1.INTRODUCTION

1.1 General

The National Highway Authority of India (herein after referred to as the "Authority" or "NHAI") is engaged in the development of the National Highways. As part of this endeavour, NHAI has decided to undertake the project namely "Consultancy services for preparation of DPR for development of stretches for improving direct connectivity in Indian cities (Lot-8/Package-1) Surat-Nashik-Ahmednagar Greenfield Highway" through Public Private Partnership (PPP) on Design, Build, Finance, Operate and Transfer (DBFOT) basis or Hybrid Annuity Mode (HAM) or Engineering Procurement Construction mode (EPC).

- The Letter of Award was communicated vide letter No.NHAI/Bharatmala/DPR/Lot-8/Package-1 /2018/126249 dated 12th November, 2018.
- Letter of commencement was issued on 12th December, 2018 vide letter No. NHAI/Bharatmala/DPR/Lot-8/package-1/2018/127519.
- Contract agreement was signed on 12th December, 2018.

As per Contract Agreement, the details of stretches proposed for Detailed Project Report preparation under Lot-8 Package-1 are furnished in Table-1.1.

Table-1.1

S. No	Corridor Code	Stretch Name	Length (km)	Name of corridor	Remarks
		Lot-8/Package-1			
1	**EC-413**	Surat-Nashik-Ahmednagar Greenfield stretch	290.700	Surat – Nashik – Ahmednagar -Solapur	Under improving direct connectivity in Indian cities
		Total	**290.700**		

Final Feasibility Report has been prepared based on observations derived from the said surveys and in accordance with contractual stipulations

1.2 Importance of the project.

NHAI has aimed to develop the Surat-Chennai Corridor with reference to the meeting held on 09.08.2018 under the Chairmanship of Secretary (RT&H) at Transport Bhawan, New Delhi. The Surat Chennai Corridor connects two important port cities i.e Surat and Chennai. The existing popular routes for connecting the two major cities i.e Surat and Chennai are

- Via Mumbai, Pune, Satara, Kolhapur, Belgaum, Haveri, Davangere, Chitradurga, Tumukuru and Bangalore – Total Length about 1,604 km (Shown in Grey Colour)
- Via Mumbai, Pune, Solapur, Kalaburgi, Kurnool, Kadapa and Nellore–Total length about 1,567 km (Shown in Blue Colour)
- Via Mumbai, Pune, Solapur, Hyderabad, Nalgonda and Nellore–Total length about 1,614 km (Shown in Grey Colour)

The Three existing routes said above are shown in Fig 1.1.

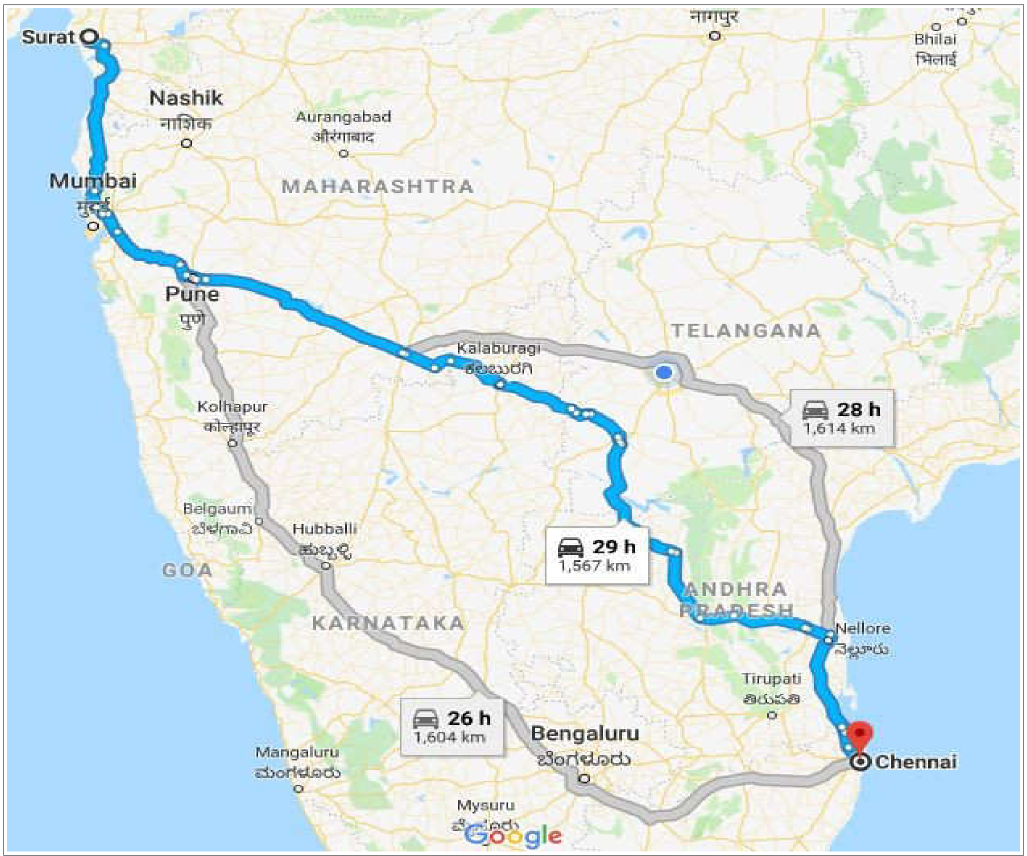


Fig 1.1.Existing popular Routes from Surat to Chennai

Surat-Mumbai-Pune – Bangalore - Chennai National Highway -48 is the most preferred route for truck traffic as it has been upgraded to 6 lane in the recent past and now, it is getting saturated. So there is a necessity to develop an alternate route for connecting these two important port cities.

As on day there is no direct connectivity to Surat – Chennai corridor, The proposed Surat-Nashik- Ahmednagar greenfield alignment reduces the travel distance and travel time between two major port cities.

In view of the above Competent Authority has aimed to develop the greenfield alignment connecting from Surat to Chenai so that it can the serves as an alternative to the existing NH 48 route via Surat, Mumbai, Pune, Banglore.

1.2.1 Surat-Nashik-Ahmednagar Greenfield Stretch.

Existing popular routes for connecting Surat to Solapur

- Via Surat, Dhule, Aurngabada, Solapur – Total Length about 680 km (Shown in voilet colour)
- Via Surat.Mumbai, Pune, Solapur 630 km (Shown in Black colour)

The above mentioned in routes are shown in Fig 1.2

The total length of proposed Greenfield alignment(Shown in green colour) from Surat to Solapur is 540 Km.

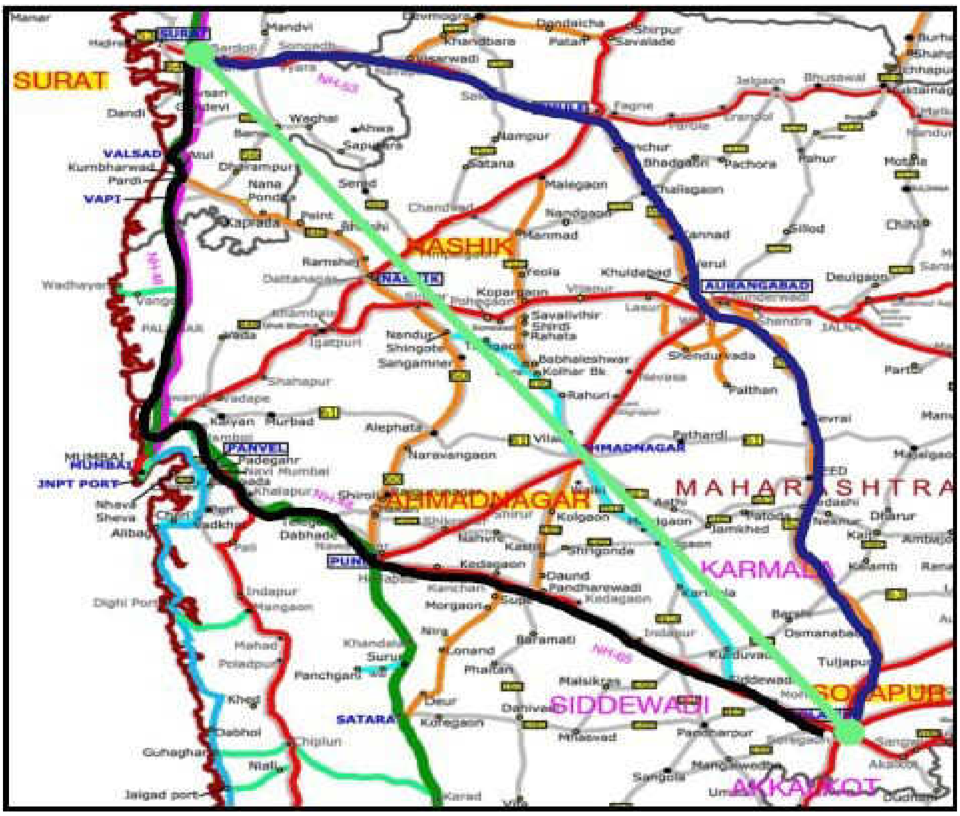


Fig 1.2 Existing popular Routes from Surat to Solapur

In view of above there is a necessity to develop a green field alignment between Surat to Ahmednagar. With this Proposed alignment the total length will be reduced by about 90 km. This would intern result in reduction of travel time.

The proposed greenfield alignment traverses through the States of Gujarat and Maharashtra.

The length of project corridor traversing in each state is given in below Table 1.2.

Table 1.2: Length of project corridor

S No.	State	Approximate length (in km)
1	Gujarat	68.360
2	Maharashtra	222.340
Total Length		**290.700**

1.3 Scope of The Study

The scope of the services to be rendered essentially involves detailed designs based on field visits and engineering surveys. As per ToR, the scope of the current study is listed as under:

- ✓ Engineering surveys and investigations
- ✓ Highway & Structural design
- ✓ Environmental and Social Impact Assessment
- ✓ Estimation of Project Cost
- ✓ Economic & Financial Analysis
- ✓ Preparation of Feasibility study report and Detailed Project Report
- ✓ Preparation of Land Acquisition Plans
- ✓ Preparation of Bid Documents
- ✓ Obtain necessary Forest/ Environmental clearances, if any etc.

As far as possible. Improvement to six lane of the existing road in built-up locations and in hilly terrain is not possible. So, to avoid land acquisition in the built-up sections, Greenfield proposals have also been considered. The Consultant shall furnish land acquisition details as per revenue records/maps for further processing.

The entire scope of services would, inter-alia, include the items mentioned in ToR. The Consultant will also make suitable proposals for proposed green field alignment for the six lane configuration and strengthening of the carriageways, as required at the appropriate time to maintain the level of service over the design period. All ready to implement 'good for construction' drawings shall be prepared.

Environmental Impact Assessment, Environmental Management Plan and Rehabilitation and Resettlement Studies shall be carried out by the Consultant meeting the requirements of the lending agencies like ADB/ World Bank/ JICA etc.

Wherever required, consultant will liaise with concerned authorities and arrange all clarifications. Approval of all drawings including GADs and detail engineering drawings will be got done by the consultant from the Concerned Authority. However, if Railways require proof checking of the drawings prepared by the consultants, the same will be got done by MORTH and payment to the proof consultant shall be made by MORTH directly. Consultant will also obtain 'No Objection Certificate' from Ministry of Environment and Forest and incorporate the estimates for shifting of utilities of all types involved from concerned local authorities in the DPR. Consultant is also required to prepare all Land Acquisition plans (i.e. all necessary schedules as per L.A. act) for acquisition of land either under NH Act.

The consultant shall prepare the Bid Documents, based on the feasibility report, due to exigency of the project for execution.

Consultant shall obtain all types of necessary clearances required for implementation of the project on the ground from the concerned agencies. The client shall provide the necessary supporting letters and any official fees as per the demand note issued by such concerned agencies from whom the clearances are being sought to enable implementation. The brief scope of work includes preparation of detailed project report for the purpose of firming up the requirements in respect of development and construction of highway and project facilities.

1.4 Objective Of The Study

The main objective of the consultancy service is to establish the technical, economic and financial viability of the project and prepare detailed project reports for construction of a green field stretch of 6-lane configuration by considering the investment requirements and financial return through toll and other revenues.

The viability of the project shall be established considering the requirements with regards to improvement based on highway design, pavement design, type of intersections, construction of new bridges and structures, road safety features, quantities of various items of works and cost estimates and economic analysis.

The list of objectives to be achieved are listed as under:

a) Conduct detailed Engineering surveys & Investigations

b) Study of alternative alignment options and fixing the final alignment by taking into account the applicable geometric standards, ecology & environment, drainage pattern, existing & proposed land uses etc.

c) Forecast the traffic demand on project stretch by conducting necessary volume count and origin-destination studies giving due weightage to the future development proposals along the project stretch

d) Design of pavement along the project stretch using respective IRC codes

e) Prepare the road geometric design along with plan & profiles based on LiDAR topographic survey

f) Design of bridges/ cross drainage structures , grade separated structures and Tunnels

g) Develop General Arrangement Drawings (GADs) of structures for assessment of quantities

h) Identify the Initial Social Impact Assessment by broadly identifying and assessing the extent of private lands to be acquired and the government lands/ forest land to be proposed for diversion

i) Identify the Initial Environmental Impact Assessment based on available reports and by assessing the levels of pollution from the projected traffic on the project highway

j) Prepare BOQ and cost estimates based on prevailing market rates and SSR

k) Prepare the economic and financial analysis of the project by bringing out the project packaging and various feasible procurement alternatives

l) Prepare Land acquisition plans, utility relocation plans along with strip plans

m) Obtain necessary forest and environmental clearances

n) Submission of necessary bid/ contractual documents

1.5 Approach

The consultant's approach towards the project is in accordance with the ToR in lines with the project objectives. The prescribed engineering surveys and investigations have been carried out on project stretch conforming to MORT&H/IRC/BIS specifications/Codes as per ToR to generate adequate database for preparing the most appropriate proposal for the rehabilitation and upgrading of the proposed project highway.

1.6 Outcome of Current Study

The Final Feasibility study assists in predicting the workability and effectiveness of highway after its implementation. The viability of the project will be established taking into account the requirements with regards to highway design, pavement design, provision of service roads wherever necessary, type of intersections, new bridges and structures, road safety features, quantities of various items of works and cost estimates and economic analysis.

The following structured outcome is presented in the current Final Feasibility report:

E.0 Executive Summary

1. Introduction
2. Overview of NHAI
3. Existing features of the project corridor
4. Alignment options study report
5. Methodology adopted for the Final feasibility study
6. Socioeconomic profile of the project area
7. Indicative design standards, methodologies and specifications
8. Traffic demand assessment on project stretch for future horizon years
9. Pavement design based on traffic and pavement investigation surveys
10. Environmental screening and Preliminary Environmental Impact Assessment
11. Initial Social Impact Assessment and preliminary land acquisition/ resettlement plan
12. Proposals
13. Cost estimates
14. Economic evaluation and Financial evaluation of the project corridor
15. Conclusions and Recommendations
16. Technical Specifications

2. OVERVIEW OF NHAI

VISION STATEMENT OF NHAI

"To meet the nation's need for the provision and maintenance of National Highways network to global standards and to meet user's expectations in the most time bound and cost effective manner, within the strategic policy framework set by the Government of India and thus promote economic well being and quality of life of the people."

2.1 Introduction

National Highways Authority of India (NHAI) is an autonomous organization under the Ministry of Road Transport & Highways and was constituted by an act of Parliament, the National Highways Authority of India Act, 1988. NHAI is responsible for the Development, Maintenance, and Management of National Highways and for matters concerned thereto. The authority was made operational with the appointment of full time Chairman and other Members in the year 1995. The first and foremost mandate for NHAI was the construction and development of five road stretches in the states of Haryana, Rajasthan, Bihar, West Bengal and Andhra Pradesh under loan assistance from Asian Development Bank. Subsequently, development works for other highway stretches were entrusted to NHAI.

NHAI is mandated to implement National Highways Development Project (NHDP) which is India's largest ever Highways Project. Presently National Highway network of about 79,243 km serve as the main road network of the country. Even though National Highways constitute only about 2% of the length of all roads, they carry about 40% of the road traffic. Rapid expansion of passenger and freight traffic makes it imperative to improve the road network in the country.

Accordingly, Government of India launched major initiatives to upgrade and strengthen National Highways through various phases of NHDP, which are:

NHDP Phase I was approved by the Government in December 2000 at an estimated cost of Rs. 30,300 crores and comprises GQ (5,846 km) and NS-EW Corridor (981km), Port connectivity (356 km) and others (315 km).

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

NHDP Phase III Government approved up-gradation and 4 laning of 4,815 km of National Highways on BOT basis at an estimated cost of Rs. 33,069 crores under NHDP Phase IIIA. In April 2007, Government approved up-gradation and 4 laning of 7294 km at an estimated cost of Rs. 47,557 crores under NHDP Phase IIIB. Total approved length of NHDP Phase III is 12,109 km at an approved cost of Rs. 80,626 crore.

NHDP Phase IV Government, in February 2012, approved upgradation/ strengthening of 20,000 km of single/intermediate/two lane NHs to two lane with paved shoulder/4-lane under NHDP Phase-IV on BOT (Toll) and BOT (Annuity) basis.

NHDP Phase V Government, in October 2006, approved six laning of 6,500 km of existing 4 lane highways under NHDP Phase-V (on DBFOT basis) at an estimated cost of Rs. 41,210 crores. Six laning of 6,500 km includes 5,700 km of GQ and about 800 km of other stretches.

NHDP Phase VI Government, in November 2006, approved for 1000 km of expressways at an estimated cost of Rs. 16,680 Crores.

NHDP Phase VII Government, in December 2007, approved implementation of NHDP Phase VII which envisages construction of approximately 700 km of stand alone bypasses, grade separators, flyovers etc. at an estimated cost of Rs. 16,680 crores.

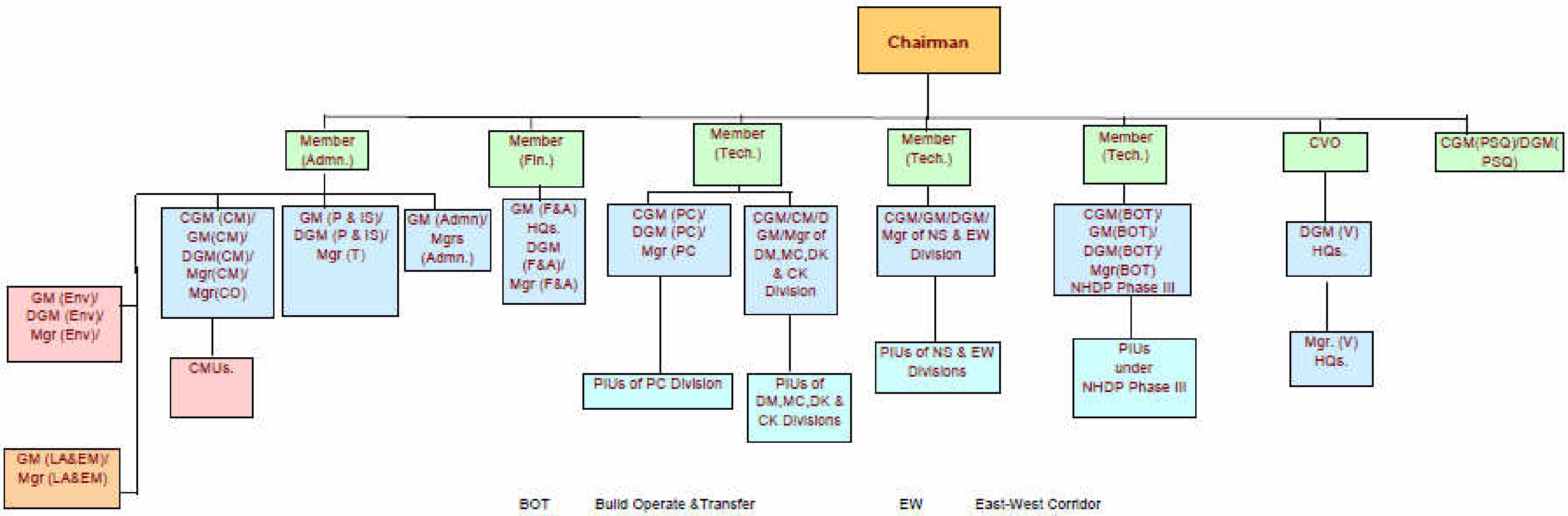
2.2 Organization Chart

As per the National Highways Authority of India Act 1988, the Authority shall consist of a Chairman, not more than five full-time Members and not more than four part time Members, to be appointed by Central Government.

The Organizational Structure of the Authority is as shown below. The total manpower strength of the Authority under various categories, as on 31.03.2013 is as under:

Group post	Total No. of Employees	Regular	Deputation	Contract
A	565	110	441	14
B	274	53	6	215
C	193	13	0	180
D	3	3	0	0
Total	**1035**	**179**	**447**	**409**

Organizational Structure of the NHAI



BOT	Build Operate &Transfer	EW	East-West Corridor
CGM	Chief General Manager	Env	Environment
CK	Chennai-Kolkata Section of GQ	F&A	Finance and Account
CM	Corridor Management	GM	General Manager
CMU	Corridor Management Unit	GQ	Golden Quadilateral
CO	Commercial Operations	L&EM	Land Acqui isition & Estate Management
CVO	Chief Vigilance Officer	MC	Mumbai-Chennai Secti tion of GQ
DGM	Deputy General Manager	P&IS	Planning and Informati ion Systems
DK	Delhi-Kolkata Section of GQ	PC	Port Connectivity
DM	Delhi Mumbai Section of GQ	NS	North-South Corridor
PIU	Project Implementation Unit		

2.3 National Highways

As National Highways comprise about 2% of the total road length in the country and yet carryover 40% of total traffic, the first and the foremost task mandated to the NHAI is the implementation of NHDP – comprising of the Golden Quadrilateral and North-South & East-West Corridors. In addition to the projects under NHDP, the NHAI is also currently responsible for about 1,000 km of Highways connecting major Ports & also on National Highways 8A, 24, 6, 45 & 27. Highways length with NHAI currently is around 22,900 km. About 65% of freight and 80% passenger traffic is carried by the roads.

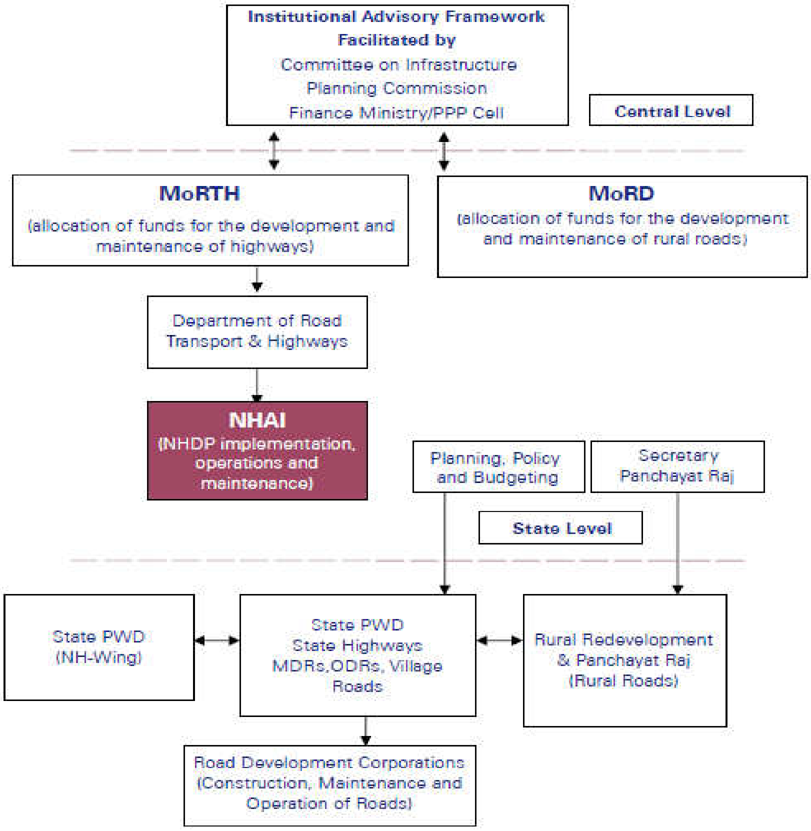
Number of vehicles has been growing at an average pace of 10.16% per annum over the last five years.

CLASS	LENGTH (km) (Approx.)
Expressways	1000
Total National Highways	92,852
National Highways (4 / 6 laned)	22,900
State Highways	1,54,522
MDR and Other district roads	25,77,396
Rural and Other roads	14,33,577
Total Approx	42,45,429

NHAI is responsible for the implementation of National Highways Development Project (NHDP) and other agencies implement the Non – NHDP projects. The administrative framework for the road sector in India is given in the below figure:

Source: Guidelines for Investment in Road Sector – NHAI

Administrative Framework for Roads



2.4 Institutional Changes

The following are the major landmark changes in the institutional framework that facilitated the faster development of National Highways in India:

- National Highways Authority of India Act, 1988
- The National Highways (Collection of fees by any person for the use of section of National Highways / Permanent Bridge / Temporary Bridge – Public funded project) Rules, 1997
- The National Highways (Rate of fee) rules, 1997
- The National Highways Laws (Amendment) Act, 1997 to the National Highways Act, 1956 that facilitated Land acquisition under NH Act, 1956
- The control of National Highways (Land and Traffic) Act, 2002
- Duty waiver for import of equipment used in highway construction
- Tax concessions for private entrepreneurs, investments in Highway sector.

2.5 National Highways Development Project (NHDP)

The Government launched the National Highways Development Project (NHDP) to upgrade and strengthen National Highways through the various phases of NHDP being implemented by NHAI. National Highways Development Project is being implemented in all phases except phase VI at present. The present phases improving more than 49,260 km of arterial routes of NH Network to international standards.

The project-wise details NHDP all Phases as below.

NHDP Phase		Total Length (km.)	Already 4/6Laned (km.)	Under Implementation (km.)	Contracts Under Implementation (No.)	Balance length for award (km.)
NHDP	Golden Quadrilateral	5,846	5,846	0	0	-
	NS – EW Ph. I & II	7,142	6,360	365	42	417
	Port Connectivity	380	379	1	1	0
	NHDP Phase III	12,109	6,393	4,373	89	1,343
	NHDP Phase IV*	14,799	942	5,904	55	7,953
	NHDP Phase V	6,500	2,001	2,080	27	2,419
	NHDP Phase VI	1,000	-	-	-	1,000
	NHDP Phase VII	700	22	19	1	659
	NHDP Total	48,476	21,943	12,742	215	13,791
Others (Ph.-I, Ph.-II & Misc.)		1754	1428	326	10	-
SARDP -NE		388	99	12	1	277
Total by NHAI		50,618	23,470	13,080	226	14,068

*Total 20,000 Km. was approved under NHDP Phase IV.Out of which 14,799 Km. was assigned to NHAI remaining Km. with MORTH.*Source:* *www.nhai.org* *(as per 31.01.2015)*

Various phases of National Highways Development Project (NHDP)*- includes about 47,054 km of total NHs other than overlapping lengths of NHs (about 5,700 km common under NHDP-I and NHDP-V).

