Junction Improvement
32800	35450	2650	D	7	11	1.5	0.5	
35450	36000	550	A	7	12	1.5	1	
36000	38000	2000	B	7	12	1.5	1	
38000	45000	7000	B	7	12	1.5	1	
45000	45500	500	F	7	11	1.5	0.5	
45500	46300	800	B	7	12	1.5	1	
46300	46600	300	G	7	10	1	0.5	
46600	46840	240	C	7	17.5		1	Intersection Improvement
46840	47500	660	B	7	12	1.5	1	
47500	50000	2500	E	7	10	1	0.5	
50000	50700	700	A	7	12	1.5	1	
50700	50900	200	D	7	11	1.5	0.5	
50900	51200	300	D	7	11	1.5	0.5	
51200	52800	1600	D	7	11	1.5	0.5	
52800	54000	1200	A	7	12	1.5	1	
54000	56000	2000	F	7	11	1.5	0.5	
56000	56700	700	F	7	11	1.5	0.5	
56700	58300	1600	D	7	11	1.5	0.5	
58300	59300	1000	D	7	11	1.5	0.5	
59300	60300	1000	E	7	10	1	0.5	
60300	60500	200	D	7	11	1.5	0.5	
60500	63600	3100	D	7	11	1.5	0.5	
63600	64000	400	D	7	11	1.5	0.5	

Start Chainage	End Chainage	Length	Cross-Section Type	Existing Width	Proposed Formation width	Proposed Paved Shoulder	Proposed Hard shoulder	Remarks
64000	65500	1500	B	7	12	1.5	1	
65500	66400	900	G	7	10	1	0.5	
66400	67700	1300	G	7	10	1.5	0.5	Canal Approach
67700	67935	235	G	7	10	1	0.5	
67935	68417.1	482.1	C1	14	17.5		1	Existing Four Lane
Total Length		**38735.3**						

6.9 IMPROVEMENT PROPOSAL FOR STRUCTURES

A. Dabhoi - Bodeli Corridor

107. **Major and Minor Bridges:** Major Bridge on Narmada main canal crosses the project corridor at km 66+800 on SH-011. As condition of this bridge is good it is proposed to be retained. Out of 12 minor bridges, one minor bridge is proposed to be replaced by new structure, another one is retained and among rest of ten minor bridges 6 needs repair and the other 4 needs widening and repair. Also one railway crossing at chainage 30+075 is there for which one ROB is proposed. The details of proposed treatments for bridges are provided in Table 6.13.

Table 6.13: Proposed Treatment: Dabhoi-Bodeli (SH-011)

Sr. No.	Design Chainage (km)	Type of Bridge	Nos. of Span	Span length (m).	Total Length of Bridge	Total Width of Bridge	Carriageway Width (m)	Proposal
1	30+077	ROB	-	-	-	-	-	-
2	30+665	Minor	1	6.90	6.90	10.00	6.70	Repair
3	44+487	Minor	3	8.25	24.75	8.40	7.00	Repair
4	51+070	Minor (Narmada main Canal)	3	9.45	28.35	8.40	6.10	Retain new structure
5	52+907	Minor	1	6.00	6	10.80	6.10	Repair
6	54+775	Minor	1	7.25	7.25	9.90	6.10	Repair
7	55+520	Minor	1	6.50	6.50	9.90	6.10	Repair
8	56+280	Minor	3	6.00	18.00	7.50	6.90	Replace by new bridge (2 nos. 9 m. span)
9	59+362	Minor	4	6.90	27.60	7.40	5.60	Repair & widening
10	61+640	Minor	4	6.80	27.20	7.50	6.00	Repair & widening
11	63+062	Minor	3	6.70	20.10	7.50	6.20	Repair & widening
12	65+110	Minor	1	6.80	6.80	9.70	6.70	Repair
13	65+225	Minor	3	5.60	16.80	7.50	5.90	Repair & widening
14	66+925	Major (Narmada main Canal)	5	22.32	111.60	11.40	7.50	Repair

108. **Culverts:** The condition of some culverts along this corridor is poor, more over these are very old structures with loose joints, blockage of pipes, scour and growth of vegetation. Head walls of some culverts are damaged. Hence reconstruction is suggested of such highly damaged culverts.