Government, in December 2007, approved implementation of NHDP Phase VII which envisages construction of approximately 700 km of stand alone bypasses, grade separators, flyovers etc. at an estimated cost of Rs.16,680 crores.

Tentative list of NHDP Phase VII projects

S.No.	Name of City project
1	Ring road/bypass for Hyderabad
2	Ring road/bypass for Tirunelveli
3	Ring road/bypass for Kanpur
4	Grade Separated Intersection/ Flyover at Ranchi on NH-75
5	Ring road/bypass for Tiruchchirapalli
6	Ring road/bypass for Nasik
7	Grade Separated Intersection/Flyover at Solapur at Junction of NH-9 and NH-211
8	Ring road/bypass for Chennai
9	Ring road/bypass for Jaipur
10	Ring road/bypass for Amritsar
11	Grade Separated Intersection/flyover at Padalsingi and at Gandhi at Junction of NH-211and 222
12	Ring road/bypass for Madurai
13	Ring road/bypass for Patna
14	Ring road/bypass for Thiruvanthapuram
15	Ring road/bypass for Surat
16	Ring road/bypass for Aligarh
17	Ring road/bypass for Bangalore
18	Grade Separated Intersection/Flyover at Alephata at Junction of NH-50 and 222
19	Ring road/bypass for Ahmedabad.
20	Ring road/bypass for Vishakhapatnam.
21	Ring roads/bypasses for Jammu & Srinagar citites
22	Ring road/bypass for Kolkata
23	Elevated link road to Chennai Port
24	Ring Road/bypass for Meerut
25	Ring Road/bypass for Coimbatore

S.No.	Name of City project
26	Ring road/bypass for Bhopal
27	Ring road/bypass for Salem
28	Ring road/bypass for Nagpur
29	Ring road/bypass for Indore
30	Ring road/bypass for Lukcnow
31	Ring road/bypass for Imphal
32	Ring road/bypass for Pune
33	Ring road/bypass for Varanasi
34	Ring road/bypass for Dhanbad
35	Ring road /bypass for Ranchi
36	Grade Separated Intersection/flyover near Ratangiri at Junction of NH 17 and 204

2.6 Salient Features of NHDP Projects

2.6.1 Steps Taken for Expediting Project Execution

NHAI is quickly adapting to the site problems by effectively utilising the experience gained in the earlier projects. Its efforts to complete all the pre-construction activities well before the award of the civil works contract are steps in the right direction. The sizes of the contracts, the technical guidelines to the consultants are being constantly updated based on the feedback received from time to time.

2.6.2 Safety Aspects

Fatality rate on Indian highways is very high. NHAI has introduced many safety provisions in the design of highways for making highway travel safer. Some of these are listed below:

- Safety Barriers /Delineators hard shoulders on main road.
- Traffic signs and pavement markings.
- Underpasses and other grade separators at congested junctions.
- Removal of junctions and direct access points on main roads
- Improved median openings with stacking lanes
- Separate provision for safety and diversion in BOQ.
- Service roads in towns and villages for segregating local and through traffic.
- Safety audit for all the projects during FS/DPR as well as project implementation.

2.6.3 Way Side Amenities

Wayside amenities are being provided with some of the following features:

- Fueling and servicing facilities.

- Restaurants
- Rest areas
- Telephone facilities
- Separate parking areas for goods and passenger vehicles
- Trauma care for accident victims

2.7 Funds for Highway Development and Maintenance

Traditionally, financing for development of National Highways in India was from the budgetary resources of the Government of India. In order to augment the available resources, loans have also been raised from multilateral agencies like World Bank, Asian Development Bank (ADB) and Japan Bank of International Cooperation (JBIC).Around 80 per cent of the external assistance is provided to NHAI as a grant by the Central government. The balance is made available as long-term loans to NHAI, with the Centre bearing the foreign exchange risk. Such loans are usually provided for 15-25 years with a moratorium of 5 years. Total cost of NHDP has been estimated to be Rs. 54,000 Crores or US$ 13.2 billions whose components are as below:

Likely sources	Rs.Cr. (1999 prices)	US$ Billions (1999 prices)
Cess on Petrol and Diesel	20000	4.9
External assistance	20000	4.9
Market borrowings	10000	2.4
Private Sector Participation	4000	1

2.7.1 Central Road Fund

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

- Construction and Maintenance of State Highways by State Governments
- Development of Rural Roads by State Governments
- Construction of Rail over- bridges by Indian Railway

- Construction and Maintenance of National Highways by NHDP and Ministry of Road Transport & Highways

Today, The Cess contributes between Rs 5 to 6 thousand crores per annum towards NHDP. The annual accruals on account of this increase are approximately Rs. 5,800 Crores and this amount is distributed among National Highways, State Roads, Roads of Economic Importance and Railways for taking up safety works such as ROBs, manning of level crossings etc. The share of the National Highways from the Central Road Fund is Rs. 2,000 Crores per annum.

2.7.2 Highway Infrastructure Bonds

Highway Infrastructure bonds are issued with benefits of tax savings for raising funds for NHAI.

Policy Initiatives for Attracting Private Investment:

- Government will carry out all preparatory work including land acquisition and utility removal. Right of way (ROW) to be made available to concessionaires free from all encumbrances.
- NHAI / GOI to provide capital grant up to 40% of project cost to enhance viability on a case to case basis 100% tax exemption for 5 years and 30% relief for next 5 years, which may be availed of in 20 years.
- Concession period allowed up to 30 years
- Arbitration and Conciliation Act 1996 based on UNICITRAL provisions.
- In BOT projects entrepreneur are allowed to collect and retain tolls.
- Duty free import of specified modern high capacity equipment for highway construction.
- Foreign Direct Investment up to 100 % in road sector.Declaration of the road sector as an industry (Infrastructure as defined in section 18(1) (12) of the Infrastructure Act includes Roads).
- Easier external commercial borrowing norms.

2.7.3 Modes Of Procurement

Broadly, modes of procurement adopted for implementation of highway projects may be classified into Public Private Partnership (PPP) and public funded projects. The details of modes of procurements are given below: -

PPP Projects: PPP projects are categorized into two types, namely, BOT (Toll) and BOT (Annuity).

BOT(Toll) Model: Concessionaire is procured through steps of Request For Qualification (RFQ) and Request For Proposal (RFP). Construction, operation, maintenance and tolling responsibility rests with the Concessionaire during entire concession period, which is normally, between 20 to 30 year.

- In a BOT (Toll) Model, the concessionaire (private sector) is required to meet the upfront/construction cost and the expenditure on annual maintenance.
- The Concessionaire recovers the entire upfront/construction cost along with the interest and a return on investment out of the future toll collection.
- The viability of the project greatly depends on the traffic (i.e., toll). However, with a view to bridge the gap between the investment required and the gains arising out of it, i.e., to increase the viability of the projects, capital grant is also provided (up to a maximum of 40% of the project cost has been provided under NHDP).

BOT(Annuity) Model: Concessionaire is procured through steps of RFQ and RFP. Construction, operation and maintenance rest with the Concessionaire during the concession period. While toll is collected by the Authority through a bidding process, the developer receives annuity payments through the concession period.

I. In an BOT (Annuity) Model, the Concessionaire (private sector) is required to meet the entire upfront/construction cost (no grant is paid by the client) and the expenditure on annual maintenance.

II. The Concessionaire recovers the entire investment and a pre-determined cost of return out of the annuities payable by the client every year.

III. The selection is made based on the least annuity quoted by the bidders (the concession period being fixed).The client (Government/NHAI) retains the risk with respect to traffic (toll), since the client collects the toll.

Private Sector Participation:

- Major policy initiatives have been taken by the Government to attract foreign as well as domestic private investments. To promote involvement of the private sector in construction and maintenance of National Highways, Some Projects are offered on Build Operate and Transfer (BOT) basis to private agencies. After the concession period, which can range up to 30 years, this road is to be transferred back to NHAI by the Concessionaires
- NHAI funds are also leveraged by the setting up of Special Purpose Vehicles (SPVs).The SPVs will be borrowing funds and repaying these through toll revenues in the future. This model will also be tried in some other projects.

Some more models may emerge in the near future for better leveraging of funds available with NHAI such as Annuity, which is a variant of BOT model.

Public Funded Projects:

The traditional mode of executing public funded projects was Item Rate Contract. This was prone to time and cost overruns. This mode has been replaced by New Engineering Procurement and Construction (EPC) contracts. The projects which are not viable under BOT (Toll) mode, such as those in far flung areas would have to be done under EPC mode. Model EPC Contract Agreement has been finalised and implemented all across highway projects. Model EPC agreement relies on assigning the responsibility for investigations, design and construction to the contractor for a lump sum price determined through competitive bidding. Model EPC agreement incorporates international best practices and provides a sound contractual framework that specifies the allocation of risks and rewards, equity of obligations between Government and the Contractor, precision and predictability of costs, force majeure, termination and dispute resolution, apart from transparent and fair procedures.

2.8 Future Programmes

A committee headed by the Honorable Prime Minister has proposed a massive infrastructure developmental programme for the next 7 years.

The following development projects will be taken up under this programme.

a) Completion of GQ and EW-NS corridors.
b) Completion of 4-laning of 10,000 km under NHDP Phase-III
c) 2-laning with paved shoulders of 20,000 km of National Highways under NHDP Phase- IV.
d) Augmenting highways in North East under Special Accelerated Programme.
e) 6-laning of selected stretches of National Highways under NHDP Phase-V.
f) Development of 1000 km of expressways under NHDP Phase-VI, and
g) Construction of ring roads, flyovers and bypasses on selected stretches under NHDP Phase-VII.
h) Government has planned that all the future NHDP projects i.e. NHDP Phase- III to Phase-VII will be implemented through public private sector participation. Out of the above proposal Government has approved 4-laning of 4000 km of National Highways under Phase-IIIA and preparation of detailed project reports for balance 6000 km under NHDP Phase-IIIB.

i) Actions have been initiated for getting the approval of the Government for the remaining projects.

j) In June 2009, it was decided to build 20km per day of National Highways. After oneyear, from June 2010 onwards, the Government has geared itself towards achieving this target. The total achievement now stands at 15.96km per day as on 31.01.2012.

Improvement of Road Connectivity in Left Wing Extremism (LWE) affected areas:

The Government has also taken up a programme for the development of about 5,477 km (1,126 km of NH and 4,351 km of State Roads) in Left Wing Extremism (LWE) affected areas as a special project estimated to cost about Rs. 7,300 crore in 34 districts in eight states namely in Andhra Pradesh, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha and Uttar Pradesh. Development of 1,084 km length has been completed by March, 2012. It has been targeted to complete all the works by March, 2015.

Special Programme for 2-laning of entire balance NH network not covered under any approved programmes:

Out of the total NH length of 76,818 km, the total balance length of NHs not covered under any programme is about 23,500 km. Out of this, about 10,000 km are less than 2-lane standards, i.e. 27 less than the minimum stipulated standards for NHs. MORTH has taken initiatives to develop/ upgrade about 4,614 km length of such stretches of NHs to 2-lane standards following Corridor Development Approach by December 2014 through budgetary resources [1,564 km of less than 2-lane NHs] and also through possible Loan Assistance from the World Bank [3,770 km having 3,050 km length of less than 2-lane NHs]. The balance length of about 5,400 km length of NHs having less than 2-lane NH standards are required to be upgraded to minimum acceptable 2-lane NH standards also. Total length proposed to be taken up through World Bank funding is about 3,770 km. The DPRs are under preparation for these projects proposed to be funded through World Bank loan assistance.

Creation of National Road Safety and Traffic Management Board:

The Government had introduced a Bill in LokSabha on 4.5.2010 to create a National Road Safety and Traffic Management Board to oversee the road safety activities in the country which was referred to the Department related Parliamentary Standing Committee for examination. The Parliamentary Committee submitted its report on 21.7.2010. Its recommendations have been examined. The Government is in the process of carrying out certain amendments in the Bill for consideration by the Parliament.

2.9 Borrowings from Multi-Lateral Agencies

Borrowing from multi – lateral funding agencies such as ADB, World Bank and JBIC (OECF) is also one of the major sources for funding of Highway projects.

2.10 Cost Recovery Mechanisms and Finance Mechanism

The investments are being recovered either directly through tolls or indirectly through cess on petrol and diesel.

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

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

Loan Assistance from International Funding Agencies: Loan assistance is available from multilateral development agencies like Asian Development Bank and World Bank or Other overseas lending agencies like Japanese Bank of International Cooperation.

Market Borrowing: NHAI proposes to tap the market by securities cess receipts.

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

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

2.11 Issues to be Addressed by NHAI

2.11.1 Expressways

The road development plan of MORT&H envisages construction of expressways for a total length of 10,000 Km. The stretches of National Highways that are required to be upgraded to Expressways need to be identified and FS/ DPR studies may need to be carried out for the construction of expressways and their implementation needs to be taken up.

2.11.2 Data Center

- NHAI should endeavor to set up a road data center for all the highways under its control. There is urgent need to store vast records pertaining to the projects that are completed and or under execution so that the data can be retrieved any time. For example, the land records of the lands acquired for the purpose of road widening, As-built drawings, details of highway furniture etc are to be stored in a database so that the information can be retrieved any time.
- Road data in respect of all the highways entrusted to NHAI such as road inventory, Bridge Inventory, traffic data, riding quality etc
- Unit rates for various items of work along the highway.
- Locations of borrow areas and the material available from them.
- Location of congested towns and villages existing along Nhs.
- Permissions being accorded from time to time and due date for their renewal
- Guarantees provided by the contractors / suppliers for various equipment such as expansion joints, bearings, delineators, traffic safety devices installed on highways.
- Location of toll gates, the details of the concessionaires/ contractors and the revenues
- Details of specialized equipment and their details such as name of supplier, the type of material, the warranty provided its performance and so on.

2.11.3 Corridor Management

There is urgent need for effective Corridor management covering all the aspects of pavement maintenance, land management, removing traffic hazards, preventing ribbon development and control overloading of vehicles and incidence management. The scope of existing institutional framework should be enlarged to include control of misuse of highway property such as highway furniture by way of theft, defacing by means of sticking posters, painting colors, or damaging. Though the required legislation by way of National Highways (Land and Traffic) Act, 2002 is in place, proper corridor management is yet to be effected. For making corridor control effective, NHAI may consider creation of a Highway Protection Force on the lines of Railway Protection Force and Industrial Protection Force. Highway police may be activated for enforcing adherence to traffic rules.

Video monitoring of highways which is being done on experimental basis on NH 8 is to be extended to all Highways in a phased manner for effective corridor management and enforcing driver discipline.

2.11.4 Check Posts

NHAI and MORT&H should interact with the State Governments to regulate the location and operation of check posts so that vehicular traffic is put to minimum inconvenience and delay. The concerned regulating agencies should be made to interact with NHAI for finalising the location and layout of the check posts so that through traffic is put to minimum inconvenience.

2.11.5 Institutional Strengthening

The principle of NHAI to be a lean and thin organization is laudable. But, it is imperative for NHAI to have a dedicated cadre of personnel with specialization in various aspects such as legal, contract administration, transport planning, land management, project preparation, project execution, social aspects, inter-modal transportation etc.

2.11.6 Dispute Resolution

The mechanism of Dispute Resolution should be monitored from time to time to see whether the mechanism could be improved further.

2.11.7 Land Acquisition

There has been inordinate delay in acquisition of land in some States mostly due to procedural formalities, court cases and low level of cooperation from the State Govt. officials. There have been delays in disbursement of compensation by the Competent Authority to the affected land owners, although NHAI deposits the compensation amount determined by the competent authority well in advance.

2.11.8 Environment and Forest clearances

The Ministry of Environment & Forests (MoEF), vide circular dated 31.03.2011, linked the grant of environment clearance (EC) with the forest clearance whereby EC is to be considered only after submission of in-principle approval of Govt. of India (Stage-1

clearance) for diversion of forest irrespective of the quantum of forest area to be diverted.This linking had a major adverse impact on the NHDP Programme as NHAI was unable to declare the Appointed Date for many projects to start the work even if a small part of the ROW falls within the forest area. With constant pursuance of NHAI at several forums in the meetings of Committee of Secretaries, Finance and Law Ministry, MOEF approached Hon'ble Supreme Court for necessary modifications in the guidelines for National Highways projects and the process for obtaining environment and forest clearances has been simplified. As per latest notification of MoEF, Environmental clearance is not required for projects upto 100 kms and also for projects having more than 100 km. length in case it involves acquisition of additional ROW less than 40 Mtrs in case of existing alignments and less than 60 Mtrs in case of by-passes or new alignments respectively.

There have been considerable delays in obtaining forest clearances. Besides the conditions stipulated by the Central Government (MOEF) in the first stage clearance (in-principle approval), the State forest departments impose additional conditions which are, at times, unreasonable and difficult to meet such as staff quarters, wireless systems, vehicles etc. The demand for compensatory afforestation also varies greatly from state to state from two times in some states to as much as twelve times in some states.

NHAI along with the Government of India and other institutions and authorities is working towards implementing the changes and reforms to achieve the target of building 20km per day.

2.12 Bharatmala Pariyojana

Program at a glance

Bharatmala Pariyojana is a new umbrella program for the highways sector that focuses on optimizing efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps through effective interventions like development of Economic Corridors, Inter Corridors and Feeder Routes, National Corridor Efficiency Improvement, Border and International connectivity roads, Coastal and Port connectivity roads and Green-field expressways. A total of around 24,800 kms are being considered in Phase I. In addition, Phase I also includes 10,000 kms of balance road works under NHDP. Estimated outlay for Phase I is Rs 5,35,000 crores spread over 5 years. The objective of the program is optimal resource allocation for a holistic highway development/improvement initiative. Effective delegation in appraisal /approval of individual project stretches and encouraging State Governments to participate in the development process through "Grand Challenge" are two distinguishing features of the program.

Background

The National Highways Development Program (NHDP) has reached a certain level of maturity. It is now important to re-define road development and have a macro approach while planning expansion of the national highways network. The focus has to be on recasting road development by bridging critical infrastructure gaps.Hence Bharatmala has been launched as a new umbrella program whose primary focus is on optimizing the efficiency of the movement of goods and people across the country. This program envisages a corridor approach in place of the existing package-based approach which has, in many cases, resulted in skewed development. For instance, in areas of high traffic, even upto 30,000 Passenger Carrying Units (PCUs), there are NH stretches of single and even intermediate lane. These have naturally become an impediment to seamless freight and passenger movement.The NH Network and ongoing programs - India has about 54.82 lakh km of road network, which is the second largest in the world in terms of length. National Highways (NHs) constitute about 2% of the total road network, but carry about 40% of the total road traffic. NHDP spread across Phase-I to VII is the most significant program taken up so far by MoRTH. In addition, MoRTH is implementing other important programs like Special Accelerated Road Development Program for North-Eastern Region (SARDP-NE) for development of roads in the North East, and also the Left Wing Extremism (LWE) Affected Area projects. Funding for these programs has been separately allocated. The program of upgrading single-lane National Highways to at least two-lane with paved shoulders through Externally Aided Projects (EAPs) is also being carried out. MoRTH is also implementing a comprehensive bridge building program called "Setu Bharatam" where 1,500 bridges and 208 Railway Over Bridges (ROB)s /Railway Under Bridges (RUBs) are being taken up. Other ongoing programs of MoRTH are - a special package for Jammu & Kashmir and NH(O). NHDP had aggregate length of 55,792 kms. Out of this, 30,108 kms have been completed already and another 4,900 kms will be completed this year. The balance is 20,784 kms against which projects for 6,399 kms are under implementation. Of the remaining 14,385 kms, 4,385 kms are a part of Bharatmala Component like Corridors/Expressways. Unfinished outstanding stretches of 10,000 kms will be subsumed in Bharatmala and implemented as an integrated program. The extensive experience gathered by MoRTH and its implementing agencies like NHAI in implementing NHDP shall be utilized in implementing Bharatmala.

2.12.1 Identification of project stretches under Bharatmala

Bharatmala focuses on enhanced effectiveness of already built infrastructure, multi– modal integration, bridging infrastructure gaps for seamless movement and integrating National and Economic Corridors. Identification of the project stretches under the components of the proposed program has been done based on detailed O-D(Origin- Destination) study, freight flow projections and verification of the identified infrastructure gaps through geo mapping, using data from Bhaskaracharya Institute for Space Applications and Geo-Informatics (BISAG) as well as from other sources. This O-D study has also taken into account integration of economic corridors with the ongoing projects under NHDP and infrastructure asymmetry in major corridors.

2.12.2 Bharatmala Phase I – Components and outlay

As per the CCEA approval, Phase-I of Bharatmala shall be implemented over a period of five years i.e. 2017-18 to 2021-22. Summary of Phase I components and approved outlay for the same are as follows:

Components:

Economic Corridors: - Identified Highways Corridors of Economic importance are expected to carry 25% of freight in the coming years. Once built, the National and Economic corridors along with their inter-corridor and feeder routes would be able to carry 80% of our freight traffic. Around 26,200 km of Economic corridors have been identified to be developed as Economic corridors out of which 9,000 kms are being taken up in Phase-I of Bharatmala.

Inter-corridor and feeder roads to National and Economic Corridors: - Around 8,000 km of inter-corridor and around 7,500 km of feeder routes have been identified out of which 6,000 kms are being taken up in Phase-I of Bharatmala.

National Corridors Efficiency Improvement: The Golden-Quadrilateral and NS-EW, corridors carry 35% of India"s freight and would be declared as National corridors. The average traffic in the 6 national corridors is >30,000 PCU. The 6/8 laning of these corridors would be done as per need. The National Corridors have developed choke points impacting logistics efficiency. There is a requirement to build Ring Road and bypasses/ elevated corridors in addition to lane expansion to decongest these National Corridors. Further, Logistics Parks would also be developed at strategic locations to enhance logistics efficiency. A list of such identified locations of Logistics Parks is attached. Around 5,000 kms are being taken up under this category in Phase-I of Bharatmala.

Border and International connectivity roads: Around 3,300 km of border roads have been identified to be built along the international border for their strategic importance. Around 2,000 km of roads are required for connecting India"s major highway corridor to International trade points so as to facilitate Export-Import (EXIM) trade with our neighbors: Nepal, Bhutan, Bangladesh and Myanmar. Around 2,000 kms are being taken up under this category in Phase-I of Bharatmala

Coastal and Port connectivity roads: Around 2,100 km of coastal roads have been identified to be built along the coast of India. These roads would boost both tourism and industrial development of the coastal region. Around 2,000 km of port connectivity roads have been identified to facilitate EXIM trade with an emphasis to improve connectivity to non-major ports. The roads identified have been synergized with the Sagarmala program. Around 2,000 kms are being taken up under this category in Phase-I of Bharatmala.

Green-field expressways : Certain sections of National and economic corridors have traffic exceeding 50,000 PCUs and have also developed several choke points. About 1,900 km of these stretches have been identified for development of green-field expressways. Around 800 kms are being taken up under this category in Phase-I of Bharatmala.

MoRTH is authorized to substitute/replace up to 15% length of 24,800 kms for Phase I of the program by other suitable projects, if development of certain identified stretches under the program cannot be taken up on account of issues pertaining to alignment finalization, land availability and other unforeseen factors. MoRTH shall retain the same target and budget proposed above.

In addition to Rs. 5,35,000 crore for Bharatmala Phase-I, there is a requirement of Rs. 1,57,324 crore for ongoing schemes like NH(O), SARDP-NE, EAP and LWE under implementation in the Highways Sector. Thus, the overall outlay for Bharatmala and all existing schemes put together will be Rs 6,92,324 crore over a period of 5 years.

Gross Budgetary Support for the Bharatmala program and existing schemes from 2017- 18 to 2021-22 will be restricted to Rs. 2,37,024 crore from Central Road Fund (CRF), Rs 59,973 crore as Budgetary support, Rs. 34,000 crore from expected monetization through ToT route and Rs. 46,048 crore collected as Toll-Permanent Bridge Fee Fund (PBFF) by NHAI

S.No	Components	Length -km	Outlay -Rs crore
a.	Economic corridors development	9,000	1,20,000
b.	Inter-corridor & feeder roads	6,000	80,000
c.	National Corridors Efficiency improvements:	5,000	100,000
d.	Border & International connectivity roads	2,000	25,000
e.	Coastal & port connectivity roads	2,000	20,000
f.	Expressways	800	40,000
	Total:	**24,800**	**385,000**
	Balance road works under NHDP	**10,000**	**1,50,000**
	Total		**5,35,000**

3. EXISTING FEATURES OF THE PROJECT CORRIDOR

3.1 General

Gujarat:

Gujarat is situated on the western coast of Indian Peninsula at North Lattitude betweeen 20º1′ to 24º7′ and Eastern Longitude betweeen 68º4′ to 74º4′.It has long coastal line with Arabian sea and is bounded by Rajasthan to the North East Daman and Diu to the South, Dadra and Nagar Haveli and Maharastra to the South east, Madhya Pradesh to the east. The State shares a Maritime border with the nation of Pakistan.

Gujarat State has been divided into 33 districts and each district has further been divided into number of Blocks for effective administrative control. It has an area of 1,96,024 Sq. Km standing at Eleventh largest state in India. As per the 2011 Census , Gujarat is the ninth largest populous state having a population of 60,383,628. Its official language is Gujarati, which is one of the longest-surviving classical languages in the world.

Gujarat has the third largest economy state in India with a current GSDP of ₹14.96 lakh crore (US$210billion). Over 60% of the state is urbanized, accounting for 16% of the urban population in the country while only comprising 5% of India's total population. Services contributes to 55% of the economic activity in the state, followed by manufacturing at 31% and agriculture at 14%. Government is the major investor in the state with 58% of total investments, followed by private Indian investors at 30% and foreign private investors at 12%. Gujarat has historically been an agricultural state, while its advances in other fields launched the state into competition with other areas.

The perennial rivers flowing the state are Narmada, Tapi and Sabarmati and non perennial rivers include Ambica, Bhadar, Bhurud, Chirai, Dhadhar, Gajansar, Kankawati, Kolak, Mahi, Nagmati.

The state has several historical, natural and religious tourist destinations, such as Great Rann of Kutch, Satpura mountains, Statue of unity, Gir National Park, Dholavira, Somnath temple, Champaner – Pavagadh Archaeological park , Dwaraka, Ahmedabad, Vadodara.

Maharashtra:

Maharashtra is situated on the western region of India. It has long coastal line with Arabian sea and is bounded by states Karnataka, Telangana, Goa, Gujarat, Chattisgarh and Madhya Pradesh and union territory Dadra and Nagar Haveli.

Maharsahtra state has been divided into 36districts and each district has further been divided into number of Blocks for effective administrative control. It has an area of 307,713 Sq.m. standing at third largest area state in India. As per the 2011 census Maharastra is having an population 11,23,72,972 standing at second most populous state in India. It's official language is marati which is one of the longest survival languages in the world.

Maharashtra is the wealthiest state by many mojor economic parameters and also the most industialized state in India. The economy of Maharashtra is the largest state economy in India with ₹27.96 lakh crore (US$390 billion) in GDP and a per capita GDP of ₹1,80,000 (US$2,500).Maharashtra contributes to be the single largest contributor to the national economy with a share of 15% in the country GDP. Maharashtra accounts for the 17% of the industrial output of the country and 16% of the country service sector output.

The major rivers flowing the state are Godavari, Krishna, Tapi, Bhima, Wardha, Wainganga.

The state has several historical, natural and religious tourist destinations, such as Ajanta and Ellora caves, ancient fort at Devgiri and Bibi Ka Maqbara in Aurangabad, Gateway of India, Shirdi, Nashik, Mahabaleswar.

"The Green field alignment starts from proposed Vadodara – Mumbai Expressway of Navsari District near to Toli village in the state of Gujarat with start point coordinates 20°55'17.78"N, 73° 3'47.56"E and ends at road connecting NH-61 near Wakodi village in Ahmednagar District (Des. Ch 290+700) in the State of Maharashtra with end point coordinates 19° 5'41.56"N, 74°49'56.40"E. and passes through 39 Villages in the state of Gujarat and 115 Villages in the State of Maharashtra.. The project highway between Surat and Ahmednagar traverses through Ambada, Surkhai, Ravaniya, Bedmal, Hathanbari, Bendwal, Wirmal, Kalambari, Deoghar, Mahaje, Golshi, Dhaur, Rasegaon, Dhakambe, Warvandi, Adgaon and Chehedi kh. , Deshwandi, Ajampur, sadatpur, Hasnapur, Digras, Vambori, Munjarsumba, Sarolabaddhi. The alignment falls in the districts of Navsari and Valsad in the state of Gujarat and in the district of Nashik and Ahmednahar in Maharastra. It traverses through plain terrain, rolling terrain and a mixed land use of agricultural, barren, forests can be seen throughout the corridor. The project stretch details are mentioned in below Tables 3.1, 3.2. The index map of the project stretch is shown in Fig 3.1.

Table 3.1 Project Stretch Coordinates

S.No	Strech	Chainage (Km)		Geograhic Co-ordinates(UTM)	
		From	To	Start	End
1	Surat – Nashik- Ahmendnagar	0.000	290.700	21° 7'38.39"N 72°54'10.16"E	19° 5'41.56"N 74°49'56.40"E

Table-3.2: Project Stretch Details

S.No	Stretch	Length	Settlements/ Villages	Districts	States
1.	Km 0.000 to Km 290.700	290.700 Km	Sarpor, Dabhalal, Surkhai, kukeri, Mama bacha, Bendwal, Ambedgoan, Adgoan, Telegoan, Rahuri, Khadambe Bk, Vambori etc.	Navsari and Valsad in Gujarat State Nashik and Ahmednagar in Maharashtra	Gujarat and Maharastara
Total Length = 290.700 Km					

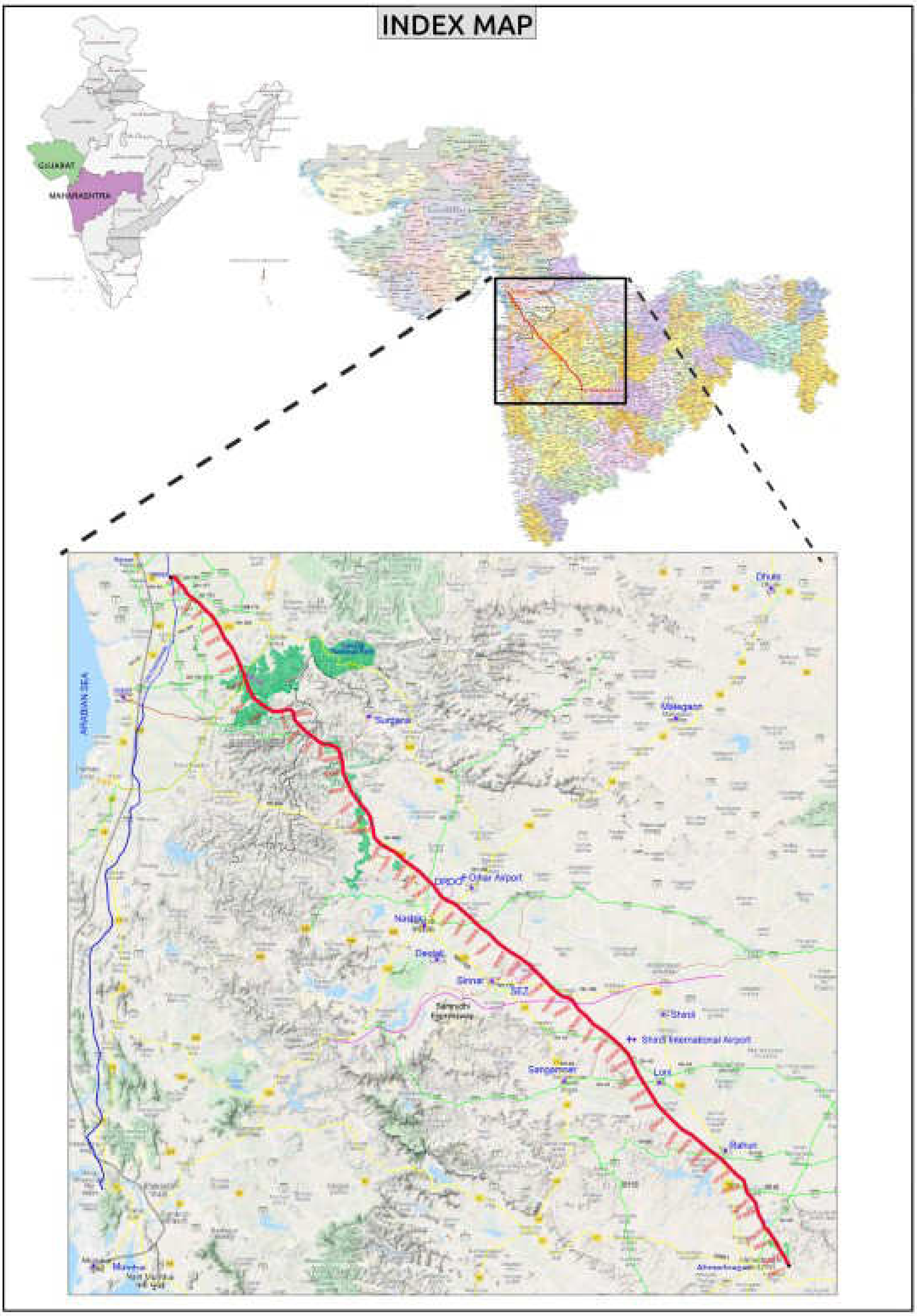


Fig 3.1 Location map for project Stretch

The Consultant had conducted detailed survey to get acquainted with the actual site conditions. The observations made are discussed in subsequent sections

3.2 Abutting Land use

In terms of land-use, majority of the land use pattern was observed as agriculture and the rest covered with barren lands and forests. Important crops grown along the project stretch are Sugar cane, grapes and onions etc.

Fig 3.2 Land use pattern along the corridor

3.3 Intersections

During the reconnaissance survey lot of cross roads which lead to the adjacent towns/villages are crossing the project corridor may require provision of grade separated structures. Many intersections were observed along the project corridor. Apart from these, there are few local gravel and earthen roads leading to clusters of houses and hamlets in villages and small towns. The list of major intersections are given in Table- 3.3 below.

Table-3.3: Major Intersections along Project Road

S.No	Chainage (Km)	LHS	RHS	Intersecting Road
1	2.335	Satem	Ashtgam	SH-180
2	10.600	Saraiya	Tankal	SH-177
3	11.000	Saraiya	Tankal	SH-703
4	19.100	Kukeri	Surkhai	SH-178

S.No	Chainage (Km)	LHS	RHS	Intersecting Road
5	20.150	Kukeri	Donja	NH-360
6	35.910	Kelia	Mandav kedak	SH-701
7	37.120	Pipal Khed	Zari	SH-5
8	86.550	Pahuchibaro	Nanashi	SH-21
9	90.650	Kalambari	Nanashi	SH-21
10	91.020	Kalambari	Nanashi	SH-21
11	107.050	Chachadgaon	Ambegaon	NH-848
12	118.000	Jambutake	Nalegaon	NH-848
13	128.150	Talegaon Dindori	Pimpalnare	SH-17
14	138.800	Ojhar	Adgaon	NH-60 (old-NH-03)
15	147.320	Varne Darna	Chehedi Khurd	SH-30
16	163.450	Nimgaon Deopur	Baragaon pimpri	-
17	177.220	Dharangaon	Bhokani	NH-160
18	185.150	Wavi	Fulenagar	Samrudhhi Expressway
19	198.390	Junegaon	Talegaon Dighe	Sangamner-Kopargaon Road
20	208.900	Lohare	Mirpur	SH-45
21	217.600	Chandrapur	Chinchapur kh.	SH-44
22	248.050	Rahuri	Malharwadi	SH-49
23	251.280	Rahuri	Ahmednagar	NH-160
24	261.350	Vambori	Dhamori Kh.	SH-49

S.No	Chainage (Km)	LHS	RHS	Intersecting Road
25	275.850	Dhangarwadi	Pokhardi	SH-60
26	288.700	Sonewadi	Shahapur	NH-61

NH 60

NH -61

NH -160

NH -848

Fig 3.3 Cross Roads of the Project Corridor

3.4 Grade Separators

The project corridor passes completely through green field alignment, so there are no grade separators were observed all along the project corridor.

3.5 Cross Drainage Works

As this project corridor is entirely green field road, there are no existing cross drainage structures observed all along the project corridor. But, During the ground truthing it was observed that the proposed alignment crosses streams at certain locations at where cross drainage structures need to be proposed. Apart from these streams, there are ponds, lakes through which proposed alignment is passing. The details of streams are mentioned in the following table 3.4.

Table-3.4: Major Streams crossing across Project Road

S. No	Stream/River	Design Chainage (Km)	Span Arrangement(m)
1	Ambika River	7.676	1x15.0+10 x 30.00+ 1 x 15.0
2	Kaveri	21.620	4x30.0
3	Stream+Canal	35.435	1x15.0+3x30.0+1x15.0
4	Stream	43.032	3x30.0
5	Stream	60.755	4x30.0
6	Stream	68.319	2x30.0
7	Par River	70.665	4x30.0
8	Stream cum canal cum road	142.595	1x20.0+1x30.0+1x20.0
9	Godavari River	152.017	6x30.0
10	Stream	166.311	2x30.0
11	Stream	173.935	4x30.0
12	Stream	176.247	2x30.0
13	Paravara NB Canal	224.895	6x30.0
14	Mula River	249.720	6x30.0
15	Stream	256.450	4x30.0
16	Stream, Weir on Left Side	273.875	6x30.0

Par River @ Km 70.650

Godavari River@ Km 152.000

3.6 Forest

The project corridor traverses through the forest of tentative length 29.16km and 30.39km in the state of Gujarat and Maharashtra respectively.

3.7 RAILWAY LEVEL CROSSINGS

The alignment of the project corridor crosses the existing railway lines at some locations. The details of railway lines are shown in below table.

Table 3.6: Railway Level Crossings

S.No	Chainage (Km)	Railway Line
1	17.978	Near Rankuva village
2	144.134	Near Odha Railway Station
3	258.467	Near Khadambe kurud village

Narrow Gauge Crossing @ Km 17.978

Railway Crossing @ Km 144.134

3.8 Industries and Research centres

Industrial area as a part of Special Economic Zone (SEZ) in Sinnar in the state of Maharashtra and Advanced Centre for Energetic Materials (ACEM), DRDO Near Nashik are located near by project alignment.

ACEM, DRDO @ Nashik

Industries @ SEZ

Fig 3.6 Industries and Research Centers

4. OVERVIEW OF ALIGNMENT OPTIONS

4.1 General

The main scope of this report is to identify feasible alignment from various options keeping in view of the requirements specified in Terms of Reference (ToR). The alignment of project stretch follows greenfield alignment. Numerous factors shall be taken into consideration, while selecting the feasible alignment, which vary according to the areas through which the Highway passes. Two of the most important considerations made in selecting the route for the project highway are:

- The physical features of the area through which the alignment passes and
- How these features relate to the geometric design controls.

Physical features that affect the alignment include topography, soil conditions and surrounding land use. Possible environmental Impacts posed by the construction of green filed alignment was also considered.The highway alignment is usually influenced by terrain. In plain terrain, selection of an alignment is influenced by factors such as the cost of right-of-way, land use, existing roads and subgrade conditions. In rolling terrain, factors to be considered are: grade and curvature, depths of cut and heights of fill, drainage structures, and number of bridges.

Selection of an alignment is a trial and error process, as the proposed alignments are checked for compliance with the horizontal and vertical design criteria. The selection of the final feasible alignment is based on a comparison of costs, environmental and social impacts.

4.2 Factors Considered

Various factors considered in developing the project highway alignment options are:

- **Geometric design**: Geometric design factors such as gradient, radius of curve, sight distance etc. govern the alignment of project stretch. Alignment options were developed by adopting the minimum curve radius. Different alignments are designed such that the obstructions to visibility do not restrict the minimum requirements of sight distance. Flat curves are opted wherever necessary.

- **Cost:** All the three costs i.e. construction, maintenance, and operating cost should be minimum. The construction cost can be further decreased much by maintaining a balance between cutting and filling. To avoid excessive cutting and filling, the alignment has been changed where ever found necessary. Very high embankments and very deep cuttings are avoided as the construction cost will be very higher in such cases. The alignment shall preferably pass through better soil area to minimize pavement thickness. Its location shall be near to the sources of embankment and pavement materials.

- **Ecology and Environment:** The proposed alignment shall not pass through unstable natural slopes and ecologically & environmentally sensitive areas such as parks, sanctuaries, tiger reserves, reserve forests etc. The impact on wild life habitat, biodiversity, forest resources, displacement of human settlements, religious places etc. shall be nil or marginally minimal, the former being preferred. The effect of alignment on productive lands on selection of borrow areas, erosion and consequent modification of natural conditions, destabilization of slopes, diversion of natural surface water flows etc. shall be nil.
- **Drainage:** Slope geomorphology and hydrologic factors shall be important considerations in fixing the alignment of a road. Adequate drainage facility shall be feasible along the alignment in such a way where the number of cross drainage structures required are minimum. This will reduce the construction cost. The alignment is planned to have efficient drainage pattern along the stretch
- **Structures:** Bridges can be located only where the river has straight and permanent path and also where the abutment and pier can be strongly founded. The road approach to the bridge should not be curved and skew crossing should be avoided as possible. The road alignment should cross a railway line preferably at 90° (or) skew angle less than 20°
- **Land Acquisition:** As far as possible, the existing right of way has been be utilized for curtailing the cost of land acquisition. It is ensured that the alignment avoids large scale land and property severance, acquisition of residential, commercial and institutional areas etc. Acquisition of fertile agricultural land shall be nil/ minimal. The project stretch is aligned along non-agricultural waste lands, government lands etc. to minimize the negative social and economic impact of expressway construction.
- **Land-use:** The alignment of roads should be decided so that costly agricultural land and forest areas are avoided for the acquisition of the land. The presence of a lake

or pond on the alignment path would also necessitate deviation of the alignment. As religious places pose critical issues, these points were avoided while aligning.

- **Length:** The alignment is planned to be short with minimal curves to the possible extent. For new bypasses, shorter alignment lengths play key role in arriving at the final cost estimates. However other critical factors shall too be given due weightage.

4.3 Alignment alternatives for Surat-Nashik-Ahmednagar Greenfield Stretch

4.3.1 Alignment options for Surat- Nashik- Ahmednagar road in Gujarat State

In the Gujarat State it was understood during surveys and investigations along the proposed alignment that there was resentment for a new greenfield highway among general public since land was acquired for different greenfield alignments namely Vadodara – Mumbai (V–M) Expressway, Mumbai – Ahmedabad bullet train projects. We were advised to stop field activities and to study the feasibility of alignment options making use of the Vadodara – Mumbai (V-M) Expressway from Surat Outer Ring Road and make use of the existing road network.

Three alignment options have been studied duly making use of the proposed Vadodara – Mumbai (V-M) Expressway for some distance and detailed alignment option study is given in this report.

Since, alignment of Greenfield highway connecting Vadodara to Mumbai has already been approved and the Land acquisition is in advance stage, the three alignment options have been prepared in such a way that part of the Vadodara – Mumbai (V-M) Expressway is utilized by the Surat – Ahmed Nagar Road.

The details of the three alternative alignment options are discussed here under:

The alignment options have been shown below on the google map.

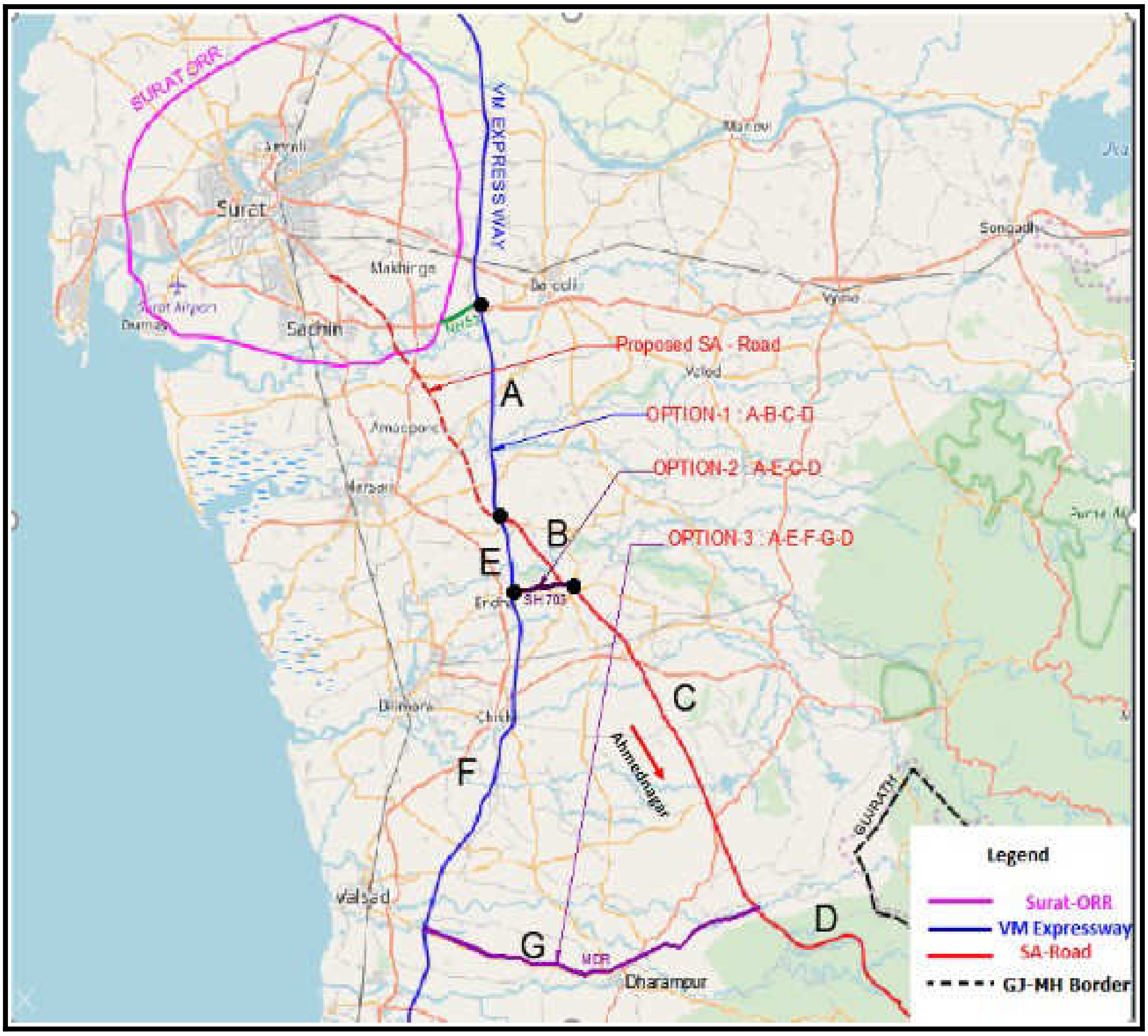


Figure 4.1: Alignment Options with S-A Road and V-M Expressway

Connectivity from Surat to V-M Expressway:

Proposed Vadodara Mumbai (V-M) Expressway traverses on the east side of Surat city and 3 Km away from proposed Surat ORR. Traffic from the city could join the VM expressway and we can utilize expressway for lengths of 21 Km, 28 Km & 62.5 Km for option-1, option-2 & option-3 respectively.

Option-1: A-B-C-D

This option follows VM expressway for a length of approximately 21 Km (from Km 218 to Km 197) and connects the proposed Surat to Ahmednagar green field alignment near Satem village. Thus, the proposed green field S - A highway will take off near Satem village through a grade separator.

Option-2: A-E-C-D

The alignment follows V - M expressway for a length of approximately 28 km (from Km 218 to Km 190) till Kharel village. The new green field S – A highway will take off from V – M Expressway and then traverses along SH 703 for a length of 7 km from Kharel village to Tankal village and merges with proposed S – A alignment.

Option-3: A-E-F-G-D

The alignment follows V – M Expressway for a length of approximately 62.5 km (from Km 218 to Km 155.5) till Pathri village, Valsad district. The new greenfield S – A highway will take off from V – M Expressway and then traverses along MDR (Valsad-Dharampur) for a length of 37 Km from Pathri Village to Khamdahad village and merges with proposed S – A alignment.

The above mentioned alignment Options were reviewed during the meetings held at NHAI, PIU, Surat on 07.06.2019 with Project Director and on 21.06.2019 with Member (Projects) at regarding alignment alternative options.

Points discussed during the meeting:

- The above three options were reviewed during the meeting.
- It was decided that the S-A alignment will take off from the proposed Vadodara – Mumbai Expressway from the point shown "X" and will follow the alignment B-C-D.
- It was also decided that the feasibility of developing any other lateral connecting proposed V – M expressway with proposed Surat – Ahmednagar road either through the present assignment or through any other consultancy services may be explored.

Alignment Option Study Map

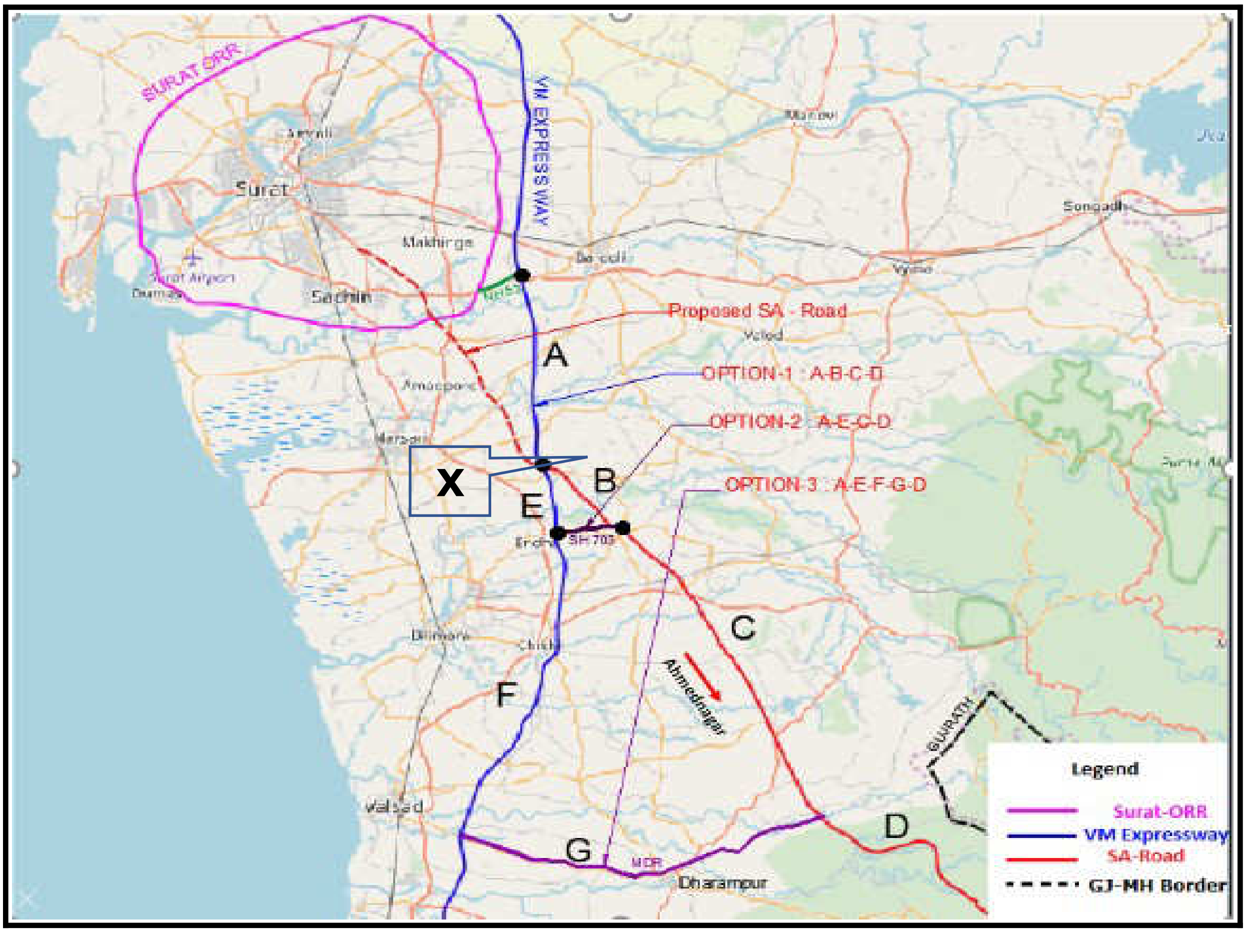


Figure 4.2:Alignment Options with S-A Road and V-M Expressway

As per the above discussions take off point of Surat-Nashik-Ahmedngar greenfield alignment has been shifted from SH-170 to intersection point of S-A road with Vadodara – Mumbai Expressway at Km.196.700 near Toli Village in Navsari Taluk and District of Gujarat State. The Alignment Plan for the modified alignment is enclosed to this report.