109. The summary of proposed treatment for culverts is presented in Table 6.14.

Table 6.14: Summary of Proposed Treatment

Treatment	Numbers
Repair	11
Repair and Widen	4
Replace with new	25
Head wall reconstruction	5
Total	**45**

7 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

7.1 ENVIRONMENTAL IMPACT ASSESSMENT

110. The proposed upgradation (strengthening and widening) of Dabhoi-Bodeli Corridor is designed within the available RoW. A 12m CoI approach has been adopted in the green tunnel stretches to avoid/ minimise impacts on avenue trees and 16m CoI approach has been adopted in the rural and urban sections to minimize the impact on Forest land diversion, structural impacts and resettlement and rehabilitation (R&R) issues. The environment and social screening and the subsequent consultations with the stakeholders confirmed that, there are no other sensitive environmental features that are present along the project corridor other than the Vadhavana reservoir (Ch 40+000 to 41+000) which is located at 750m from the project corridor, this reservoir attracts birds during the breeding seasons.

111. In addition to the construction related impacts, the key issues raised during consultations were (i) Safety issues with respect to geometric / curve improvement and provision of road safety furniture at settlement / urban areas, temples and schools (ii) Provision for sufficient drain facility including upgrading the bridges and culverts and provision of additional culverts at various locations. As per the Government of Gujarat Gazette dated 16th August, 1973, the project corridor is notified under 'Protected Forest' and requires forest clearance for diversion of 24.12 ha of forest area. For obtaining forest clearance as well as permission for tree felling, proposal has been submitted to the forest department for necessary action.

112. The environmental impacts associated with the proposed upgradation are construction related impacts associated with road widening projects. These are proposed to be addressed through good engineering practices and adoption of environmental management measures proposed in the Environmental Management Plan (EMP) for the corridor. The EMP budget of INR 2.41 million includes the management measures and provision for environmental monitoring.

7.2 LAND ACQUISITION AND RESETTLEMENT IMPACTS

113. Private land will not be affected due to the proposed project, as there are no stretches where widening or geometric improvements are proposed beyond the existing RoW of 30 m.

114. According to the census survey the proposed road improvement will impact a total of 18 commercial structures (kiosks), which belong to non-titleholders.

115. Nine public consultation meetings were held along the project corridor with road side communities to obtain their views and suggestions regarding the proposed project interventions. The consultations have provided inputs towards mitigation of impacts, improvement in designs, and preparation of resettlement plan and its implementation. Based on the suggestions design modifications including curve improvement, shifting of alignment

to protect mainly structures of religious importance, provision of road safety measures such as pedestrian crossings, warning signs, markings, etc has been carried out.

116. A resettlement budget of INR 1.4 million including compensation for the affected land & structures, assets within the affected properties and rehabilitation and resettlement assistance has been estimated. Any unforeseen impacts on resettlement during implementation will be taken up in accordance with the Resettlement Policy Framework (RPF) of the project.

8 ACCESSIBILITY AND MOBILITY TO TRANSPORT FACILITIES IN VILLAGES: SUMMARY

8.1 INTRODUCTION

117. Baseline socio-economic information related to accessibility and mobility to transport facilities in the villages along the proposed corridor has been collected and analyzed. The study intended to assess the travel pattern of villagers, which includes, travel time to major markets, educational and health institutions, frequency of trips to nearby places, perception of villagers on travel situation, etc. The findings of the present study shall form basis for measuring impacts after the proposed roads are improved. There are 60 villages located within 2 km bandwidth of the proposed corridor, of which 30 villages are chosen for the survey. Altogether 150 households are surveyed.

8.2 PROFILE OF SAMPLE POPULATION

118. **Gender and Age Distribution:** Age distribution shows that 50 percent of the population belongs to the age group of 26-60 and 16 percent of the population is in the age group of 6-14.

119. **Education profile:** Female population has a lower level of education compared to male population. 30 percent of the population have secondary level of education and 7 percent are having graduation or above level of qualification.