4.3.2 Alignment Modificatios after Site Visit

4.3.2.1 Alignment Modification at Tunnel Location

The Initially proposed alignment was crossing the Man River at proposed chianages Km.81.1000, Km.82.200 , Km.82.900, Km.83.600, Km. 84.100, Km.84.800, Km.86.000 and Km.86.700. And also it passes through the hills where Tunnel length to be provided will be more. The Alternative is proposed by avoiding the multiple river crossings and reduced the tunnel length is shown below.

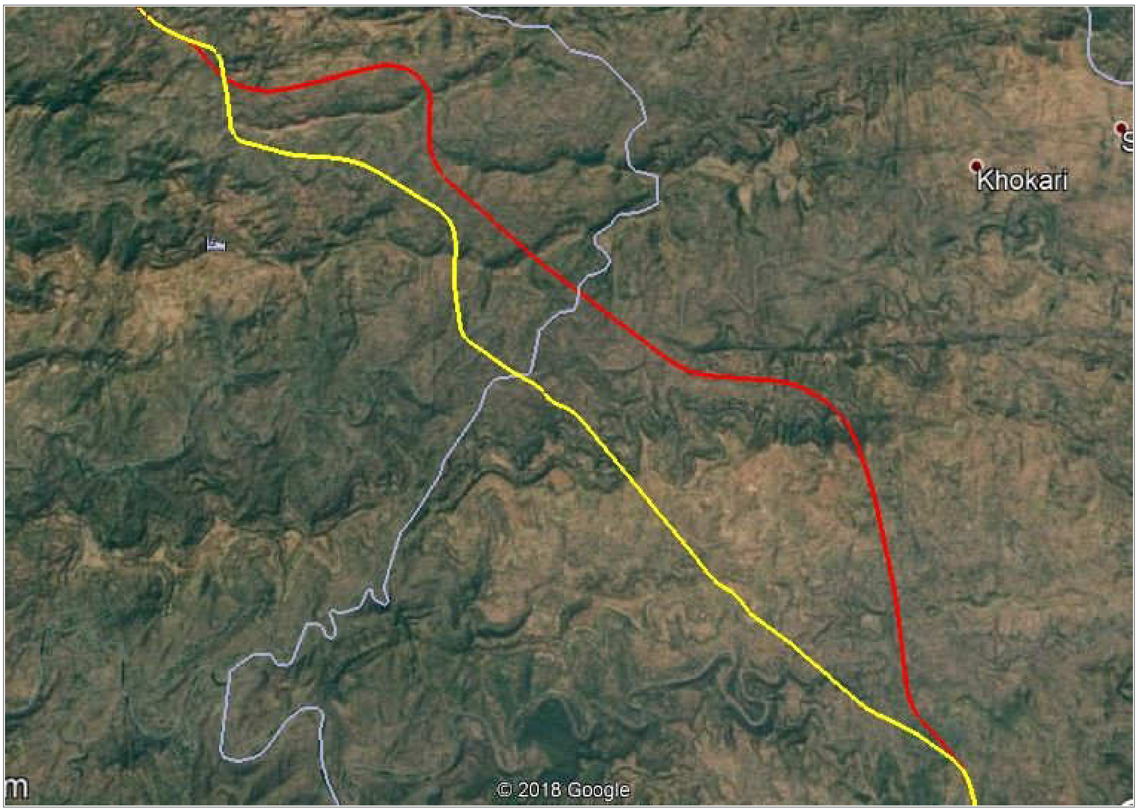


Fig-4.3:S-A Alignment Alternative proposal at Tunnel Locations

Table-4.1: S-A Alignment Alternative proposal location 2

S no.	Location	Limitations	Alternative option
1	Near Ganva , Manichnaichondi, Bendwal, Kahandolsa, Jahule, Pahuchibari Villages	Alignment crosses the Man River at multiple times and passing through the big hills where tunnel length is more (7.34 km).	Alternative is proposed by avoiding the river crossings and reduction in tunnel lengths from **7.34 km** (Tunnel-I from Km.91.300 to 92.600 & Tunnel-II from Km.100.680 to 106.720)to **2.57 km** which are at proposed chainage(Tunnel-I from Km. 65.890 to 67.110 and Tunnel-II (from Km.78.290 to Km.79.640)

4.3.2.2 Alignment Modification at Km.258+500 (ROB Location)

The Initially proposed alignment was crossing the ROB with high skew angle and it passes over the densely built-up area consisting of residential buildings. The alignment alternative is proposed by avoiding the skew angle with Railway Line and avoided the builtup area is shown below.

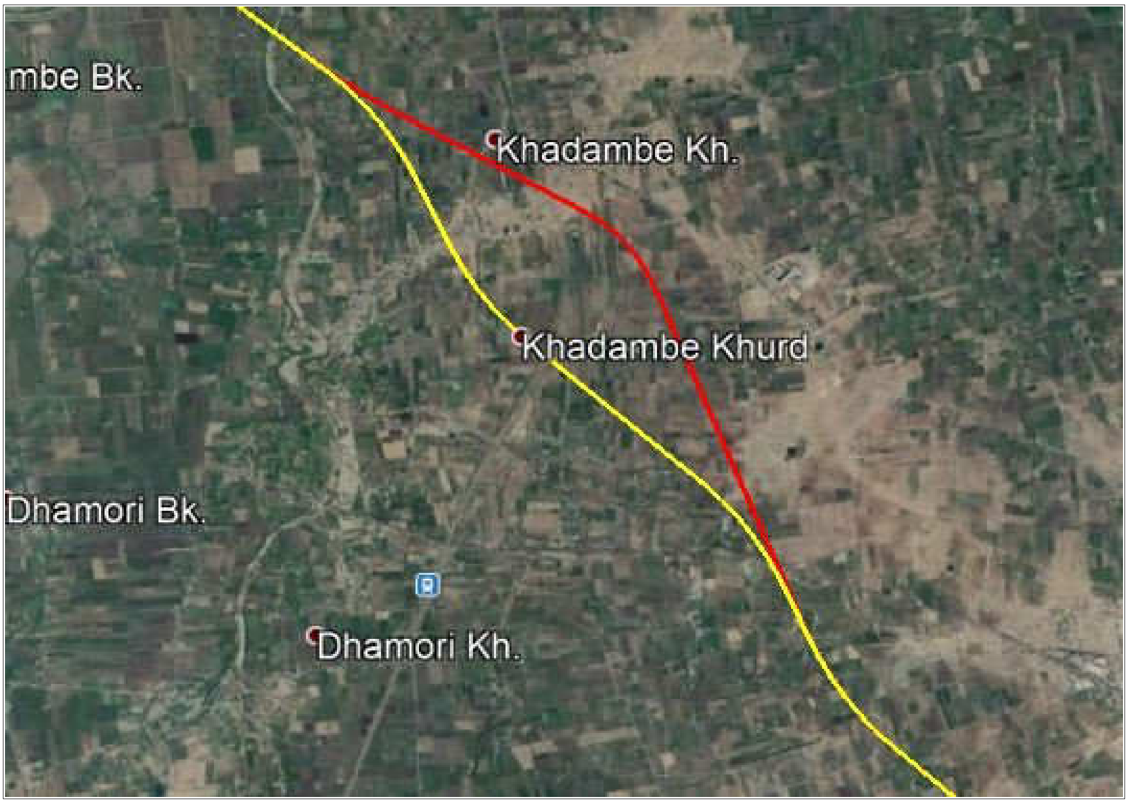


Fig-4.4 : S-A Alignment Alternative proposal at ROB Locations

Table-4.3 :S-A Alignment Alternative proposal location 3

S no.	Location	Limitations	Alternative option
1	Near Khadambe Village	Alignment passes through the builtup area and crossing the Railway line with high skew angle	- Alternative alignment is proposed by avoiding the Builtup area and reducing the skew angle with Railway line at proposed chainage **Km.258.500**

4.3.2.3 Alignment Modifications in Ahmednagar District

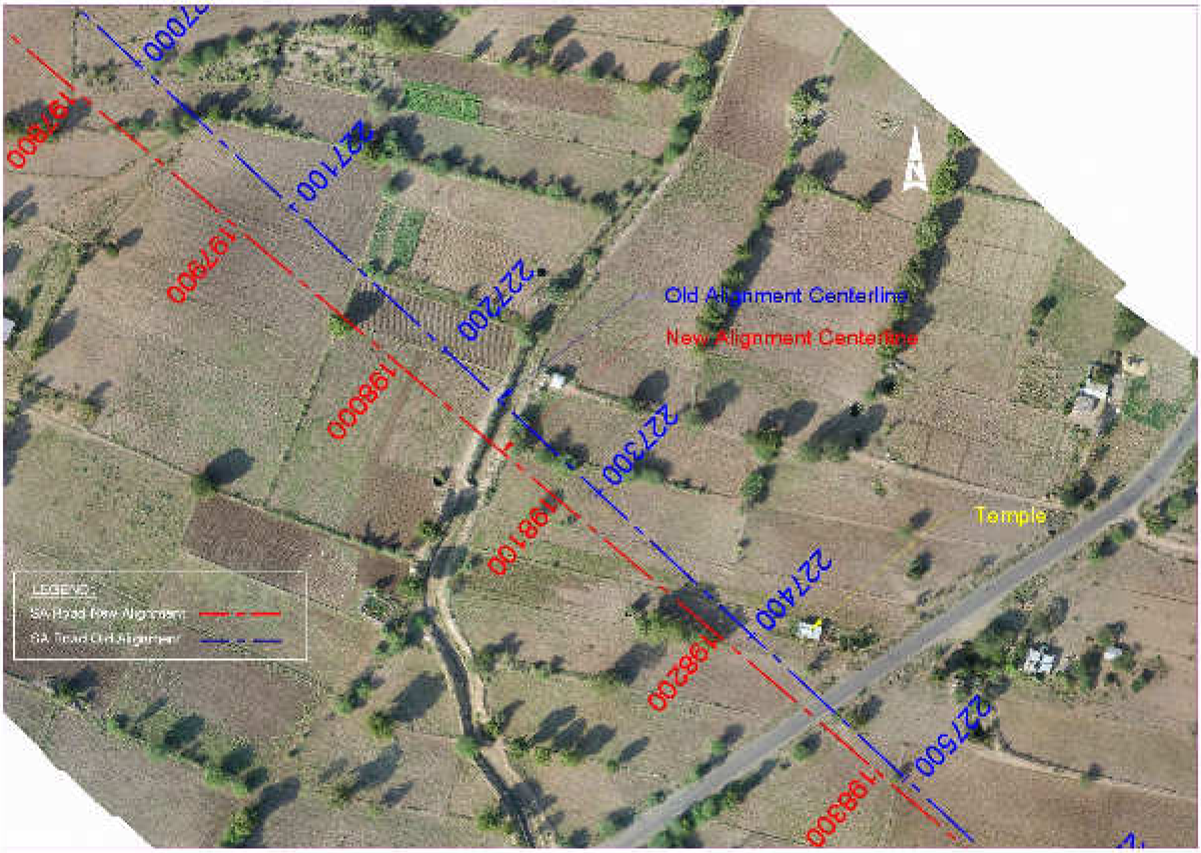
The public representations were received regarding modification of the alignment near Pimpalgaon-Malvi , Manjarsumbha and Vambori Vilages.

A joint site visit was conducted with Project Director, Ahmednagar on 13.02.2019 and discussed regarding modifying the alignment at above mentioned villages.

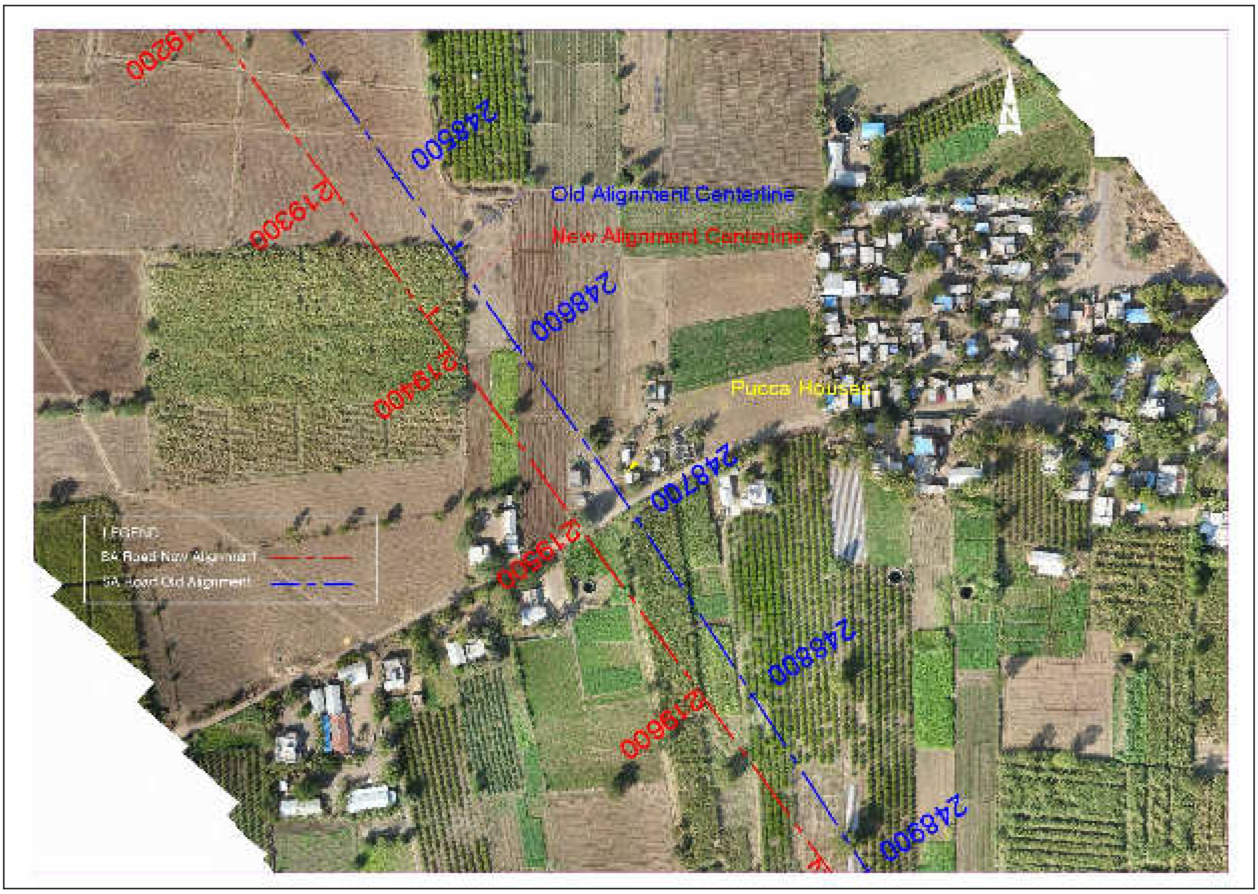
Accordingly, alignment has been modified at below mentioned locations.

S. No	Proposed Old Chainage(Km)	Proposed New Chainage(Km)	Reasons for Shifting the Alignment
1.	227+400	198+200	To avoide the Temple at L.H.S side of the old alignment.
2.	248+700	219+500	To avoid the Pucca Houses at L.H.S side of the old alignment.
3.	254+100	224+900	To avoid the Building at R.H.S side of the old alignment.
4.	297+900	268+800	To avoid the Builtup Area at L.H.S side of the old alignment.
5.	300+000 to 306+000	270+800 to 276+800	The alignment was changed for a length of 6Km near Pimpalgaon Malvi Village to avoid the Wells and agricultural land.

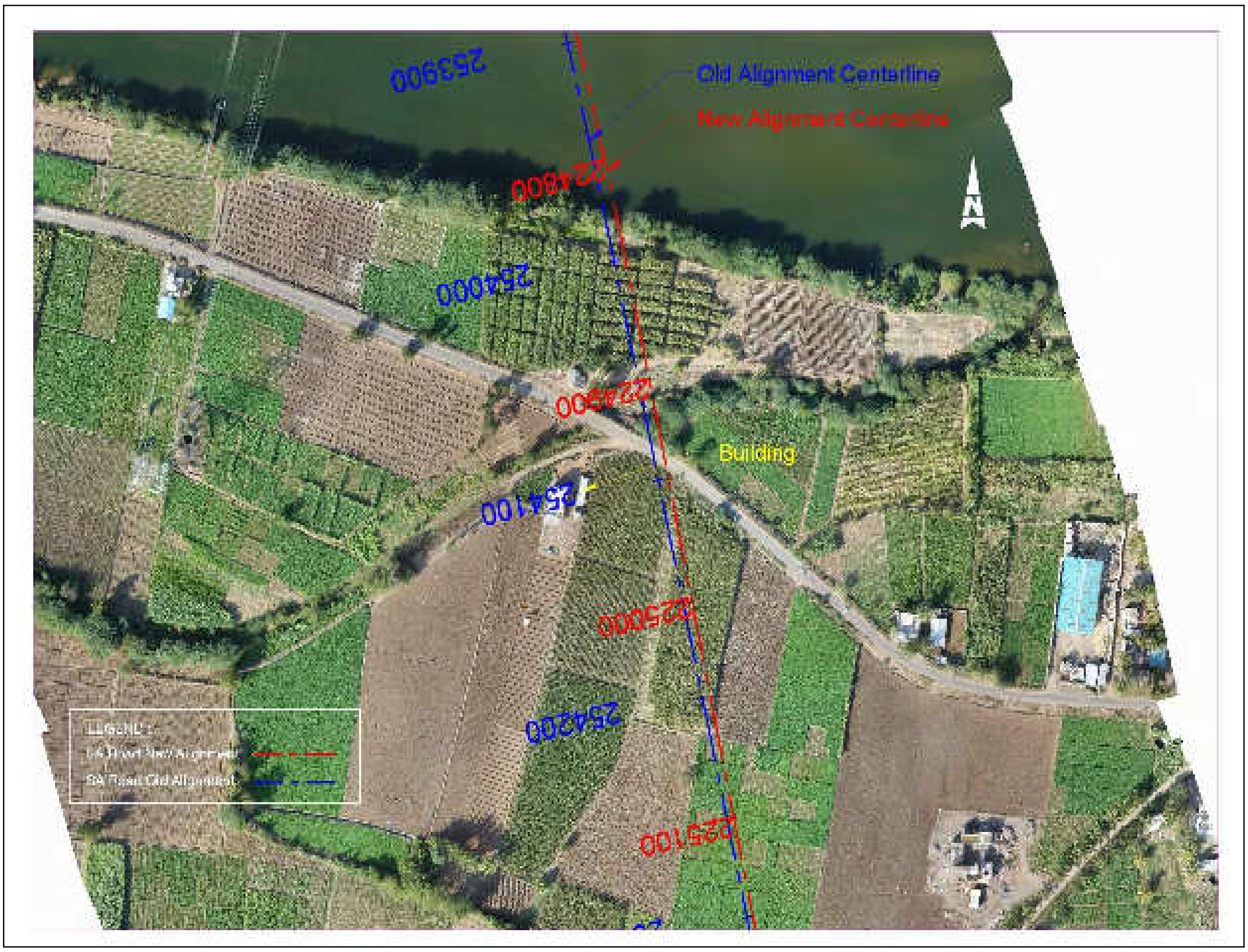
Detailed maps showing the modifications are shown below.



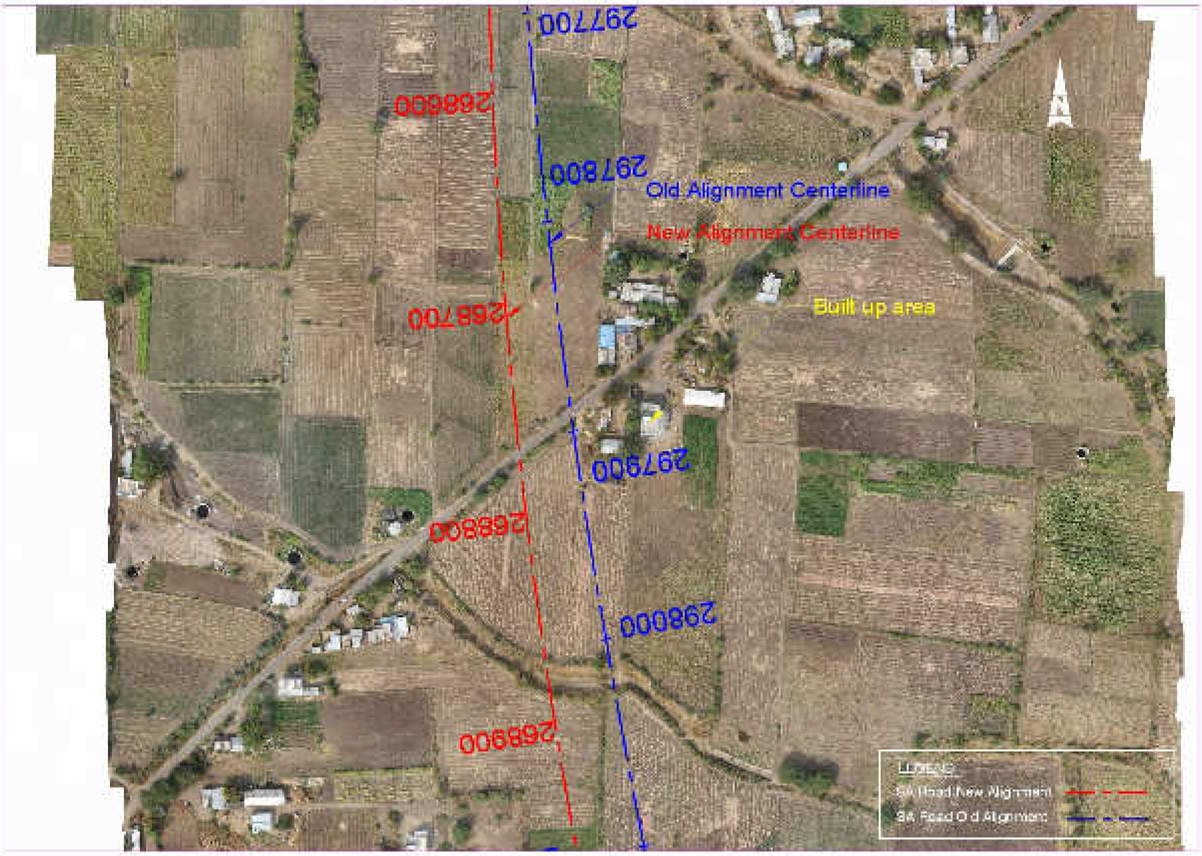
Location 1: **At Km.198.200 Avoiding the Temple**



Location 2: At Km.219.500 Avoiding the Pucca Houses



Location 3: **At Km.224.900 Avoiding the Building**



Location 4: At Km.268.800 Avoiding the Builtup Area

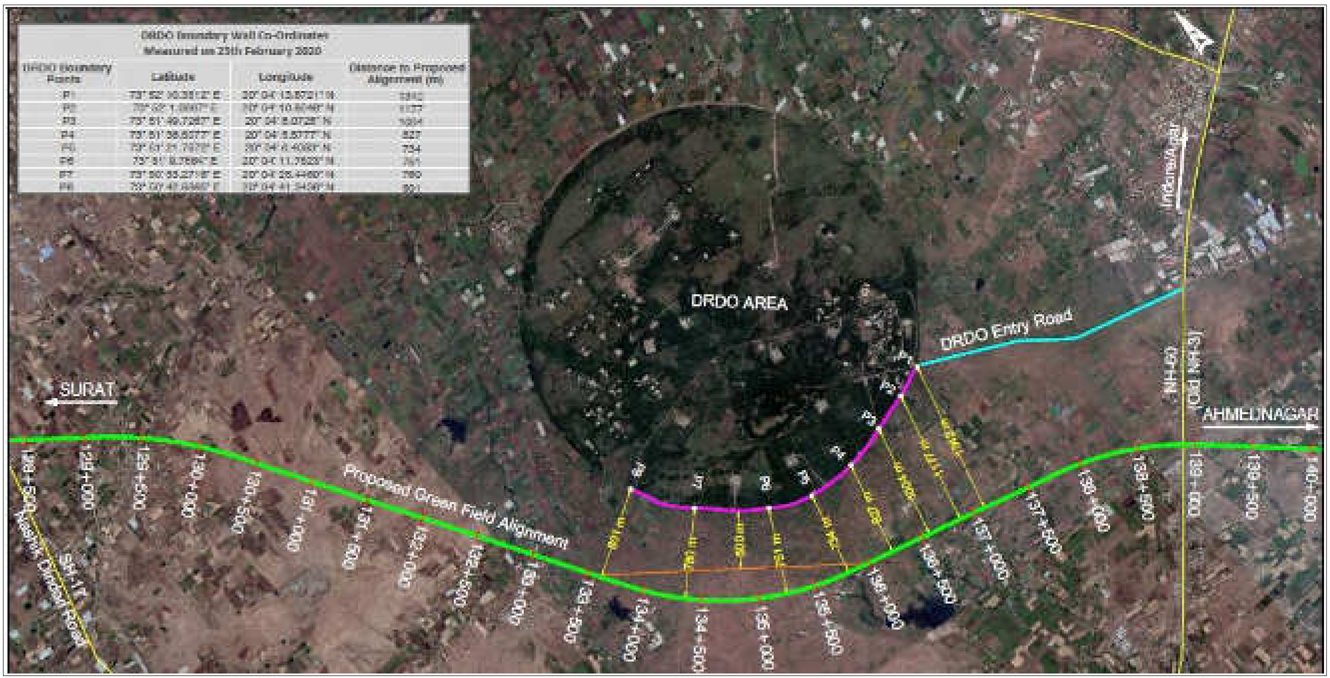
Location 5: **From Km. 270.800 to Km.276.800 Avoiding the Wells and Agricultural Land.**

4.3.2.3 Alignment Modifications in Nashik District

The Site visit with Project Director, PIU Nashik was conducted on 28.01.2020 & 29.01.2020 and verified the project proposals and proposed alignment on field. During the site visit It was observed that alignment was passing near by DRDO at Ojhar Township, Nashik District.

After conducting the Joint site inspection with DRDO officials on 25.02.2020 consultants have revised proposed alignment from Km.133+500 to Km.137+000 and presented to DRDO Officials on 26.11.2020 and found to be in order.

Detailed map showing the Alignment modification shown below.



Location 1: From Km. 133+500 to Km.137.000 Avoiding the DRDO Lands

4.4 Methodology for selection Of feasible alternative

The methodology adopted for deciding the most feasible alternative alignment is explained in the following chapters.

4.4.1 Major Steps in Evaluation

The following flow chart describes the major steps in evaluation process.The evaluation process includes initial evaluation of alternative alignments through reconnaissance and discussions with various agencies followed by detailed evaluation.

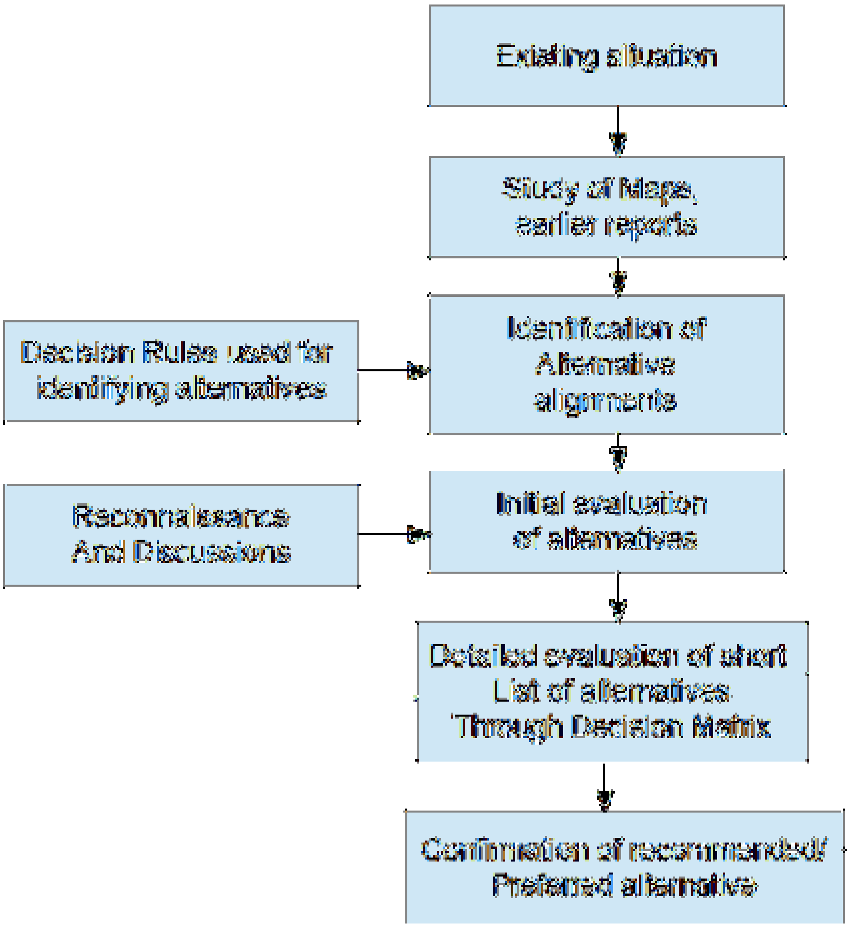


Figure 4.5: Major Steps in Evaluation Process

4.4.2 Criteria for Evaluation Methodology

To evaluate alternative alignments few major criteria have been identified. The attributes examined in study may take many forms, but of prime importance are physical, economical, social and environmental ones. After considering all the major aspects, the alternative alignments have been evaluated with respect to the following five major criteria;

- Engineering Aspects
- Socioeconomic Aspects
- Environmental Aspects
- Cost Aspects
- Safety Aspects
- Evaluation for each criteria & Overall evaluation through Decision Matrix.

4.4.3 Parameters for Engineering Aspects

This criterion measures the degree to which the alignment would have a negative impact on current services such as existing pipelines, cables and/or drainage. This also reflects on the stage-ability of the alignment construction.

Following are sub-division of Engineering aspect parameters:

1. Physical location away from the city
2. Terrain
3. Gradient
4. Proposed road length
5. Number of Horizontal curves
6. Number of Interchanges
7. Number of ROBs/ RUBs
8. Number of VUPs/LVUPs
9. Number of PUPs
10. Number of Major Bridges
11. Number of Minor Bridges
12. Tunnels
13. Viaducts

Each of the parameter has been assigned with the same unit value.

4.4.4 Parameters for Social Aspects

This assessment refers to the impact on community facilities, the social/community severance or integration, aesthetic factors, noise factors, and heritage issues. The following are sub-division of Social aspect parameters:

1. Total Land Acquisition required
2. Percent of Agricultural land
3. Percent of Residential land
4. Percent of Commercial land
5. Percent of Industrial land
6. Percent of Open/barren land
7. Percent of Garden/Plantation land
8. Percent of land for Recreational land
9. Percent of land covered by Pond/Ditch/Water body

10. Demolition of small type houses
11. Demolition of important buildings/houses.

Each of the parameter has been assigned with the same unit value.

4.4.5 Parameters for Environmental Aspects

The Environmental assessment measures the degree to which there is an undesirable impact on environmental factors along and in the vicinity of the alignment. The following are sub-division of Environmental aspect parameters:

1. Alignment length
2. Cross Roads
3. Canal/river crossings
4. Damage of Agricultural land
5. Damage of residential and commercial land
6. Damage of Garden/ Plantation
7. Use of pond/ Ditch/ Barren
8. Length through Habitation
9. Presence of sensitive locations
10. Reserve forests/ Protect forests/ Breeding center
11. School, College, Religious structures and Hospitals

Each of the parameter has been assigned with the same unit value.

4.4.6 Parameters for Safety Aspects

To evaluate Safety aspects following parameters have been considered.

1. Road Geometry
2. Number of Intersections
3. Road Safety

4.4.7 Overall Evaluation through Final Decision Matrix

The final choice of alternatives as most favoured, one needs to be confirmed through assessment with relative weightage factors from Engineering, Socio-economic, Cost, Safety and Environmental considerations.

In the overall evaluation of candidate options, the following weightages for the major criteria as listed in earlier paras have been assigned after considering relative importance and impact of each criteria on this study.

(A) Engineering Aspect: 25%

(B) Socioeconomic Aspect: 20%

(C) Environmental Aspect: 20%

(D) Cost Aspect: 15%

(E) Safety Aspect: 20%

The above percentages of weightages are admittedly subjective, but based on the overall understanding on the study area with particular reference to the objective and requirements of the project.

4.5 Overview of Feasible Alignment Options

Alignment Options Shown below:

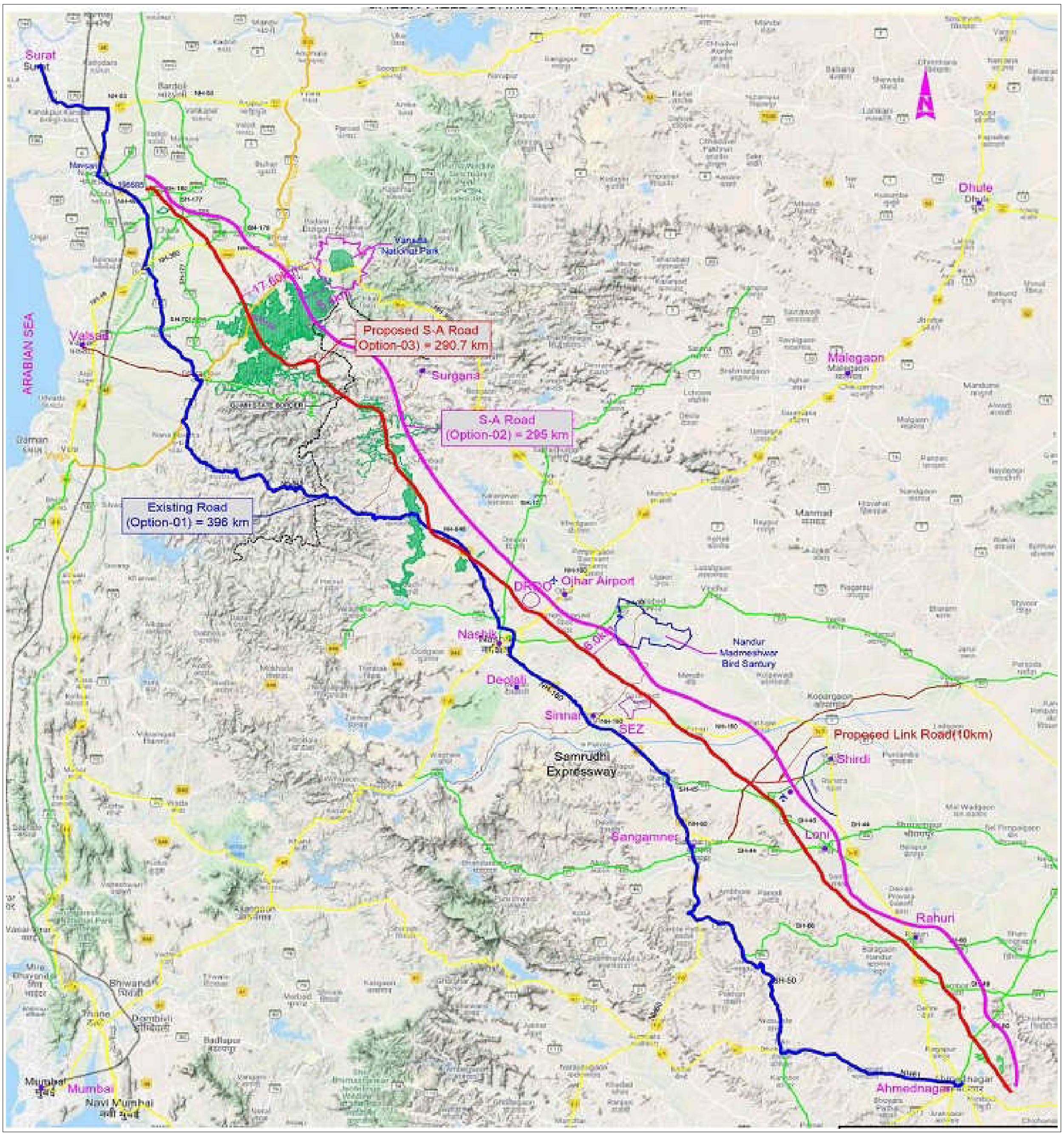


Figure 4.3: **Proposed Alignment Options for S-N-A Greenfield Alignment**

The project corridor is to be designed as a "SIX Lane" with geometric improvements and providing developments in the form of major/minor bridges, service roads (if needed), acceleration/deceleration lanes, vehicular, pedestrian and animal underpasses etc. with an objective to connect the existing national highways and to provide enhanced safety and level of service for the road users. The project corridor follows the completely greenfield alignment. The proposals required for enhancing the project road is presented in detail in this chapter.

4.5.1 Option-1 : Existing Road (Blue Color):

The Existing Road traverses from Surat to Ahmednagar via NH-53, NH-48, SH-181,NH-848,NH-160, SH-50,NH-61 for a length of 396 km which is shown in Blue Color.

The existing route from Surat in Gujarat to Nashik in Maharashtra passes through mountains and wild life/Reserved Forests. The alignment apart from being longer (compared to a straight alignment) is substandard with many hair pin bends and steep gradients in sections where the alignment passes through hilly terrain. The existing Nasik to Ahmednagar route is having four lane configuration in some sections and two lane configuration in other sections. In view of the deficiencies and drawbacks brought out in the present alignment from Surat to Nashik, this route is not serving efficiently as an economic corridor connecting the Industrial city of Surat with port city of Chennai, with Nashik and Ahmednagar enroute. Authority has therefore, decided to finalize DPR for a green field alignment connecting these cities. Existing Surat to Ahmednagar alignment is shown in the above mentioned Map.

4.5.2 Option-2 : Proposed Greenfield Alignment (Magenta Color):

The Proposed greenfield alignment takeoff at Km.0+000 from SH-170 near Khambasala village and traverses through Nashik District and ends at Km.318+000 on NH-61 near Sarollabaddi village of Ahmednagar Distrct which is shown in Magenta Color.

4.5.3 Option-3 : Proposed SA Road Alignment(Red Color):

The Proposed greenfield alignment takeoff at Km.0+000 from Vadodara-Mumbai Expressway near Sarpor Village of Navsari Taluk & District of Gujarat State and and traversed through Nashik District and ends at Km.290+700 on NH-61 near Kolhewadi village of Ahmednagar Distrct which is shown in Magenta Color.

4.5.4 Alternative Options Comparison

Table-4.2: Alternative Options Comparison

Sl. No.	Description	Existing Route (Option -I)	Greenfield Alignment (Option -2)	Greenfield Alignment (Option -3)
1	**Starting & Ending Chainages**	Starts Near Surat and traverses through Nashik district and ends near Ahemdnagar district. It follows NH-53, NH-48, SH-181 NH-848, NH-160, SH-50,NH-61.	Chainage: Starting at Design Km.0+000 & Ending at Km.295+000	Chainage: Starting at Design Km.0+000 & Ending at Km.290+700
2	**Length of Proposed alignment**	-	295 km	290.700 km
3	**Length of Existing Road**	396 km	Nil	Nil
4	**Existing ROW**	Varies (15m , 45m, 60m)	-	-
5	**Proposed ROW, in m**	70m ROW	70m ROW & at Tunnel Section- 150m ROW	70m ROW & at Tunnel Section- 150m ROW
6	**Land Acquisition Required (Ha)**	1598 Ha.	2539	2402
7	**Design Speed, in kmph**	100 kmph	100 kmph	100 kmph
8	**Proposed Lane**	6-Lane with future	6-Lane with future widening to 10-lane	6-Lane with future widening to

Sl. No.	Description	Existing Route (Option -I)	Greenfield Alignment (Option -2)	Greenfield Alignment (Option -3)
	Configuration	widening to 10-lane		10-lane
9	**Proposed Pavement**	Flexible Pavement	Flexible Pavement	Flexible Pavement
10	**Estimated Total Traffic-AADT (PCU)**	Homogeneous Section-1 (Surat-Nashik Section):47083 PCUs/Day (Year -2022) Homogeneous Section-2 (Nashik- Ahmednagar Section) :37004(PCUs/Day) (Year -2022)	Homogeneous Section-1 (Surat-Nashik Section):47083 PCUs/Day (Year -2022) Homogeneous Section-2 (Nashik- Ahmednagar Section): 37004(PCUs/Day) (Year -2022)	Homogeneous Section-1 (Surat-Nashik Section):47083 PCUs/Day (Year -2022) Homogeneous Section-2 (Nashik- Ahmednagar Section) :37004(PCUs/Day) (Year -2022)
11	**Interchange (in Nos.)**	05	13	12
12	**ROB Numbers**	04	03	03
13	**Major Bridges (in Nos.)**	14	18	16
14	**Tunnels (in Nos) & Length in (Km)**	-	03 & 15.4 kms	02 & 2.57
15	**Viaducts (in Nos & Length**	-	13 & 14.1 lms	14 & 15.95 kms
16	**Total Civil Cost+ Centages(18%)- in Crore**	11,880+2139=14019 Cr.	17022+3064=20086 Cr.	10929+1967 = 12896 Cr.
17	**LA Cost (Cr.)**	5593	4547	4533
18	**Preconstruction**	650	671	521

Sl. No.	Description	Existing Route (Option -I)	Greenfield Alignment (Option -2)	Greenfield Alignment (Option -3)
	Activities (Utility Shifting , Forest (NPV) , Afforestation Compensation Cost, Componsation For Forest Dwellers (Cr.)			
19	**Total Cost (Cr.)**	20,262	25,305	17,950
20	**cost per km**	51.17	85.78	61.75
21	**Recommendation**	Not Recommended	Not Recommended	Recommended

From the above comparision table Option-3 has less Civil cost and LA Cost compared to Option-2 and Option-1. Option-2 has more Tunnel length and cause more damage to adjacent eco sensitive lands. Option-3 has less travel distance compared to option2 & Option-1 which intern reduces travel time. Hence, Option-3 Proposed S-A Green field alignment with 290.7km length is recommended for the project corridor. It serves as the Economic corridor and provides direct connectivity between two major Indian cities from Surat to Ahmednagar.

4.5.5 Recommended Surat- Nashik- Ahmednagar Greenfield stretch :

"The Green field alignment starts from proposed Vadodara – Mumbai Expressway of Navsari District near to Toli village in the state of Gujarat with start point coordinates 20°55'17.78"N, 73° 3'47.56"E and ends at road connecting NH-61 near Wakodi village in Ahmednagar District (Des. Ch 290+700) in the State of Maharashtra with end point coordinates . and passes through 39 Villages in the state of Gujarat and 117 Villages in the State of Maharashtra.

The entire project stretch passes through the Navsari and Valsad districts of Gujarat State, Nashik, Ahmednagar districts of Maharashtra state The upgradation proposals required for enhancing the project road is presented in detail in this chapter.

Table-4.3: Surat- Nashik- Ahmednagar Greenfield Alignment

S. No	Proposals	Green field distance		Remarks
		Starting Chainage	Ending Chainage	
1.	Green Field alignment	0.000	290.700 Km	Surat- Nashik- Ahmednagar Greenfield Alignment

Design requirements for the project road comprise the following main fundamental features:

- 100 kmph design speed
- Lane configuration - Six Lane
- Access Control with Close Tolling System
- Minimum pavement composition satisfying the design standards

4.6 Surat- Nashik- Ahmednagar Green Field Stretch

Greenfield Alignment:

Table-4.4: Recommended Structures

Alternative		Green Field road (Option-3)
Design Chainage	From	0.000
	To	290.700
	Length	290.700
Tunnels		2
Viaducts		11
SVUP		20
LVUPs		54
VUPs		31

Alternative	Green Field road (Option-3)
ROBs	03
VOPs	13
Box Culverts	430
Major Bridges	16
Minor Bridges	130
Interchanges	12
Recommendation	**Yes**

4.7 Conclusions

Green field option (Option-3) has been recommended as there is no direct connectivity betweeen surat and Chennai.

4.8 Geometric Standards Adopted for the Project Stretch

4.8.1 Horizontal Alignment Report

Curve details for the Horizontal Geometry for the Proposed Surat- Nashik – Ahmednagar road is described in the Table 6.2

Table – 4.5: Horizontal Geometry of Surat-Nashik-Ahmednagar Alignment

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
1	415.288	298250.329	2314948.065	75	75.285	60	40	5.00%	Left
2	1739.013	299726.107	2314992.990	1300	71.958	195	120	4.92%	Right
3	5008.069	301799.882	2312255.520	3500	11.249		120	NC	Left
4	7073.565	303319.717	2310853.545	3500	13.994		120	NC	Right
5	9471.026	304638.900	2308846.535	3000	33.899		120	NC	Left
6	11007.423	306104.872	2308230.751	2600	23.670		120	NC	Right
7	14410.447	308460.004	2305752.860	2600	10.400		120	NC	Left
8	15397.664	309259.169	2305171.052	5000	8.087		120	NC	Right
9	16656.299	310163.216	2304293.660	4000	3.497		120	NC	Left
10	17844.194	311064.588	2303519.835	2600	21.633		120	NC	Right
11	18867.811	311546.242	2302603.233	2600	8.284		120	NC	Right
12	19524.187	311777.932	2301988.846	1000	20.223	195	120	5.00%	Left
13	21052.821	312742.601	2300803.256	2600	15.274		120	NC	Right
14	22723.366	313434.062	2299277.992	3000	5.599		120	NC	Left
15	25355.912	314742.070	2296993.285	1800	16.026	140	120	3.56%	Right

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
16	25990.599	314920.524	2296383.261	1000	23.819	195	120	5.00%	Left
17	27416.089	315780.377	2295245.938	3500	5.636		120	NC	Right
18	29974.672	317141.739	2293079.268	5000	2.079		120	NC	Right
19	31241.634	317776.445	2291982.731	4000	9.100		120	NC	Right
20	32727.809	318308.628	2290593.674	5000	4.995		120	NC	Left
21	33667.554	318720.087	2289748.487	8000	1.888		120	NC	Right
22	34594.223	319098.047	2288902.374	3000	5.200		120	NC	Left
23	35260.429	319414.693	2288316.306	1200	15.252	195	120	5.00%	Right
24	36013.416	319607.071	2287588.465	2600	7.207		120	NC	Left
25	36933.090	319940.200	2286730.782	7000	1.862		120	NC	Left
26	41869.351	321875.963	2282189.892	10000	1.831		120	NC	Left
27	44608.554	323030.102	2279705.673	2600	16.536		120	NC	Left
28	47956.799	325250.220	2277192.304	3500	20.566		120	NC	Left
29	49903.703	326973.968	2276258.934	1500	23.086	170	120	4.27%	Right
30	52626.357	328698.798	2274148.835	2600	69.848		120	NC	Left
31	58709.788	334925.721	2276156.437	1500	106.428	170	120	4.27%	Right

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
32	61798.174	335219.134	2272125.045	2400	48.668	105	120	2.67%	Left
33	64715.540	337559.317	2270201.829	10000	6.319		120	NC	Right
34	66919.960	339110.811	2268634.261	3500	13.156		120	NC	Left
35	68489.401	340442.749	2267797.459	5000	5.179		120	NC	Right
36	72858.277	343917.485	2265148.688	2600	34.931		120	NC	Left
37	77224.540	348330.905	2264964.685	2800	72.117		120	NC	Right
38	80051.942	349227.609	2261705.474	1200	10.880	195	120	5.00%	Right
39	80932.171	349305.011	2260828.811	3500	8.147		120	NC	Left
40	82743.244	349705.268	2259061.660	10000	8.446		120	NC	Right
41	86169.600	349990.548	2255645.148	1500	38.185	170	120	4.27%	Left
42	88278.944	351395.255	2254043.289	1700	30.693	150	120	3.76%	Right
43	91092.344	352007.455	2251284.472	2000	29.053	125	120	3.20%	Left
44	96913.076	355813.534	2246861.084	3500	10.007		120	NC	Right
45	101521.860	358167.791	2242897.342	2000	22.608	125	120	3.20%	Right
46	107945.527	359101.610	2236535.841	3400	52.306		120	NC	Left
47	110705.791	361710.040	2235063.161	12000	1.220		120	NC	Left

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
48	115228.931	365695.237	2232923.747	3500	15.703		120	NC	Right
49	118866.767	368319.428	2230395.601	3000	11.141		120	NC	Left
50	120834.308	369974.998	2229329.030	3000	7.696		120	NC	Right
51	122269.969	371067.360	2228396.501	12000	1.315		120	NC	Right
52	126037.996	373876.258	2225884.886	10000	0.605		120	NC	Left
53	127600.951	375052.295	2224855.436	10000	1.432		120	NC	Left
54	129248.269	376318.554	2223801.733	2600	24.603		120	NC	Right
55	130894.204	377038.116	2222302.009	3000	10.006		120	NC	Left
56	134975.692	379416.972	2218983.803	2600	38.031		120	NC	Left
57	138307.857	382678.294	2218028.165	2600	27.761		120	NC	Right
58	141525.734	385007.552	2215771.541	10000	6.152		120	NC	Left
59	145676.940	388282.211	2213218.563	3000	6.706		120	NC	Right
60	147498.469	389578.436	2211938.238	12000	1.802		120	NC	Right
61	149515.018	390967.865	2210476.705	5000	19.661		120	NC	Left
62	151268.180	392548.087	2209678.895	2600	13.363		120	NC	Right
63	154349.254	394905.227	2207690.441	6000	12.439		120	NC	Right

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
64	156034.614	395932.243	2206347.673	3000	10.035		120	NC	Left
65	158789.317	397962.448	2204483.783	7500	16.138		120	NC	Left
66	160685.563	399673.304	2203633.897	4100	22.976		120	NC	Right
67	162044.340	400583.120	2202595.264	1300	20.109	195	120	4.92%	Left
68	163171.849	401562.161	2202035.267	2000	10.612	125	120	3.20%	Left
69	163898.551	402249.193	2201797.669	2600	20.122		120	NC	Right
70	166507.764	404290.220	2200156.974	5000	11.853		120	NC	Left
71	168020.472	405642.062	2199469.928	3500	17.408		120	NC	Right
72	173648.032	409672.172	2195530.302	2600	10.635		120	NC	Right
73	174981.633	410438.196	2194436.954	3500	8.080		120	NC	Left
74	175841.052	411025.928	2193808.798	2600	9.261		120	NC	Right
75	176639.012	411470.746	2193145.215	4000	16.613		120	NC	Left
76	178842.535	413176.084	2191736.842	4000	5.061		120	NC	Left
77	181291.080	415194.390	2190350.141	6500	13.722		120	NC	Left
78	184145.285	417862.446	2189316.044	2000	38.202	125	120	3.20%	Right
79	187406.344	419580.701	2186499.870	3500	21.297		120	NC	Left

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
80	189172.268	420990.426	2185411.279	4000	2.718		120	NC	Right
81	191196.360	422532.020	2184099.570	2600	15.097		120	NC	Right
82	192020.859	423001.387	2183416.861	3500	9.930		120	NC	Left
83	193281.112	423884.819	2182515.957	2600	14.658		120	NC	Right
84	194011.434	424267.000	2181890.034	1000	28.105	195	120	5.00%	Left
85	196106.831	426031.784	2180757.772	4000	3.108		120	NC	Left
86	197099.807	426900.255	2180276.248	2600	11.308		120	NC	Right
87	198570.229	428022.734	2179323.829	10000	2.663		120	NC	Right
88	202465.126	430872.383	2176668.575	3500	9.550		120	NC	Left
89	204490.236	432563.629	2175552.221	3500	11.083		120	NC	Right
90	207342.560	434588.269	2173540.360	2000	28.923	125	120	3.20%	Right
91	209541.036	435233.954	2171423.643	3500	14.149		120	NC	Left
92	213439.368	437227.358	2168068.377	3500	5.530		120	NC	Left
93	214957.670	438125.198	2166843.665	5000	3.251		120	NC	Right
94	215784.345	438575.416	2166150.252	8000	2.441		120	NC	Right
95	217731.776	439565.399	2164473.165	2600	6.119		120	NC	Right

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transi tion Length (Ls)	Speed (V)	Super elevation (e)	HOC
96	218365.641	439827.708	2163895.832	2600	11.607		120	NC	Left
97	220250.622	440932.118	2162366.192	1700	12.321	150	120	3.76%	Right
98	220891.614	441215.483	2161791.601	800	29.670	195	120	5.00%	Left
99	221749.186	441879.726	2161248.149	1400	26.191	180	120	4.57%	Right
100	222623.082	442297.511	2160476.231	2600	7.298		120	NC	Left
101	223336.541	442701.842	2159887.859	5000	4.091		120	NC	Right
102	224448.508	443264.718	2158928.705	3500	18.685		120	NC	Right
103	226076.107	443622.143	2157330.779	1600	37.407	160	120	4.00%	Left
104	227574.793	444755.937	2156316.100	3500	10.832		120	NC	Right
105	228780.223	445518.546	2155380.460	1500	27.129	170	120	4.27%	Left
106	229659.192	446307.848	2154980.929	1500	24.145	170	120	4.27%	Right
107	231511.810	447544.559	2153597.055	4000	3.084		120	NC	Left
108	233113.373	448664.426	2152452.037	3000	5.824		120	NC	Right
109	234276.404	449389.217	2151542.131	3400	21.238		120	NC	Left
110	237999.289	452618.703	2149660.787	3500	14.470		120	NC	Right
111	239459.638	453660.210	2148630.394	5000	2.244		120	NC	Left