120. **Income Profile and Dependency Ratio:** 31 percent of the sample households have a monthly income of less than Rs.3000; of which12 percent have a monthly income less than Rs.2000. The dependency ratio is 2.1:1

121. **Occupation Profile:** major percentage of sample population is engaged business and trade and 35 percent in agricultural activities.

8.3 MAJOR FINDINGS

122. **Trip Information:** Analysis of trip information of villagers is based on 545 cases of usual trip information of 150 surveyed households. Analysis based on chi-square test shows that trip information does not vary significantly between income-groups.

123. **Mode of Travel:** Amongst the 545 usual trip information, 39 (7 percent) travel on foot and 446 trips (82 percent) are by bicycle, auto-rickshaw, bus or *chakda*.

124. **Frequency of Travel:** 20 percent of the 545 usual trips are on daily basis; 44 percent of the trips are for 3-4 times in a week and 5 percent trips are on monthly basis. Among all vehicles *chakda* and bus are the most used modes for usual trip. Bus is used for 45 percent of usual trips. Of the total trips using vehicles, 18 percent trips are on daily basis.

125. **Perception about Present Transport Situation:** Villagers opined about the requirement of good quality roads, more number of buses, improved access to health centres, etc.

9 PROJECT COSTING

9.1 PROJECT COST

126. The project corridor is designed involving widening, reconstruction and maintenance of both pavement and cross-drainage structures. Based on the estimated quantities and extensive rate analysis, combined project cost including environmental and social cost is Rs 114.6 crore. The total cost is presented in two subheads as Civil Construction Cost and Social Cost. Environmental Management Plan (EMP) related cost is factored in construction cost itself. The total cost under two sub heads is given in Table 9.1.

Table 9.1: Project Cost

Sr. No.	Description	Amount (INR)
1	Civil Construction Cost	**1,14,45,81,013**
2	Social Cost	**14,21,400**
Grand Total		**1,14,60,02,413**

10 ECONOMIC ANALYSIS

10.1 RESULTS OF ECONOMIC ANALYSIS

10.1.1 Base Analysis

127. The economic analysis has been undertaken for the project road by using RUCS equations. The results obtained are in terms of the Economic Internal Rate of Return (EIRR), Net Present Value (NPV), as presented below for project corridor as a whole.

Table 10.1: Result of Economic Analysis

Scenarios	Description	EIRR					
		Without Time		With Time		With Accidents	
		20 years	30 years	20 years	30 years	20 years	30 years
I	Base Costs + Base Benefits	30.77%	31.29%	49.29%	49.36%	55.84%	55.87%
		NPV (in million Rupees)					
I	Base Costs + Base Benefits	1,900	2,670	3,940	4,950	4,780	5,971

The project is economically viable, even in case of only savings in the VOCs. With VOT and accident cost savings, it becomes a very desirable project from the perspective of the society Sensitivity Analysis

128. Any investment is subject to risks and uncertainties. All risks culminate into either increase in project cost, reduction in benefits or both put together. In order to cover the above stated risks, a detailed sensitivity analysis, with respect to the sensitive parameters, has been undertaken. The various sensitivity scenarios considered are as follows:

- Sensitivity 1: Base Costs plus 15% and Base Benefits (15% Increase in cost);
- Sensitivity 2: Base Costs and Base Benefits minus15% (15% reduction in benefits); and
- Sensitivity 3: Base Costs plus 15% and Base Benefits minus 15% (15% Increase in costs and 15% reduction in benefits).