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transi tion Length (Ls)	Speed (V)	Super elevation (e)	HOC
112	240819.801	454663.874	2147712.368	3500	7.302		120	NC	Left
113	241949.558	455588.150	2147061.652	5000	1.154		120	NC	Right
114	243023.908	456453.995	2146425.612	5000	2.932		120	NC	Left
115	244570.543	457745.712	2145574.895	3500	6.340		120	NC	Right
116	246000.574	458846.147	2144661.023	3500	10.289		120	NC	Left
117	247861.702	460468.747	2143745.994	3500	13.432		120	NC	Right
118	249096.591	461376.827	2142903.564	3500	5.824		120	NC	Right
119	250205.118	462109.008	2142070.844	5000	1.982		120	NC	Left
120	252755.876	463858.577	2140214.647	3500	6.181		120	NC	Left
121	254627.352	465281.672	2138998.672	3500	13.249		120	NC	Right
122	256030.177	466113.091	2137864.280	2600	10.626		120	NC	Left
123	257132.991	466918.873	2137109.312	5000	7.674		120	NC	Left
124	259073.506	468481.727	2135959.237	1000	38.549	195	120	5.00%	Right
125	262289.477	469412.034	2132872.355	2000	26.449	125	120	3.20%	Left
126	264945.879	471201.426	2130894.742	5000	2.134		120	NC	Left
127	267144.151	472726.232	2129311.579	2000	44.947	125	120	3.20%	Right

Sno	Chainage	Easting	Northing	Radius	Total Deflection angle Δ (θs+ Δc+θs)	Transition Length (Ls)	Speed (V)	Super elevation (e)	HOC
128	269001.538	472738.575	2127388.279	2600	17.354		120	NC	Left
129	270286.707	473115.681	2126153.327	3500	16.067		120	NC	Left
130	272744.473	474447.270	2124080.220	1500	21.458	170	120	4.27%	Right
131	273428.103	474605.281	2123413.003	1500	10.774	170	120	4.27%	Left
132	275086.657	475251.497	2121886.624	1000	30.898	195	120	5.00%	Left
133	275904.091	475884.549	2121365.053	1200	21.916	195	120	5.00%	Right
134	276873.093	476402.573	2120545.388	2600	8.654		120	NC	Left
135	277538.225	476825.918	2120031.484	2000	12.209	125	120	3.20%	Right
136	278261.537	477178.498	2119399.622	1000	17.016	195	120	5.00%	Left
137	279377.827	477956.898	2118599.893	3200	21.563		120	NC	Right
138	282219.327	479083.932	2115975.761	3500	18.368		120	NC	Left
139	284051.561	480307.103	2114598.589	3500	13.060		120	NC	Right
140	285369.661	480938.724	2113437.723	3500	5.558		120	NC	Left

4.8.2 Vertical Alignment Report

Table – 4.6: Vertical Geometry of Surat-Nashik-Ahmednagar Alignment

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
1	190.097	27.193	210	Sag	40	0.466	2.500	2.034	103.266	HSD	
2	549.000	36.166	290	Hog	40	2.500	-2.061	-4.561	63.589	ISD	
3	784.705	31.309	150	Sag	40	-2.061	-0.198	1.863	80.514	HSD	
4	1233.030	30.423	280	Sag	100	-0.198	0.997	1.195	234.327	HSD	
5	1607.875	34.162	250	Hog	100	0.997	-0.217	-1.215	205.826	ISD	
6	2028.219	33.248	250	Sag	100	-0.217	0.397	0.615	406.720	HSD	
7	2705.653	35.941	350	Hog	100	0.397	-0.508	-0.906	386.418	ISD	
8	3284.681	33.054	225	Sag	100	-0.477	0.454	0.932	241.457	HSD	
9	3725.222	35.056	250	Hog	100	0.454	0.221	-0.234	1070.013	ISD	
10	4376.493	36.493	300	Sag	100	0.221	1.200	0.980	306.201	HSD	
11	4746.406	40.934	200	Hog	100	1.200	-0.097	-1.297	154.145	ISD	
12	5181.175	40.512	200	Hog	100	-0.097	-1.376	-1.279	156.340	ISD	
13	5511.556	35.965	250	Sag	100	-1.376	-0.207	1.170	213.724	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
14	5843.410	35.280	220	Hog	100	-0.207	-1.769	-1.562	140.808	ISD	
15	6192.666	29.102	220	Sag	100	-1.769	1.804	3.573	61.569	HSD	
16	6592.292	36.312	250	Hog	100	1.804	0.073	-1.732	144.369	ISD	
17	7169.086	36.731	260	Hog	100	0.073	-1.802	-1.874	138.725	ISD	
18	7451.088	31.650	150	Sag	100	-1.802	0.000	1.802	83.258	HSD	
19	7857.815	31.650	150	Sag	100	0.000	2.197	2.197	68.269	HSD	
20	8146.151	37.985	280	Hog	100	2.197	0.161	-2.036	137.521	ISD	
21	8854.152	39.126	200	Hog	100	0.161	-0.340	-0.501	398.979	ISD	
22	9465.564	37.046	300	Sag	100	-0.340	0.294	0.634	473.203	HSD	
23	10600.714	40.382	250	Sag	100	0.294	1.564	1.271	196.764	HSD	
24	11017.152	46.896	460	Hog	100	1.564	-1.678	-3.242	141.886	ISD	
25	11831.254	33.239	800	Sag	100	-1.678	0.488	2.166	369.386	HSD	
26	12727.080	37.611	300	Hog	100	0.488	-0.382	-0.870	344.698	ISD	
27	13346.152	35.245	400	Sag	100	-0.382	0.559	0.942	424.801	HSD	
28	14027.102	39.054	300	Sag	100	0.559	1.208	0.649	462.349	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
29	14766.151	47.984	450	Hog	100	1.208	-2.082	-3.290	136.768	ISD	
30	15114.424	40.733	200	Sag	100	-2.082	0.395	2.477	80.758	HSD	
31	15698.054	43.036	250	Hog	100	0.395	-0.411	-0.806	310.268	ISD	
32	16212.275	40.921	300	Sag	100	-0.411	0.762	1.173	255.758	HSD	
33	16767.257	45.149	300	Hog	100	0.762	-0.571	-1.332	225.162	ISD	
34	17249.285	42.398	300	Sag	100	-0.571	2.500	3.071	97.701	HSD	
35	17737.350	54.600	345	Hog	100	2.500	0.000	-2.500	138.000	ISD	
36	18125.657	54.600	200	Hog	100	0.000	-1.437	-1.437	139.208	ISD	
37	18614.890	47.571	350	Sag	100	-1.437	2.500	3.937	88.898	HSD	
38	19103.152	59.780	560	Hog	100	2.500	-1.413	-3.913	143.111	ISD	
39	19781.155	50.202	350	Sag	100	-1.413	1.504	2.916	120.007	HSD	
40	20275.393	57.634	350	Hog	100	1.504	-0.946	-2.450	142.851	ISD	
41	21126.166	49.584	200	Sag	100	-0.946	0.683	1.629	122.771	HSD	
42	21400.990	51.460	250	Hog	100	0.683	0.000	-0.683	366.152	ISD	
43	21897.934	51.460	250	Hog	100	0.000	-0.546	-0.546	457.997	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
44	22609.111	47.578	350	Sag	100	-0.546	0.715	1.261	277.646	HSD	
45	23046.726	50.706	200	Hog	100	0.715	-0.757	-1.471	135.936	ISD	
46	23260.770	49.087	150	Sag	100	-0.757	1.166	1.923	78.002	HSD	
47	23971.832	57.381	350	Hog	100	1.166	-1.094	-2.260	154.860	ISD	
48	24284.329	53.964	150	Sag	100	-1.094	1.641	2.735	54.852	HSD	
49	24533.434	58.051	340	Hog	100	1.641	0.301	-1.341	253.635	ISD	
50	25369.687	60.564	200	Sag	100	0.301	1.024	0.724	276.391	HSD	
51	26240.155	69.479	480	Hog	100	1.024	-0.300	-1.324	362.505	ISD	
52	26652.984	68.241	250	Sag	100	-0.300	2.293	2.593	96.413	HSD	
53	27301.154	83.103	710	Hog	100	2.293	-2.500	-4.793	148.133	ISD	
54	27798.449	70.671	200	Sag	100	-2.500	1.173	3.673	54.447	HSD	
55	28142.289	74.705	450	Hog	100	1.173	0.300	-0.873	515.278	ISD	
56	28776.560	76.608	260	Hog	100	0.300	-0.542	-0.842	308.788	ISD	
57	29111.924	74.790	250	Sag	100	-0.542	1.523	2.065	121.083	HSD	
58	29719.094	84.036	470	Hog	100	1.523	-0.937	-2.459	191.098	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
59	30361.074	78.022	300	Sag	100	-0.937	0.541	1.478	202.964	HSD	
60	31155.997	82.325	200	Hog	100	0.541	-0.064	-0.605	330.482	ISD	
61	31427.290	82.151	200	Sag	100	-0.064	2.081	2.145	93.246	HSD	
62	32154.156	97.278	630	Hog	100	2.081	-2.500	-4.581	137.525	ISD	
63	32741.844	82.585	300	Sag	100	-2.500	1.183	3.683	81.448	HSD	
64	33200.490	88.013	330	Hog	100	1.183	0.548	-0.635	519.395	ISD	
65	34024.893	92.530	250	Sag	100	0.548	1.385	0.837	298.619	HSD	
66	34391.784	97.612	200	Hog	100	1.385	1.044	-0.341	586.650	ISD	
67	34946.254	103.402	300	Sag	100	1.044	2.500	1.455	206.143	HSD	
68	35943.602	128.331	700	Hog	100	2.500	-2.500	-5.000	140.013	ISD	
69	36653.190	110.591	270	Sag	100	-2.500	2.500	5.000	54.001	HSD	
70	37135.915	122.659	650	Hog	100	2.500	0.164	-2.336	278.286	ISD	
71	37700.317	123.586	350	Sag	100	0.164	2.500	2.335	149.869	HSD	
72	40143.247	184.648	2000	Hog	100	2.500	-1.236	-3.736	535.403	ISD	
73	43099.892	148.106	800	Sag	100	-1.236	0.300	1.536	520.852	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
74	46652.018	158.762	1500	Sag	100	0.300	2.500	2.200	681.794	HSD	
75	49688.023	234.665	1300	Hog	100	2.500	-1.152	-3.652	355.942	ISD	
76	52910.732	197.532	3800	Sag	100	-1.152	1.397	2.549	1490.700	HSD	
77	58885.284	280.993	1050	Hog	100	1.397	-2.500	-3.897	269.443	ISD	
78	60527.433	239.939	800	Sag	100	-2.500	1.679	4.179	191.433	HSD	
79	61956.698	263.937	800	Hog	100	1.679	-0.973	-2.652	301.677	ISD	
80	63182.255	252.014	800	Sag	100	-0.973	2.025	2.998	266.827	HSD	
81	66354.848	316.271	2200	Hog	100	2.025	-1.049	-3.075	715.562	ISD	
82	68332.551	295.522	1000	Sag	100	-1.049	1.461	2.510	398.353	HSD	
83	69689.222	315.346	1000	Hog	100	1.461	-1.925	-3.387	295.277	ISD	
84	70814.307	293.683	800	Sag	100	-1.925	2.500	4.426	180.765	HSD	
85	75870.528	420.098	1500	Hog	100	2.500	1.977	-0.523	2866.613	ISD	
86	80118.004	504.067	1200	Hog	100	1.977	-2.500	-4.477	268.023	ISD	
87	84118.826	404.033	3000	Sag	100	-2.500	2.336	4.836	620.332	HSD	
88	90340.790	549.366	1000	Sag	100	2.336	2.500	0.164	6094.255	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
89	96921.433	713.876	1200	Hog	100	2.500	0.345	-2.154	556.990	ISD	
90	98699.479	720.018	500	Hog	100	0.345	-0.719	-1.065	469.505	ISD	
91	99463.683	714.520	550	Sag	100	-0.719	0.651	1.371	401.264	HSD	
92	100734.261	722.793	1000	Hog	100	0.651	-1.827	-2.478	403.472	ISD	
93	102334.288	693.556	500	Sag	100	-1.827	-0.803	1.025	487.995	HSD	
94	103898.585	680.999	160	Sag	100	-0.803	1.748	2.551	62.727	HSD	
95	104264.425	687.394	550	Hog	100	1.748	-2.303	-4.051	135.765	ISD	
96	104694.396	677.491	249.99986	Sag	100	-2.303	0.000	2.303	108.547	HSD	
97	105873.246	677.492	900	Sag	100	0.000	0.529	0.529	1702.819	HSD	
98	107051.000	683.717	350	Hog	100	0.529	-1.630	-2.158	162.164	ISD	
99	107497.732	676.437	350	Sag	100	-1.630	0.355	1.985	176.315	HSD	
100	109149.409	682.307	900	Sag	100	0.355	2.500	2.145	419.652	HSD	
101	111427.507	739.259	1450	Hog	100	2.500	-2.500	-5.000	290.000	ISD	
102	114027.617	674.256	1000	Sag	100	-2.500	2.192	4.692	213.120	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
103	117894.309	759.022	1760	Hog	100	2.192	-2.035	-4.227	416.385	ISD	
104	121195.338	691.857	1650	Sag	100	-2.035	1.243	3.278	503.377	HSD	
105	123655.521	722.441	1550	Hog	100	1.243	-1.690	-2.934	528.378	ISD	
106	124974.939	700.139	250	Sag	100	-1.690	-0.332	1.358	184.053	HSD	
107	125379.445	698.796	350	Hog	100	-0.332	-2.578	-2.246	155.835	ISD	
108	125939.631	684.355	200	Sag	100	-2.578	-0.216	2.362	84.669	HSD	
109	126273.445	683.634	200	Hog	100	-0.216	-1.608	-1.392	143.655	ISD	
110	126533.446	679.453	200	Sag	100	-1.608	-0.261	1.347	148.509	HSD	
111	127223.445	677.650	200	Hog	100	-0.261	-1.270	-1.009	198.289	ISD	
112	127604.773	672.807	200	Sag	100	-1.270	1.929	3.199	62.527	HSD	
113	128166.445	683.640	900	Hog	100	1.929	-2.500	-4.428	203.237	ISD	
114	129171.370	658.520	500	Sag	100	-2.500	0.330	2.830	176.696	HSD	
115	129831.594	660.699	350	Sag	100	0.330	1.944	1.614	216.902	HSD	
116	130737.784	678.312	700	Hog	100	1.944	-0.815	-2.759	253.735	ISD	
117	132721.127	662.146	950	Sag	100	-0.815	0.793	1.608	590.759	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
118	134115.681	673.205	750	Hog	100	0.793	-2.500	-3.293	227.756	ISD	
119	135620.746	635.579	800	Sag	100	-2.500	-0.585	1.915	417.691	HSD	
120	136970.434	627.687	600	Sag	100	-0.585	0.251	0.836	718.052	HSD	
121	137691.589	629.496	350	Hog	100	0.251	-0.698	-0.949	368.874	ISD	
122	138260.463	625.526	350	Sag	100	-0.698	2.147	2.845	123.023	HSD	
123	138844.421	638.064	650	Hog	100	2.147	-2.500	-4.647	139.874	ISD	
124	140083.725	607.081	750	Sag	100	-2.500	0.260	2.760	271.749	HSD	
125	141068.680	609.641	690	Hog	100	0.260	-2.500	-2.760	250.016	ISD	
126	141940.892	587.836	500	Sag	100	-2.500	0.288	2.788	179.354	HSD	
127	142591.824	589.710	400	Hog	100	0.288	-0.810	-1.098	364.213	ISD	
128	143851.672	579.500	160	Sag	100	-0.810	0.000	0.810	197.433	HSD	
129	144273.076	579.500	350	Hog	100	0.000	-2.500	-2.500	140.000	ISD	
130	145089.678	559.085	550	Sag	100	-2.500	-0.165	2.335	235.523	HSD	
131	146086.843	557.442	300	Hog	100	-0.165	-0.815	-0.650	461.584	ISD	
132	146453.202	554.457	250	Sag	100	-0.815	1.580	2.395	104.396	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
133	146826.000	560.348	450	Hog	100	1.580	-0.643	-2.223	202.391	ISD	
134	147340.000	557.040	250	Hog	100	-0.643	-1.461	-0.818	305.796	ISD	
135	147672.600	552.181	300	Sag	100	-1.461	-0.105	1.356	221.246	HSD	
136	148562.534	551.247	200	Sag	100	-0.105	1.222	1.327	150.765	HSD	
137	148902.896	555.405	400	Hog	100	1.222	-1.718	-2.940	136.074	ISD	
138	149245.920	549.512	200	Sag	100	-1.718	-0.070	1.648	121.325	HSD	
139	149757.528	549.156	200	Sag	100	-0.070	1.768	1.838	108.842	HSD	
140	150147.731	556.055	560	Hog	100	1.768	-2.021	-3.789	147.806	ISD	
141	150641.099	546.085	250	Sag	100	-2.021	0.236	2.256	110.801	HSD	
142	152049.021	549.401	500	Hog	100	0.236	0.174	-0.062	8108.651	ISD	
143	153241.015	551.474	1350	Sag	100	0.174	1.520	1.346	1003.014	HSD	
144	154438.607	569.675	300	Hog	100	1.520	1.311	-0.209	1436.777	ISD	
145	155828.793	587.901	370	Hog	100	1.311	0.118	-1.193	310.023	ISD	
146	156180.464	588.314	250	Sag	100	0.118	1.431	1.313	190.355	HSD	
147	156798.960	597.164	370	Hog	100	1.431	-0.681	-2.112	175.171	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
148	157232.733	594.209	325	Sag	100	-0.681	1.617	2.298	141.416	HSD	
149	158037.100	607.214	560	Hog	100	1.617	0.862	-0.755	741.815	ISD	
150	158746.396	613.328	380	Sag	100	0.862	2.500	1.638	231.987	HSD	
151	159738.440	638.129	820	Hog	100	2.500	-0.203	-2.703	303.405	ISD	
152	160852.169	635.871	250	Hog	100	-0.203	-1.903	-1.700	147.058	ISD	
153	161142.823	630.341	250	Sag	100	-1.903	-1.190	0.713	350.671	HSD	
154	161581.646	625.120	300	Sag	100	-1.190	1.198	2.388	125.649	HSD	
155	162011.171	630.265	520	Hog	100	1.198	-2.500	-3.698	140.624	ISD	
156	162413.567	620.205	200	Sag	100	-2.500	-0.569	1.931	103.593	HSD	
157	163088.672	616.362	200	Sag	100	-0.569	0.730	1.299	153.915	HSD	
158	163451.434	619.010	400	Hog	100	0.730	-1.935	-2.665	150.110	ISD	
159	163821.029	611.860	250	Sag	100	-1.935	-0.338	1.597	156.590	HSD	
160	164544.750	609.413	600	Hog	100	-0.338	-1.068	-0.730	821.492	ISD	
161	165140.669	603.045	300	Sag	100	-1.068	-0.446	0.623	481.735	HSD	
162	166090.179	598.813	350	Sag	100	-0.446	0.847	1.293	270.645	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
163	166708.847	604.056	340	Hog	100	0.847	-0.493	-1.341	253.565	ISD	
164	167306.117	601.109	350	Hog	100	-0.493	-1.528	-1.034	338.368	ISD	
165	167932.775	591.535	350	Sag	100	-1.528	1.475	3.002	116.573	HSD	
166	168308.127	597.070	350	Hog	100	1.475	-0.794	-2.268	154.308	ISD	
167	168725.242	593.760	300	Sag	100	-0.794	1.293	2.086	143.797	HSD	
168	169997.012	610.200	500	Hog	100	1.293	-1.632	-2.925	170.948	ISD	
169	170804.267	597.024	500	Sag	100	-1.632	0.104	1.736	287.978	HSD	
170	171394.085	597.638	250	Sag	100	0.104	2.500	2.396	104.358	HSD	
171	171882.267	609.841	690	Hog	100	2.500	-2.500	-4.999	138.016	ISD	
172	172617.868	591.453	300	Sag	100	-2.500	0.222	2.722	110.216	HSD	
173	173075.267	592.469	400	Hog	100	0.222	-2.500	-2.722	146.940	ISD	
174	173373.664	585.009	170	Sag	100	-2.500	0.836	3.336	50.962	HSD	
175	173763.236	588.265	250	Hog	100	0.836	-0.422	-1.257	198.808	ISD	
176	174117.749	586.770	310	Sag	100	-0.422	0.461	0.882	351.289	HSD	
177	175051.269	591.071	290	Hog	100	0.461	-0.780	-1.241	233.696	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
178	175380.760	588.501	200	Sag	100	-0.780	-0.131	0.650	307.927	HSD	
179	175763.930	588.000	250	Sag	100	-0.131	1.492	1.622	154.107	HSD	
180	176289.766	595.843	260	Hog	100	1.492	-0.383	-1.875	138.704	ISD	
181	176621.231	594.574	250	Sag	100	-0.383	2.396	2.779	89.970	HSD	
182	177238.268	609.357	580	Hog	100	2.396	-1.892	-4.287	135.283	ISD	
183	178251.018	590.201	600	Sag	100	-1.892	0.256	2.147	279.418	HSD	
184	179075.795	592.311	300	Sag	100	0.256	2.343	2.088	143.711	HSD	
185	179658.268	605.960	600	Hog	100	2.343	-2.062	-4.405	136.208	ISD	
186	180136.984	596.090	250	Sag	100	-2.062	-0.755	1.307	191.294	HSD	
187	180845.115	590.745	260	Hog	100	-0.755	-1.899	-1.144	227.300	ISD	
188	181266.782	582.739	250	Sag	100	-1.899	0.225	2.124	117.712	HSD	
189	181689.759	583.692	200	Sag	100	0.225	1.117	0.892	224.313	HSD	
190	182030.769	587.500	340	Hog	100	1.117	-1.369	-2.486	136.786	ISD	
191	182418.967	582.186	200	Sag	100	-1.369	-0.277	1.092	183.107	HSD	
192	182707.528	581.388	200	Sag	100	-0.277	1.595	1.872	106.834	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
193	183048.556	586.829	330	Hog	100	1.595	-0.755	-2.351	140.377	ISD	
194	184010.433	579.564	1050	Sag	100	-0.755	2.059	2.814	373.093	HSD	
195	185138.999	602.800	625	Hog	100	2.059	-2.500	-4.559	137.104	ISD	
196	185880.353	584.270	700	Sag	100	-2.500	1.569	4.068	172.060	HSD	
197	186589.635	595.396	390	Hog	100	1.569	-0.354	-1.923	202.817	ISD	
198	187133.529	593.470	300	Hog	100	-0.354	-1.337	-0.983	305.121	ISD	
199	187595.576	587.291	150	Sag	100	-1.337	0.368	1.705	87.957	HSD	
200	187897.636	588.402	390	Hog	100	0.368	-2.377	-2.745	142.094	ISD	
201	188273.296	579.474	200	Sag	100	-2.377	2.126	4.503	44.416	HSD	
202	188640.636	587.284	450	Hog	100	2.126	-1.159	-3.285	136.970	ISD	
203	189094.488	582.023	350	Sag	100	-1.159	2.350	3.509	99.750	HSD	
204	189525.636	592.153	480	Hog	100	2.350	-0.993	-3.342	143.616	ISD	
205	190090.379	586.547	350	Sag	100	-0.993	0.913	1.905	183.691	HSD	
206	190605.103	591.245	250	Hog	100	0.913	-0.844	-1.757	142.306	ISD	
207	191003.673	587.881	200	Sag	100	-0.844	2.361	3.205	62.405	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
208	191441.636	598.220	600	Hog	100	2.361	-1.875	-4.236	141.649	ISD	
209	192005.375	587.650	325	Sag	100	-1.875	-0.439	1.436	226.387	HSD	
210	192620.904	584.945	280	Sag	100	-0.439	1.972	2.412	116.108	HSD	
211	193059.636	593.597	500	Hog	100	1.972	-1.708	-3.680	135.852	ISD	
212	193591.216	584.516	400	Sag	100	-1.708	2.500	4.208	95.050	HSD	
213	194058.636	596.201	450	Hog	100	2.500	-0.852	-3.352	134.246	ISD	
214	194438.059	592.968	200	Sag	100	-0.852	-0.186	0.667	300.046	HSD	
215	194839.636	592.223	260	Hog	100	-0.186	-1.083	-0.897	289.758	ISD	
216	195229.636	588.000	400	Sag	100	-1.083	0.600	1.683	237.696	HSD	
217	195729.635	591.000	300	Sag	100	0.600	1.359	0.759	395.175	HSD	
218	196111.636	596.192	310	Hog	100	1.359	-0.873	-2.232	138.869	ISD	
219	196599.634	591.931	230	Hog	100	-0.873	-2.500	-1.627	141.404	ISD	
220	197074.356	580.064	450	Sag	100	-2.500	1.543	4.043	111.314	HSD	
221	197511.358	586.807	320	Hog	100	1.543	-0.806	-2.349	136.225	ISD	
222	198047.108	582.488	350	Sag	100	-0.806	1.845	2.651	132.007	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
223	198964.000	599.407	560	Hog	100	1.845	-1.726	-3.571	156.824	ISD	
224	199571.881	588.917	525	Sag	100	-1.726	2.500	4.225	124.253	HSD	
225	200372.498	608.929	570	Hog	100	2.500	-1.353	-3.853	147.951	ISD	
226	201120.454	598.809	400	Sag	100	-1.353	-0.301	1.052	380.224	HSD	
227	202261.341	595.375	170	Sag	100	-0.301	1.274	1.575	107.930	HSD	
228	202467.343	598.000	230	Hog	100	1.274	-0.369	-1.643	139.961	ISD	
229	202756.126	596.934	250	Sag	100	-0.369	2.063	2.433	102.773	HSD	
230	203335.344	608.885	535	Hog	100	2.063	-1.875	-3.939	135.838	ISD	
231	203838.784	599.444	350	Sag	100	-1.875	-0.013	1.862	187.950	HSD	
232	204330.343	599.380	440	Hog	100	-0.013	-2.500	-2.487	176.920	ISD	
233	204852.796	586.319	350	Sag	100	-2.500	0.614	3.114	112.395	HSD	
234	205573.593	590.745	300	Hog	100	0.614	-1.433	-2.047	146.544	ISD	
235	206209.641	581.629	190	Sag	100	-1.433	0.300	1.733	109.640	HSD	
236	206525.343	582.576	345	Hog	100	0.300	-1.558	-1.858	185.669	ISD	
237	206943.966	576.052	250	Sag	100	-1.558	0.693	2.251	111.056	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
238	207905.342	582.712	260	Hog	100	0.693	-0.804	-1.497	173.737	ISD	
239	208381.845	578.882	300	Sag	100	-0.804	2.500	3.304	90.796	HSD	
240	208892.342	591.646	685	Hog	100	2.500	-2.500	-5.000	136.987	ISD	
241	209422.705	578.387	300	Sag	100	-2.500	0.985	3.485	86.073	HSD	
242	209855.342	582.649	320	Hog	100	0.985	-1.309	-2.294	139.477	ISD	
243	210402.683	575.485	300	Sag	100	-1.309	2.500	3.809	78.766	HSD	
244	210943.344	589.000	450	Hog	100	2.500	-0.497	-2.997	150.158	ISD	
245	211425.441	586.604	310	Hog	100	-0.497	-2.500	-2.003	154.778	ISD	
246	211800.895	577.218	260	Sag	100	-2.500	2.500	5.000	51.998	HSD	
247	212196.343	587.105	500	Hog	100	2.500	-0.854	-3.354	149.085	ISD	
248	213102.434	579.371	430	Sag	100	-0.854	1.417	2.270	189.421	HSD	
249	213680.343	587.558	500	Hog	100	1.417	-2.128	-3.545	141.051	ISD	
250	214196.335	576.576	300	Sag	100	-2.128	0.936	3.064	97.896	HSD	
251	214889.432	583.066	550	Hog	100	0.936	-1.706	-2.642	208.182	ISD	
252	215540.226	571.965	300	Sag	100	-1.706	-1.270	0.436	687.864	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
253	216442.623	560.509	400	Sag	100	-1.270	-0.992	0.277	1442.898	HSD	
254	217194.715	553.046	300	Sag	100	-0.992	0.948	1.941	154.597	HSD	
255	217592.000	556.813	250	Hog	100	0.948	0.145	-0.804	311.119	ISD	
256	218073.000	557.509	400	Hog	100	0.145	-1.624	-1.769	226.109	ISD	
257	218659.480	547.982	400	Sag	100	-1.624	-0.236	1.389	288.053	HSD	
258	219338.187	546.382	160	Sag	100	-0.236	0.503	0.739	216.630	HSD	
259	219637.745	547.888	390	Hog	100	0.503	-1.735	-2.238	174.297	ISD	
260	220080.082	540.215	400	Sag	100	-1.735	0.660	2.395	167.050	HSD	
261	220577.977	543.500	350	Hog	100	0.660	-1.258	-1.918	182.527	ISD	
262	221303.145	534.379	250	Sag	100	-1.258	-0.849	0.409	610.928	HSD	
263	222127.283	527.386	300	Sag	100	-0.849	0.254	1.103	272.072	HSD	
264	222578.422	528.532	300	Hog	100	0.254	-1.355	-1.610	186.391	ISD	
265	223164.873	520.583	550	Sag	100	-1.355	2.089	3.444	159.682	HSD	
266	223920.789	536.374	650	Hog	100	2.089	-2.500	-4.589	141.643	ISD	
267	224438.448	523.432	320	Sag	100	-2.500	1.161	3.661	87.408	HSD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
268	224935.498	529.202	460	Hog	100	1.161	-1.559	-2.720	169.132	ISD	
269	225325.151	523.128	200	Sag	100	-1.559	0.663	2.221	90.033	HSD	
270	225897.471	526.920	300	Hog	100	0.663	-0.264	-0.926	323.849	ISD	
271	226364.994	525.687	250	Sag	100	-0.264	2.500	2.764	90.464	HSD	
272	226765.607	535.701	450	Hog	100	2.500	-0.784	-3.284	137.025	ISD	
273	227419.677	530.571	500	Sag	100	-0.784	2.500	3.284	152.258	HSD	
274	227946.258	543.733	510	Hog	100	2.500	-1.152	-3.651	139.674	ISD	
275	228735.871	534.638	270	Sag	100	-1.152	1.698	2.850	94.729	HSD	
276	229062.267	540.182	350	Hog	100	1.698	-0.729	-2.427	144.196	ISD	
277	229590.602	536.331	280	Sag	100	-0.729	0.747	1.476	189.758	HSD	
278	230208.705	540.947	320	Sag	100	0.747	2.500	1.754	182.491	HSD	
279	230738.266	554.187	700	Hog	100	2.500	-1.307	-3.807	183.848	ISD	
280	231287.890	547.002	300	Sag	100	-1.307	0.208	1.515	198.035	HSD	
281	231864.195	548.199	250	Sag	100	0.208	1.560	1.352	184.909	HSD	
282	232274.266	554.594	450	Hog	100	1.560	-1.118	-2.678	168.032	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
283	232666.240	550.210	250	Sag	100	-1.118	1.786	2.905	86.072	HSD	
284	233062.280	557.284	455	Hog	100	1.786	-0.897	-2.683	169.595	ISD	
285	233560.155	552.820	250	Sag	100	-0.897	0.089	0.986	253.510	HSD	
286	234183.125	553.377	400	Sag	100	0.089	2.500	2.411	165.935	HSD	
287	234920.015	571.799	480	Hog	100	2.500	-0.967	-3.467	138.448	ISD	
288	235408.521	567.075	250	Sag	100	-0.967	0.383	1.350	185.227	HSD	
289	235831.457	568.694	300	Sag	100	0.383	1.340	0.957	313.506	HSD	
290	236307.855	575.076	525	Hog	100	1.340	-2.478	-3.818	137.520	ISD	
291	236914.182	560.051	210	Sag	100	-2.478	0.337	2.815	74.595	HSD	
292	237254.530	561.198	400	Hog	100	0.337	-1.759	-2.096	190.862	ISD	
293	237621.859	554.738	250	Sag	100	-1.759	0.171	1.929	129.581	HSD	
294	238202.447	555.730	220	Sag	100	0.171	1.346	1.175	187.186	HSD	
295	238478.463	559.445	250	Hog	100	1.346	-0.141	-1.487	168.141	ISD	
296	238819.537	558.964	250	Sag	100	-0.141	1.630	1.771	141.178	HSD	
297	239880.301	576.255	600	Hog	100	1.630	-2.500	-4.130	145.279	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
298	240412.055	562.961	300	Sag	100	-2.500	-0.389	2.111	142.144	HSD	
299	240966.850	560.800	350	Hog	100	-0.389	-1.727	-1.337	261.685	ISD	
300	241602.118	549.829	550	Sag	100	-1.727	2.500	4.227	130.117	HSD	
301	242490.098	572.029	615	Hog	100	2.500	-1.878	-4.378	140.470	ISD	
302	244463.799	534.960	350	Sag	100	-1.878	0.347	2.225	157.298	HSD	
303	245011.530	536.860	500	Hog	100	0.347	-2.311	-2.658	188.093	ISD	
304	245398.477	527.916	200	Sag	100	-2.311	-0.336	1.975	101.253	HSD	
305	247643.091	520.373	250	Sag	100	-0.336	1.999	2.335	107.082	HSD	
306	248073.531	528.976	540	Hog	100	1.999	-1.913	-3.911	138.061	ISD	
307	248478.700	521.226	200	Sag	100	-1.913	-0.601	1.312	152.436	HSD	
308	249098.868	517.501	250	Sag	100	-0.601	0.108	0.709	352.730	HSD	
309	250656.315	519.184	400	Sag	100	0.108	2.500	2.392	167.224	HSD	
310	251497.000	540.202	650	Hog	100	2.500	-2.234	-4.734	137.292	ISD	
311	252183.300	524.867	280	Sag	100	-2.234	1.989	4.223	66.303	HSD	
312	252592.531	533.006	500	Hog	100	1.989	-1.664	-3.652	136.905	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
313	252981.256	526.539	200	Sag	100	-1.664	0.671	2.335	85.663	HSD	
314	253266.530	528.454	270	Hog	100	0.671	-0.712	-1.383	195.257	ISD	
315	253670.409	525.580	400	Sag	100	-0.712	0.814	1.526	262.172	HSD	
316	254085.530	528.960	330	Hog	100	0.814	-1.018	-1.833	180.070	ISD	
317	254376.503	525.996	200	Sag	100	-1.018	0.220	1.239	161.433	HSD	
318	255398.489	528.249	300	Sag	100	0.220	1.353	1.133	264.869	HSD	
319	255876.730	534.720	320	Hog	100	1.353	0.246	-1.107	289.168	ISD	
320	256224.757	535.577	200	Sag	100	0.246	1.691	1.444	138.472	HSD	
321	256533.985	540.806	380	Hog	100	1.691	-0.363	-2.054	185.030	ISD	
322	257430.962	537.550	400	Sag	100	-0.363	2.500	2.863	139.716	HSD	
323	258240.964	557.800	340	Hog	100	2.500	0.000	-2.500	136.000	ISD	
324	258683.020	557.800	340	Hog	100	0.000	-2.500	-2.500	136.001	ISD	
325	259171.807	545.580	325	Sag	100	-2.500	0.254	2.754	118.023	HSD	
326	260757.169	549.603	300	Sag	100	0.254	1.463	1.209	248.090	HSD	
327	261309.892	557.689	600	Hog	100	1.463	-1.620	-3.083	194.621	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
328	261819.727	549.429	260	Sag	100	-1.620	1.088	2.708	96.027	HSD	
329	262523.157	557.080	250	Hog	100	1.088	0.419	-0.668	374.052	ISD	
330	263015.351	559.143	300	Sag	100	0.419	1.369	0.949	316.023	HSD	
331	263548.264	566.437	300	Hog	100	1.369	0.290	-1.079	278.115	ISD	
332	263968.444	567.655	350	Sag	100	0.290	2.500	2.210	158.361	HSD	
333	269250.019	699.694	3000	Hog	100	2.500	-0.594	-3.094	969.527	ISD	
334	271299.601	687.513	400	Sag	100	-0.594	0.185	0.780	513.119	HSD	
335	272614.696	689.950	420	Hog	100	0.185	-1.852	-2.037	206.187	ISD	
336	272991.624	682.970	250	Sag	100	-1.852	0.734	2.586	96.689	HSD	
337	273738.852	688.454	350	Sag	100	0.734	1.947	1.213	288.456	HSD	
338	274732.875	707.810	500	Hog	100	1.947	0.172	-1.775	281.614	ISD	
339	275346.739	708.864	300	Sag	100	0.172	0.682	0.510	588.104	HSD	
340	275901.000	712.643	440	Hog	100	0.682	-2.500	-3.182	138.273	ISD	
341	276567.596	695.977	350	Sag	100	-2.500	1.337	3.837	91.221	HSD	
342	277039.505	702.284	460	Hog	100	1.337	-1.107	-2.444	188.252	ISD	

S.No.	IP CHAINAGE	IP LEVEL	CURVE LENGTH	TYPE	Design Speed	n1	n2	n2-n1	K VALUE	Type (SSD/ISD)	REMARKS
343	277672.305	695.280	200	Sag	100	-1.107	1.246	2.353	85.012	HSD	
344	278038.848	699.845	490	Hog	100	1.246	-1.818	-3.064	159.940	ISD	
345	278499.263	691.475	250	Sag	100	-1.818	0.218	2.036	122.779	HSD	
346	279225.440	693.060	500	Sag	100	0.218	2.264	2.046	244.388	HSD	
347	280520.051	722.371	1200	Hog	100	2.264	-2.020	-4.284	280.128	ISD	
348	282077.846	690.909	650	Sag	100	-2.020	0.880	2.900	224.168	HSD	
349	283235.166	701.093	450	Hog	100	0.880	-0.866	-1.746	257.778	ISD	
350	283868.385	695.611	350	Sag	100	-0.866	1.539	2.405	145.560	HSD	
351	284849.206	710.704	400	Sag	100	1.539	2.500	0.961	416.138	HSD	
352	285838.134	735.427	500	Hog	100	2.500	0.300	-2.200	227.273	ISD	
353	286562.224	737.599	350	Sag	100	0.300	1.312	1.012	345.922	HSD	
354	287239.632	746.485	300	Sag	100	1.312	2.500	1.188	252.556	HSD	
355	288717.690	783.432	680	Hog	100	2.500	-2.500	-5.000	136.010	ISD	
356	290128.522	748.161	500	Sag	100	-2.500	-0.971	1.529	327.082	HSD	

5. METHODOLOGY ADOPTED

5.1 General Approach

Various engineering surveys and investigations have been carried out on the Project Road strictly following the relevant specifications mentioned in MoRTH/ IRC/ BIS Codes to generate adequate database for preparing the most appropriate proposal for the proposed green fileld alignment of Surat –Nashik – Ahmednagar stretch.

Various engineering surveys and investigations carried out are listed below:

- Alignment Study
- Topographic Surveys
- Road Inventory and Condition survey
- Traffic Surveys
- Inventory and condition survey of bridges and culverts
- Hydraulic and Hydrological Investigations
- Pavement Investigations
- Soil and Material Investigations
- Sub-soil Investigations

5.2 Reconnaissance and Alignment Study

In-depth study of the available land width (RoW), study of topographic maps of the project area was made and other available relevant information have been collected concerning the existing alignment and the vicinity of the project corridor.

The detailed ground reconnaissance has been taken up immediately after the study of maps and other data. The primary tasks of reconnaissance survey include:

- Topographical features of the area.
- Typical physical features within the RoW for understanding land use pattern along the project stretch.
- Possible alignment alternatives, vis-à-vis, scheme for the construction of additional lanes or paved shoulders parallel to the existing road to the left or right or central widening.
- Provision of the interchanges and underpasses for vehicle/pedestrian/animal crossing
- Traffic pattern and preliminary identification of traffic homogeneous sections.

- Identification of sections passing through congested areas.
- Critical areas requiring detailed investigations
- Requirement for carrying out supplementary investigations.
- Soil (textural classifications) and drainage conditions.
- Type and extent of existing utility services along the alignment (within RoW).
- Identification of various agencies of the Govt. from whom the concerned project clearances for implementation are to be sought.
- General observations of the condition of existing pavement.

5.3 Topographical Survey

The basic objective of the topographic survey is to collect the essential ground features along the greenfield alignment and develop Digital Terrain Model (DTM). The equipment used for this purpose is Drone. This data forms the basis for all the designs to be carried out, so as to take care of design requirements of new carriageway, possible improvements in highway geometrics, identifying areas of restriction and their remedies and relocation of utilities. The data collected will result in the final design and for the computation of earthwork and other quantities required. The detail methodology including the various intermediate quality check procedures, control points and pillars, horizontal and vertical controls etc. have been described in detail, in the QAP, document submitted to NHAI.

5.3.1 Scope of Work

The detailed scope of services is enclosed in the contract agreement.

(a) Topographic Surveys along the Proposed Right of Way (RoW):

- Running a continuous open traverse along the proposed greenfield alignment.
- Fixation of Horizontal Intersection Points (HIP's), centre points, transit points etc.
- Fixing reference pillars on either side of centre line at safe places within the RoW.
- Establishment of Height Control by Auto Level.

(b) Detailed Topographical Survey to generate Digital Terrain Model of the defined corridor of the project road.

(c) Additional survey as required for geometric improvements like designing of Interchanges

5.4 Traffic Studies and Analysis

The methodology and details of traffic studies and analysis are mentioned in detail, in Chapter-8, of this Volume-I.

5.5 Hydraulic and Hydrological Investigations

5.5.1 Requirements for Hydraulic and Hydrological Investigation

The hydrological study aims at estimating the peak discharge of the flood generated by the run-off of rainfall within the catchment area. The hydrological study requires:

- Knowledge of the characteristics of peak rainfall in the regions
- Knowledge of the characteristics of the catchment areas
- Topographic data about the stream, upstream and downstream
- Survey of India topo sheets maps to a scale of 1:50,000 for identification of catchment area and its characteristics.

5.5.2 Data Collection

Topographic Survey Data: Topographic surveys will be done at all the major and minor river crossings with a view to obtain the cross section of the rivers at the centre line of the road and up to a reasonable distance at upstream and downstream. The High Flood Levels (HFL) will be obtained from existing flood marks/flood marks on Railway bridges or ascertained from enquiry with local knowledgeable persons.

Catchment Areas: The characteristics of the catchment areas will be ascertained from Survey of India topo sheets, to a scale of 1:50,000 from which, catchment area at the proposed bridge site, length of the stream and fall in elevation from originating point to the point of crossing, could be determined. Slope of the stream will be determined from the contours on the topo sheets.

Rainfall Data: For rivers/streams having catchment area more than 25 sq km, CWC Report No. C/16/1988 – Flood Estimation Report for Chambal sub zone 1(b), Flood Estimation Report for Upper Indo-Ganga Plains sub zone 1(e) in which the project site lies will be obtained. These Reports will be referred for determining the characteristics of peak rainfall regimes. These reports have been jointly prepared by CWC, MOST, Ministry of Railways and IMD and contain all the rainfall data required for estimation of design discharge of 25, 50 and 100 year returns periods by applying the Synthetic Unit Hydrograph approach, the parameters of which have been indicated in the above report. For streams having catchment area less than 25 sq km, IRC-SP-13 and RBF-16 have been referred to.

5.5.3 Hydrologic Design

The following methods will be used to estimate the peak discharge for bridge sites on major and minor streams:

- Rational Method
- Synthetic Unit Hydrograph Method
- Area-Velocity Method or Slope Area Method

(i) Discharge Estimation for the Catchment Areas Less than 25 Sq. Km (Rational Method) (Ref: IRC-SP-13 and BRIDGES AND FLOODS WING REPORT No. RBF- 16) This is a well-

known method given in IRC: SP-13 and has been suitably improved as per report RBF-16 and is in use from many years.

Here, 50 year Peak Discharge is calculated by following formula

$Q_{max} = 0.28fCIA$

Where,

Q_{max} = design flood (m^3/s) for 50-year return period

f = Areal Distribution Factor

C = runoff coefficient between 0 and 1.0

A = catchment area (sq.km)

I = mean intensity of rainfall in mm/h during the time of concentration (the time required for the most distant part of the catchment to Contribute to the outflow at bridge site)

Time of concentration has been taken from Bransby- Williams' formula as suggested in RBF-16:

$t_c = 0.615\ L / (A^{0.1}\ S^{\ 0.2})$

Where,

t_c = time of concentration (h)

L = mainstream length (km)

S = mean slope of mainstream (%)

A = catchment area (Km^2)

Intensity of rainfall has been determined from formula I = 2*R/ (tc+1)

(ii) Synthetic Unit Hydrograph (SUH) Approach for Bridges having Catchment Area More than 25 Sq. Km

This method has been used for those bridges, which cater for more than 25 sq km of catchment area. In this method 1 hour Synthetic Unit Hydrograph is determined for an ungauged catchment*.* Following steps have been followed as suggested in CWC report for determination of discharge by this method.

i. Physiographic parameters of the ungauged catchment viz. A, L and S will be determined from toposheets or field observations.

ii. SUH parameters will be computed using the equations set out in subzone manuals.

iii. The values calculated will be plotted to arrive at a unit hydrograph.

iv. The design storm duration is taken as equal to base period of unit graph (T_B =1.1* tp).

v. Point rainfall is available in the given plate in CWC report for 50 year 24 hr rainfall.

vi. The areal rainfall of design storm duration is split into 1-hour rainfall increments using time distribution coefficients.

vii. Estimation of effective rainfall excess unit will be done after taking design loss rate into account.

viii. Base flow will be estimated based upon the catchment area.

ix. Finally, for 50 year peak discharge, the effective rainfall excess after removing the losses from rainfall increments are arranged against unit hydrograph ordinates such that the maximum of effective rainfall is placed against the maximum UG ordinate, next lower value of effective rainfall against next lower value of UG ordinate and so on. Sum of the product of the above two added together with base flow gives peak discharge.

(iii) Area Velocity Method/Slope Area Method

This method can be utilised to calculate the discharge from the stream cross-section and stream slope/bed slope at the proposed bridge sites, for both major and minor bridges. After plotting the cross section of the river, and marking the observed HFL, the cross-sectional area (A) and wetted perimeter (P) will be computed.

The velocity and Discharge are calculated using the Manning's formula:

$$V = 1/n \ R^{2/3} \ S^{1/2}$$

$$Q = A \times V$$

Where,

V = Velocity in m/sec

R = Hydraulic mean depth in m

S = Flood slope/bed slope

n = Co-efficient of rugosity

Q = Peak Discharge in cumecs

A = Area of cross section in sq.m

5.5.4 Fixing of Design Discharge

In general, the design discharge is taken as highest of the discharges obtained from above methods. However, the general condition laid down in IRC SP-13 will be used to fix the design discharge, that is, if the discharge obtained by one method is greater than 1.5 times the discharge obtained from the other, the design discharge should be limited to 1.5 times of the smaller one. In the case where Average discharge obtained by Area Velocity method is higher than 1.5 times the discharge obtained by the other method, design discharge has been taken as that of from previous method. Accordingly, the design discharge has been established for all the bridges. Also in the case where area velocity method is governing case (i.e. discharge by catchment area method is lesser than the area velocity method) and the average discharge by area velocity method has been found lesser as compared to discharge by same at proposed bridge site, the discharge calculated at proposed bridge site has been considered as design discharge.

5.5.5 Afflux Calculation

Since some of the bridges in the alignment will have less clear waterway as compared to natural stream width and also velocities at bridge sites high due to steep bed slopes, this combined effect causes afflux at bridge sites during flood. Afflux for the bridges will be calculated using Weir and Orifice formulae as described in IRC SP-13.

5.5.6 Vertical Clearance

The vertical clearance for each structure will be calculated as per the standards set out in IRC SP-13.

5.6 Material and Geo-Technical Investigations

5.6.1 Material Investigations

It has been ensured that all Geo-technical investigations confirm to IRC, BIS codes and MoRT&H specifications. The Geo-technical investigation scheme has been prepared in accordance with the "Terms of reference". The Material investigations for road construction have been carried out to identify the potential source of construction materials and to assess their general availability, nature and quantum of materials available for the project. This is one of the most important factors for stable, economic and successful implementation of the project within the stipulated time frame. The investigation and testing of materials is carried out in accordance with MoRT&H, IS and IRC specifications.

Objectives:

The investigation on these material sources was carried out with the following basic objectives.

- Material investigation was carried out based on information collected from local PWD, Panchayat office, Zilla parishad office and from material suppliers along with public enquiry.
- Investigations have been carried out to identify and assess potential sources for bulk procurement of the following materials.
- Embankment fill material
- Gravel for sub-grade
- Natural Gravel for GSB, if any
- Stone quarry for aggregate to be used for bituminous & non bituminous layers and GSB in case of non-availability of natural GSB
- Sand to be used for Cement Concrete
- Demarcating the location of source indicating place, kilometer stone and lead distance from the project road and the status whether it is in operation or new source.
- Identify the ownership of land/quarry, (Government or Private).
- Testing of materials to indicate the quality, classification and suitability of materials.
- To asses probable use of materials at various stages of construction activities, i.e. embankment fill, sub-grade, sub-base, wearing course and structures.
- During the process of investigation, due consideration has been given such that no material shall be selected from the right of way, at the same time locally available materials were selected for reducing the cost of construction.

5.6.2 Material Testing

The samples from various identified sources have been collected for laboratory testing as per IS & AASHTO standards.

(i) Interpretation of Test Results

The test results of soil samples have been presented as per IS:1498-1959. In addition to the tests already mentioned, soil samples to be used for sub-grade purpose shall be tested for soaked CBR in the laboratory on remoulded specimen compacted to 97 per cent Modified Proctor Density at Optimum Moisture Content. For this purpose, three individual specimens are subjected to different blows (10, 30 and 65) and CBR for each of the soaked specimen is determined. Actual CBR value corresponds to 97% of MDD is determined from a graph plotted between CBR and corresponding dry density.

a) The following tests have been performed on stone aggregate collected from various quarries:

- Aggregate Impact Value
- Specific Gravity
- Water Absorption

b) Granular sub-base materials have been tested for its grading and Atterberg Limits. In addition, a soaked CBR test has been carried out following the standard procedure at 98% of modified Proctor Density. The sub-base material could be either natural granular material available in the quarries/borRoW areas or shall be designed using crushed aggregates to

meet the specific requirements of sub-base material as per MoRT&H specifications. The LL and PI of such material shall not be more than 25% and 6% respectively and soaked CBR value shall not be less than 30%.

c) For proper identification, index map and quarry charts, showing the following details will accompany the tables: Approximate Quantities and type of material available from each quarry source.

d) Location of each quarry and the distance up to the nearest link point of the Project Highway. The coarse aggregate for Wet Mix Macadam sub-Base/Base shall be crushed stone and confirm to MORT&H specification. Potential quarries have been identified in consultation with Forest dept./Mining dept. and shown in quarry charts. In case crushed gravel/shingle has to be used for advantage of availability and economy, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75mm sieve shall have at least two fractured faces.

5.6.3 Methodology For Conducting Sub-Soil Investigations

Geotechnical investigations are carried out with a view to furnish the Detailed Technical Information of the nature of sub-soil strata for foundation design and assessment of stability of high embankments.

5.6.4 Objectives And Scope Of Work

The objectives of Geo-Technical Investigation is to evaluate the following:

a) To ascertain the sub-soil strata at structure locations.
b) To study standing Ground Water Level.
c) To study the physical and engineering properties of soil strata.
d) To evaluate allowable safe bearing capacity of soils to design foundations.
e) To recommend type and depth of foundation.
f) To recommend improvements to the weak soil strata if any.
g) To evaluate the stability of high embankment.

The Scope of Geotechnical Investigations includes the following field and Laboratory Tests.

(i) Field Investigations

The scope of Field investigations is as follows:

- Boring of 150-mm dia holes in all kinds of soils up to refusal strata (N>100 Blows for 30 cms penetration) using Auger equipment.
- Boring of 150-mm dia Boreholes in all kinds of soils in Hard Rock whichever encounter early using Calyx operated Rotary Boring Rig with Wash Boring Method.
- Collecting Disturbed / Representative samples (DS / RS) during drilling and also during SPT Tests. Disturbed samples using the split spoon sampler and UDS samples

using 100 mm thin walled Shelby tubes shall be collected. The samples recovered will be packed in polythene bags, labelled and sent to the laboratory for testing.

- During field investigations, the standing Water Table levels will be studied and recorded in the Borehole log.

(ii) Laboratory Testing

The scope of Laboratory Testing is as follows:

(a) For Samples Obtained from SPT

- Grain Size Analysis as per IS 2720 part 4.

(b) For samples Obtained from UDS tube:

- Specific Gravity as per IS 2720- part 3-Section 1 and IS 2720 – part 3
- Grain Size Analysis as per IS 2720 part-4
- Atterberg Limits as per IS 2720 part 5, IS 2720 part 2.
- Determination of natural moisture content as per IS 2720 part 2.
- Determination of natural density as per IS 2720
- Determination of Tri-axial Shear Strength tests by UU and CU method as per IS 2720-part 10

(c) For samples Obtained from Rock Cores:

- Determination of Specific Gravity and Water Absorption of Rock Core Samples.
- Determination of Unit Weight and Classification of Rock Core Samples.
- Determination of Unconfined Compressive Strength of Rock Core Samples.