129. The results of the sensitivity analysis have been presented in Table 10.2.

Table 10.2: Results of Sensitivity Analysis

Scenarios	Description	EIRR					
		Without Time		With Time		With Accidents	
		20 years	30 years	20 years	30 years	20 years	30 years
I	Base Costs plus 15% and Base Benefits (15% Increase in cost)	27.76%	28.45%	44.37%	44.48%	50.29%	50.35%
II	Base Costs and Base Benefits minus 15% (15% reduction in benefits)	27.43%	28.13%	43.81%	43.92%	49.64%	49.71%
III	Base Costs plus 15% and Base Benefits minus 15% (15% Increase in costs and 15% reduction in benefits)	24.69%	25.59%	39.40%	39.58%	44.67%	44.77%
		NPV (in million Rupees)					
I	Base Costs + 15% and Base Benefits	1,768	2,538	3,807	4,817	4,647	5,839
II	Base Costs and Base Benefits minus 15%	1,488	2,143	3,222	4,080	3,936	4,949
III	Base Costs + 15% and Base Benefits minus 15 %	1,356	2,011	3,089	3,948	3,803	4,817

130. The sensitivity analysis reflects project viability in the worst scenario also, in case the VOT and/or accident cost savings are considered. If the analysis period is taken as 20 years, the project is viable in case of VOC and VOT savings (EIRR>12%). With additional benefit of accident cost savings, it tends to become more attractive.

131. The project needs to be planned and implemented soon. The savings in travel time is precious for the economy. In case, the project implementation is delayed, the cumulative loss in value of travel time is likely to go up from Rs 289.7 million in 2015 to about Rs 10163.7 million in the year 2040. Therefore, the state should get the project initiated soon. (Refer Figure 10.1).

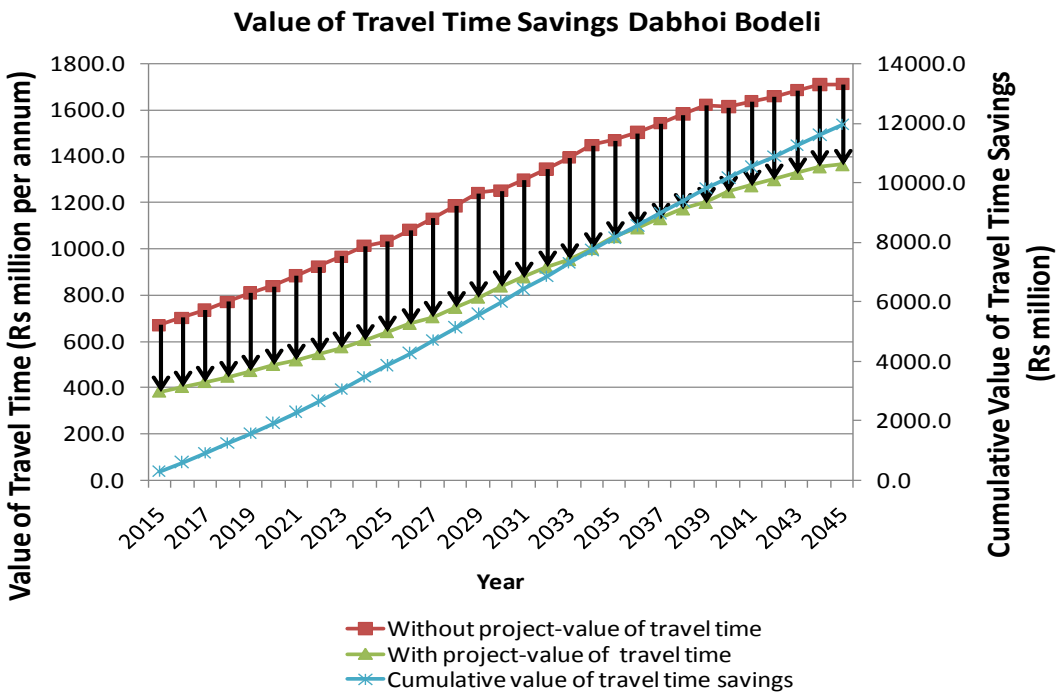


Figure 10.1: Value of Travel Time Savings

10.2 CONCLUSION

132. The road project ***is desirable from the society's point of view.*** The project corridor as a whole is found to be economically viable with positive net present values and EIRR greater than 12%, even in the worst scenario of drop in benefits coupled with increase in cost. Hence, based on the above results, the project is recommended for implementation.

133. Since the accident benefits are high, it is further recommended that due consideration should be given to the measures suggested from safety point of view. This would make Dabhoi-Bodeli a safe highway