5.6.5 Contents Of Geo-Technical Report

The report shall include in brief, the following contents:

1. The test procedure employed
2. The sample calculation with reference to formula used to evaluate various parameters.
3. Summary of various soil parameters evaluated.

4. Type and character of soil.
5. Procedure of Investigation
6. Detailed bore logs, sub-soil strata, laboratory and field-test results.
7. Results obtained and their interpretation.
8. Recommendation for type and depth of formulation. Safe bearing capacity and settlement of the foundations adopted.
9. All recommendations shall be supported by a set of sample and back up calculations.
10. Any other information of special significance encountered during investigations shall be brought out in the Geo – Technical report.

6. Socio Economic Profile

6.1 Overall Approach

The districts through which the project road passes are considered to be the primary project influence area. The greenfield alignment passes through Navsari and Valsad districts in Gujarat state and Nashik , Ahmednagar districts in Maharashtra state. Therefore, the influence area of the project corridor, for the purpose of socio economic analysis is considered with prime importance. The primary purpose of Socio-economic analysis is to provide an overview of the state's socio-economic setup and the relative status of the project influence area within the state. Data to be considered include demographic aspects, macro-economic indicators and sectoral production of agriculture and allied activities, manufacturing, mining and service sectors including infrastructure. The profile provides the present scenario, the past performance and the prospective growth of the economy, population and urbanization. The profile depicts the spatial distribution of economic activities and provides basic inputs for estimating future growth in Transport demand, on the basis of prospective economic growth rates and transport demand elasticity. Secondary data available with different state government departments have been collected and analysed for preparation of socio-economic profile.

6.2 General Features

The project passes through the Gujarat and Maharashtra state , situated in northern part of India. Maharashtra is the 2nd and Gujarat is the 9th most populous state in India and looking after area wise Gujarat stands at 6th whereas Maharashtra is at 3rd amongst the states of India. The state covers an area of (Gujarat-196,024 square kilometres with a population of 60,439,692 / (Maharashtra- 307,713 square kilometres with a population of 112,374,333) according to 2011 census, which accounts for (Gujarat- 5% and Maharashtra- 9.28%) of India. Gujarat has 33 districts, 8 municipal corporations, 159 municipalities, 9373 panchayats and 18225 villages, whereas Maharashtra has 36 districts, 28 municipal corporations, 226 municipalities, 28813 panchayats and 44198 villages.

As per 2011 census of India, the Gujarat state had a population of 6,04,39,692 with a population density of 308/square km whereas, Maharashtra had a population of 11,23,74,333 with a population density of 365/square km . The total population growth in this decade was 19.3 & 16.0 percent for Gujarat and Maharashtra respectively. Out of total population of Gujarat, 42.58% of the population with 2,57,45,083 inhabitants live in urban regions and 57.42% of population with

3,46,94,609 inhabitants live in rural areas, whereas in Maharashtra 45.23% of the population with 5,08,18,259 inhabitants live in urban regions and 54.77% of population with 6,15,56,074 inhabitants live in rural areas. There are (**Gujarat**- 3,14,91,260 male and 2,89,48,432 female citizens, **Maharashtra**- 5,82,43,056 male and 5,41,31,277 female citizens). Children of age 0-6 constitutes (Gujarat – 12.87% and Maharshtra- 11.86% of the total population). Sex ratio of (Gujarat- 919 / Maharashtra – 929) which is less than the national average of 933 per 1000. Literacy rate in Gujarat for Urban regions was 86.31 percent in which males were 85.75% literate while female literacy stood at 69.68% whereas in Maharashtra for Urban regions was 88.69 percent in which males were 92.12% literate while female literacy stood at 84.89%.

6.3 Delineation of Project Influence area

The project road runs entirely through the districts of Navsari and Valsad in Gujarat state and Nahsik, Ahmednagar in Maharshtra state. The project stretch of 290.700 km connects major towns of the districts like Sarpor, Dabhalal, Surkhai, kukeri, Mama bacha, Bendwal, Ambedgoan, Adgoan, Telegoan, Rahuri, Khadambe Bk, Vambori etc. Located in the eastern part of Gujarat and Maharashtra , the project road will mostly carry a mix of intra-state and inter-state traffic from the surrounding states like Bihar.

6.3.1 Navsari District

According to the 2011 census Navsari district has a population of 13,29,672. Its headquarters are located in Navasari City. This gives it a ranking of 9th in India (out of a total of 640). Out of the total population males are 6,78,165 and females are 6,51,507. The area of the district is 2,246 sq. km and it constitute 2.20% of the population of Gujarat. It has a population density of 592 inhabitants per square kilometer. It's population growth rate over the decade 2001-2011 was 8.15%. Navsari has a sex ratio of 961 females for every 1000 males and a literacy rate of 83.88% (higher than the national average of 74.04%). Male literacy is 88.75% and female literacy is 78.83%. 69.23% of the total population is rural and 30.77% is urban. Out of the total population of 13,29,672 rural population is 9,20,535 and urban population is 4,09,137.

Navsari is well connected with major cities by road, rail and air transport. Navsari has Surat Airport as a nearby Airport which is 45km from town.

Table 6.3: Demographic Features of Navsari District

DISTRICT: Navsari			
Total Area (sq. kms)	2246	Male population	6,78,165
Population Density (persons/sq km.)	592	Female population	6,51,507
Population Growth (%)	8.15	Sex Ratio	961
Total Population	13,29,672	Literacy rate (%)	83.88

Table 6.4: Socio-Economic Features of Navsari District

S.No	Item	Unit	Navsari
1	District Area	sq. km	2246
2	Tehsils	No.	5
3	Towns	No.	13
4	Villages	No.	372
5	Households	No.	2,95,131
6	Decade Growth Rate	%	8.15
7	Main Workers	No.	510,004
8	Marginal Workers	No.	81,830
9	Non-workers	No.	737,838

6.3.2 Valsad District

According to the 2011 census Valsad district has a population of 17,05,678. Its headquarters are located in Valsad City. Out of the total population males are 8,87,222 and females are 8,18,456. The area of the district is 3008 sq. km and it constitute 2.82% of the population of Gujarat. It has a population density of 567 inhabitants per square kilometer. It's population growth rate over the decade 2001-2011 was 20.92%. Valsad has a sex ratio of 922 females for every 1000 males and a literacy rate of 78.55% (higher than the national average of 74.04%). Male literacy is 84.55% and female literacy is 72.06%. 62.74% of the total population is rural and 37.26% is urban. Out of the total population of 17,05,678 rural population is 1,070,177 and urban population is 635,501.

Valsad is well connected with major cities by road, rail and air transport. Surat Airport is near to the town which is 57.04 km.

Table 6.5: Demographic Features of Valsad District

DISTRICT: Valsad			
Total Area (sq. kms)	3008	Male population	887,222
Population Density (persons/sq km.)	567	Female population	818,456
Population Growth (%)	20.92	Sex Ratio	922
Total Population	1,705,678	Literacy rate (%)	78.55

Table 6.6: Socio-Economic Features of Valsad District

S.No	Item	Unit	Valsad
1	District Area	sq. km	3008
2	Tehsils	No.	10
3	Towns	No.	22
4	Villages	No.	713
5	Households	No.	13,19,820
6	Decade Growth Rate	%	42.24
7	Main Workers	No.	2,405,288
8	Marginal Workers	No.	148,254
9	Non-workers	No.	3,527,780

6.3.3 Nashik District

According to the 2011 census Nashik district has a population of 61,07,187. Its headquarters are located in Nashik City. Out of the total population males are 3,157,186 and females are 2,950,001. The area of the district is 15,530 sq. km and it constitute 5.43% of the population of Maharashtra. It has a population density of 393 inhabitants per square kilometer. It's population growth rate over the decade 2001-2011 was 22.30%. Nashik has a sex ratio of 890 females for every 1000 males and a literacy rate of 82.31% (higher than the national average of 74.04%). Male literacy is 88.71% and female literacy is 76.08%. 57.47% of the total population is rural and 42.53% is urban. Out of the total population of 61,07,187 rural population is 3,509,814 and urban population is 2,597,373.

Nashik is well connected with major cities by road, rail and air transport. Nashik's Ozar Airport is situated 20km from Nashik.

Table 6.7: Demographic Features of Nashik District

DISTRICT: Nashik			
Total Area (sq. kms)	15,530	Male population	3,157,186
Population Density (persons/sq km.)	393	Female population	2,590,912
Population Growth (%)	22.30	Sex Ratio	934
Total Population	6,107,187	Literacy rate (%)	82.31

Table 6.8: Socio-Economic Features of Nashik District

S.No	Item	Unit	Nashik
1	District Area	sq. km	15,530
2	Tehsils	No.	15
3	Towns	No.	11
4	Villages	No.	1922
5	Households	No.	1,216,185
6	Decade Growth Rate	%	22.30
7	Main Workers	No.	2,523,023
8	Marginal Workers	No.	240,305
9	Non-workers	No.	3,343,859

6.3.4 Ahmednagar District

According to the 2011 census Ahmednagar district has a population of 4,543,159. Its headquarters are located in Ahmednagar City. Out of the total population males are 2,342,825 and females are 2,200,334. The area of the district is 17,048 sq. km and it constitute 4.04% of the population of Maharashtra. It has a population density of 266 inhabitants per square kilometer. It’s population growth rate over the decade 2001-2011 was 12.44%. Ahmednagar has a sex ratio of 939 females for every 1000 males and a literacy rate of 79.05% (higher than the national average of 74.04%). Male literacy is 86.82% and female literacy is 70.89%. 79.91% of the total population is rural and 20.09% is urban. Out of the total population of 4,543,159 rural population is 3,630,542and urban population is 912,617.

Ahmednagar is well connected with major cities by road, rail and air transport. Lohegaon Airport, Shiridi Airport and Nashik Airport are near to Ahmednagar.

Table 6.9: Demographic Features of Ahmednagar District

DISTRICT: Ahemednagar			
Total Area (sq. kms)	17,048	Male population	2,342,825
Population Density (persons/sq km.)	266	Female population	2,200,334
Population Growth (%)	12.44	Sex Ratio	939
Total Population	4,543,159	Literacy rate (%)	79.05

Table 6.10: Socio-Economic Features of Ahmednagar District

S.No	Item	Unit	Ahmednagar
1	District Area	sq. km	17,048
2	Tehsils	No.	14
3	Towns	No.	19
4	Villages	No.	1584
5	Households	No.	925,826
6	Decade Growth Rate	%	12.44
7	Main Workers	No.	2,039,455
8	Marginal Workers	No.	165,135
9	Non-workers	No.	2,338,569

6.4 ECONOMY

The economy of Gujarat is the third largest and Maharashtra is the first largest economy in India. In 2016-17, Uttar Pradesh's GSDP was ₹11.62 lakh crore (US$140 billion). According to 2011 census report Gujarat have 42.58% urban population. Maharashtra have 5,08,18,259 urban population while Gujarat have 2,57,45,083. Gujarat have 22 cities wherein Maharashtra have 34 cities with population more than one million. According to Tendulkar committee 16.63% population of Gujarat and 17.35% population of Maharashtra is poor in 2011-12.

7.DESIGN STANDARDS

7.1 Approach

The standards prescribed in IRC/ MORT&H / BIS are adopted in general. Where required under the TOR, the applicable sections of AASHTO/BS/ASTM are adopted for design.

Considering the physical condition and cost effectiveness, the improvement proposals are conceived and developed under following standards:

- The desirable standards which could be adopted as a rule
- The minimum standards, which could be accepted for difficult stretches where application of the desirable standards, would lead to exorbitant costs.

The above standards are in line with the IRC and other codal provisions as detailed here below.

7.2 Cross Sectional Elements

The cross-sectional elements are decided in accordance with IRC: SP: 87-2019.

7.2.1 General cross-sectional requirements

Cross section of Six lane sections of project highway will take into account the following general requirements:

- The developed cross sections for the carriageway as well as the service road will have operational safety in focus such as segregation, separation, turning radii, gradients, etc and provisions for various types of movements and maneuvers like merge, diverge, weave, etc will be comprehensively considered and provided for the project stretch.
- Provisions will be made in the cross-section for accommodating utilities both over as well as underground as the case may be. A Four meter wide strip of land at the extreme edge of ROW may be kept for accommodating utility services.

As far as possible, uniformity of design standards will be maintained throughout the length of the Project Highway. In case of any change, it shall be affected in a gradual manner.

7.2.2 Terrain

Terrain is classified by the general slope of the ground across the highway alignment as shown in Table – 7.1.

Table - 7.1: Terrain Classification

Terrain type	Percentage slope of the country
Plain	0-10
Rolling	10-25
Mountainous	25-60
Steep	>60

7.2.3 Design Speed

Design speed is one of the basic parameters, which determines geometric features of the road. The design speeds given in Table-7.2 will be adopted for various terrain conditions as per IRC: SP: 87-2019.

Table-7.2: Design Speed

Nature of Terrain	Cross slope of the ground	Design Speed (kmph)	
		Ruling	Minimum
Plain and Rolling	Up to 25 percent	100	80
Mountainous and Steep	More than 25 percent	60	40

Short stretches (say less than 1 Km) of varying terrain in the project stretch shall not be taken into consideration while deciding the terrain classification for a given section of Project Highway.

In general, the ruling design speed will be adopted for geometric design of the highway. Only in exceptional circumstances, minimum design speed may be adopted where site conditions are extremely restrictive and adequate land width is not available. Abrupt changes in design speed will be avoided.

7.2.4 Right of Way

A minimum Right of Way (RoW) of 70m is proposed for development of a 6-Lane Green Field Highway and Right of Way (RoW) of 150m is proposed at Tunnel Locations. Further the Consultants proposed to acquire the additional land for project facilities.

7.2.5 Lane width of Carriageway

The standard lane width of carriageway for the Project Highway shall be 3.5m.

7.2.6 Median

The median shall be either raised or depressed. The width of median is the distance between inner edges of carriageway. The type of median shall depend upon availability of Right of Way. The minimum width of median, subject to availability of Right of Way for various locations, shall be as in Table-7.3.

Table-7.3: Width of Median

Type of Section	Plain and Rolling terrain		Mountainous and Steep terrain
	Raised* (m)	Depressed median (m)	Raised*(m)
Open country with isolated built up area	5.0	7.0	2.5
Built up area	2.5	Not Applicable	2.5
Approach to Grade separated structures	5.0	Not Applicable	2.5

*Including Kerb shyness of 0.5 m on either side. In existing four lane with raised median to 6-laning project also minimum kerb shyness of 0.5 m shall be maintained from the vertical face exsisiting kerb, where median width shall be taken as 5.5m or 3m. The additional width of kerb shall be catered by augmenting carriageways towards shoulder side.

- The median shall have suitably designed drainage system so that water does not stagnate in the median. All median drains shall be of RCC type.
- In case of depressed median, a minimum 0.6 m width adjacent to carriageway in either direction is paved.
- As far as possible, the median will be of uniform width in a particular section of the Project Highway. However, where changes are unavoidable, a transition of 1 in 50 will be provided.

- In the case of depressed median, metal beam type (thrie beam-one side) crash barriers will be provided on either side of the median. No crash barrier is required if width of the median is more than 9m.

- For paved medians having width up to 2.5m Suitable anti glare measures such as plastic screens of total height 1.5m (including barriers) shall be provided to reduce headlight glare from opposite traffic. Where for unpaved medians wider than 2.5m suitable shrubs shall be planted.

7.2.7 Width of Shoulders

Width of shoulder on outer side of the carriageway shall be as given in Table-7.4 below.

Table - 7.4: Width of Shoulder

<table>
<tr><th rowspan="2">Type of Section</th><th colspan="2">Plain and Rolling Terrain</th><th colspan="3">Mountainous and Steep Terrain (Hilly Area)</th></tr>
<tr><th>Paved (m)</th><th>Earthen (m)</th><th>Side</th><th>Paved (m)</th><th>Earthen (m)</th></tr>
<tr><td>Open Country with isolated built-up area</td><td>1.5</td><td>2.0</td><td>Hilly</td><td>1.5</td><td>-</td></tr>
<tr><td>Built up area</td><td rowspan="2">2.0</td><td>-</td><td>Valley</td><td>1.5</td><td>1.0</td></tr>
<tr><td>Approach to grade separated structures</td><td>-</td><td>Hilly</td><td>0.25 + 1.5 (Raised)</td><td>-</td></tr>
<tr><td>Approach to bridges</td><td>1.5</td><td>2.0</td><td>Valley</td><td>0.25 + 1.5 (Raised)</td><td>-</td></tr>
</table>

- In case Retaining wall with parapet is provided on valley side, earthen shoulder may not be provided.

- Width of paved shoulder in approaches to grade separated structures as indicated in table above shall extend on either side of the structure upto 50m or the entire length of retaining RE walls.

- Where embankment is more than 6 m high, kerb with channel shall be provided at the end of paved shoulder to channelize the drainage as an erosion control device and earthen shoulder shall be raised to level of kerb.

7.2.8 Roadway width

- The width of roadway shall depend upon the width of carriageway, shoulders and the median.

- On horizontal curves with radius up to 300m, width of pavement and roadway shall be increased as per Table-7.5, given below.

Table-7.5 Extra width of pavement

Radius of Curve	Extra Width (m)
75 – 100 m	0.9
101 – 300 m	0.6

7.2.9 Cross fall

- The camber or cross fall on straight sections of road carriageway and paved shoulders of median shall be 2.5% for bituminous surface and 2% for CC pavement.
- Cross fall shall be uni-directional for each carriageway sloping towards the outer edge in straight stretches and towards lower edge on horizontal curves.
- The cross-fall for earthen shoulder is 0.5% steeper than that of the carriageway subject to a minimum of 3.0%. On super elevated sections, earthen portion of the shoulder on outer edge of the curve shall be provided with reverse crossfall of 0.5% so that earth does not drain on the carriageway.

7.3 Geometric Design

Geometric design of the highway, shall be in accordance with IRC: 73-1980, IRC: 38-1988 and IRC SP: 23-1983. Uniformity of design standards will be maintained throughout the length of Project Highway. All deficiencies in the existing highway geometry will be rectified to meet the minimum standards.

7.3.1 Horizontal Alignment

SUPER ELEVATION

Super elevation is generally considered to counteract only a fixed percentage of the centrifugal force developed, so that the slow moving traffic will be aided. The value of super elevation shall be limited to 7%, if radius of curve is less than desirable minimum radius. It shall be limited to 5%, if radius is more than desirable minimum. It is calculated by the following formula.

$e = V^2 / 225 R$

Where V is the design speed in kmph;

R is the radius in meters

RADII OF HORIZONTAL CURVES

The minimum and absolute minimum radii of horizontal curves for various classes of terrain are given in Table-7.6 as shown below.

Table-7.6: Radii of Horizontal Curves

Nature of Terrain	Desirable Minimum	Absolute Minimum
Plain and Rolling	400 m	250 m
Mountainous and Steep	150 m	75 m

The radius of horizontal curves for various terrain conditions shall not be less than the desirable minimum values given in the above table.

TRANSITION CURVES

All the curves are ensured for sufficient length with suitable transition lengths on either side for pleasing appearance. Long tangents exceeding 3 km are avoided.

SIGHT DISTANCE

The safe stopping sight distance and desirable minimum sight distance for six lane divided carriageway for various design speeds are given in Table-7.7. The desirable values of sight distance will be adopted for new carriage way. As a minimum, safe stopping sight distance will be adopted for the improvement of the existing carriageway.

Table-7.7: Safe Sight Distance

Design Speed (km/hr)	Safe Stopping sight distance (m)	Desirable minimum sight distance (m)
100	180	360
80	130	260
60	90	180
40	45	90

7.3.2 Vertical Alignment

- The vertical alignment will provide for a smooth longitudinal profile. Grade changes will not be too frequent as to cause kinks and visual discontinuities in the profile. In this regard, directions given in IRC:73-1980 will be kept in view.
- The ruling and limiting gradients are given in Table-7.8 below as per IRC: SP: 87-2019. Ruling Gradients will be adopted as far as possible. Limiting Gradient shall be adopted in difficult situations, and for short lengths.

Table-7.8: Recommended Gradients

Nature of terrain	Ruling gradient	Limiting gradient
Plain and Rolling	2.5%	3.3%
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

- Long sweeping vertical curves will be provided at all grade changes. These shall be designed as square parabolas.
- Design of vertical curves and their coordination with horizontal curves, shall be in accordance with the IRC: SP:23-1983
- Approach gradients for underpasses and flyovers is in no case steeper than 2.5%.
- On pavements in embankments camber is sufficient to drain storm water but in cut sections with kerbs min of 0.5% grade for lined drains and 1% for unlined drains shall be provided.

7.3.3 Widening of Curves

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passage of vehicles. The widening required has two components:

- Mechanical widening to compensate the extra width occupied by a vehicle on the curve due to tracking of the rear wheels, and
- Psychological widening to permit easy crossing of vehicles since vehicles in a lane tend to wander more on a curve than on a straight reach.

Based on the above considerations, the extra width of carriageway is provided at horizontal curves. For multi lane roads, the pavement widening may be calculated by adding half the widening for two lane roads to each lane.

7.3.4 Set-Back Distance at Horizontal Curves

Requisite sight distance is available across the inside of horizontal curves. Lack of visibility in the lateral direction may arise due to obstructions like walls, cut slopes, wooded areas, high crops etc. Set-back distance from the centre line of the carriageway within which the

offending obstructions should be cleared to ensure the needed visibility can be determined as given below.

$$m = R - (R - n) \cos\theta$$

Where $\theta = S/2(R-n)$ radians

m = the minimum set-back distance from the center line of the road to sight obstruction in meters at the middle of the curve

R = radius of center line of the road in meters

n = distance between the center line of the road and the inner lane in meters

S = sight distance in meters

7.3.5 Grade Compensation at Curves

At horizontal curves, the gradients should be eased by an amount known as the "Grade Compensation" which is intended to offset the extra tractive effort involved at curves. This may be calculated from the following formula:

Grade Compensation (%) = (30+R) / R, Subject to a maximum of 75/R,

where R is radius of curve in metres.

Since grade compensation is not necessary for gradients flatter than 4%, when applying grade compensation correction, the gradients need to be eased beyond 4%.

7.3.6 Geometric design requirement of additional features

(I) LATERAL AND VERTICAL CLEARANCE AT UNDERPASSES

Minimum Lateral and Vertical clearances at underpasses as given below shall be adopted.

Type of Underpass	Lateral clearance	Vertical Clearance
Vehicular Underpass(VUP)	20m	5.5 m
Light Vehicular Underpass (LVUP)	12m	4 m
Small Vehicular Underpass (SVUP)	7m	4m

(II) LATERAL AND VERTICAL CLEARANCE AT OVERPASSES

Lateral Clearance: Full Roadway width including service roads shall be carried through overpass. The abutments and piers are provided with crash barriers with suitable protection against collision of vehicles.

Vertical clearance: Minimum of 5m shall be provided at all points of carriageway and service roads of highway.

7.4 Access Control

Access to the Project Highway shall be partially controlled. In general access to the Project Highway shall be at the following locations.

- Intersection with National Highway
- Intersection with State Highway
- Intersection with Major District Road
- Intersection with Village Road and other District Roads, subject to a minimum distance of 3 km from the nearest intersection.

7.4.1 At Grade Intersections

- There shall be no at grade intersection of any road with main highway. But only with the service road. The intersection of project highway with another NH or SH shall be grade separated.
- Traffic pattern at all identified major junctions has been studied and necessities of acceleration and deceleration lanes would suitably be suggested. Geometric improvements would be carried out as per IRC SP: 41 – 1994 guidelines. Suitable drainage arrangement would also be suggested for effective drainage of surface

water.

- Intersection designs shall be as per the guidelines given in IRC SP:87-2019, Ministry of Surface Transport (MOST) "Type Designs for Intersections on National Highways", 1992 and on the basis of IRC: SP:41-1994.

7.4.2 Grade Separated Structures

The type, location, length, number and the openings required to be provided for various grade separated structures shall be as per IRC: SP: 87 -2019 for present Project Highway.

The geometric design standards for various elements of grade separators shall be as given in IRC:92-1985. The approach gradient to the grade separated structure shall not be steeper than 2.5 per cent (1 in 40).

7.5 Service roads

In open country with isolated built up area, the roadway width shall be 10 m minimum, where 7 m width of service road shall be provided with 1.5 m wide earthen shoulder on either side.

No service road is provided in built up area, but the min width of paved portion should be 7m and the rest of portion will be provided with Rcc/CC line drain-cum-footpath on ROW side

The following requirements as per IRC SP 87-2019 shall be applied

- Minimum design speed: 40 kmph
- Acceleration and Deceleration Lanes:
  1. Length: Designed for differential speed of 60 Kmph
  2. Width: 5.5m
  3. Taper at merge: 1 in 15 beyond design length

Wherever required, provision for parking bays of length 20 m and width 3 m shall be provided along the service road.

7.6 General Features Of Geometric Design

7.6.1 Median Openings

- Median openings shall not be less than 20m shall be provided for emergency and for repair/maintainance works with detachable guard barrier at spacing of 5km

7.6.2 Separator Footpath and Drain in Built-up areas

Raised Footpath of minimum width 1.5 m with kerb on either side (200 mm above road surface),drain pipes with minimum 10m interval and finished with cc paving blocks along with metal barrier shall be provided. The raised footpath shall be depressed at suitable intervals to provide for convenient use of physically challenged persons. The footpath will be designed for use of pedestrians and cyclists as per site requirements. Side drain and utility corridor can be accommodated either under footpath or separation-island between main carriageway and service road.

7.6.3 Utility Corridor

A 4.0 m wide strip of land at the extreme edge of RoW will be kept for accommodating utilities, both over as well as underground. Provisions contained in IRC 98-1997 will be followed to accommodate utility services in built-up areas of Project Highway. A utility duct in the form of 600 mm dia NP4 Pipe across the Project Highway at a spacing of 1.0 km will be proposed for crossing of underground utilities.

7.6.4 Capacity of Six Lane Highway

When project highway reaches the four lane capacity at LOS B shall be widened to Six lane i.e.,more than 40,000 PCU.

7.7 Embankment Design

7.7.1 General

The height of the embankment is decided based on the final road levels. The following principles have been followed for fixing the road level:

- No section of the road is over topped. Top of subgrade shall be at least 0.5 m above the general ground level.
- The bottom of sub-grade is at least 1.0 m above the high flood level/high water table/pond level.

7.7.2 Structural features and design of embankment:

- Embankment will be designed to ensure the stability of the roadway and shall incorporate only those materials, which are suitable for embankment construction.
- Side slopes will not be steeper than 2H: 1V and where necessary, the embankment will be retained by a retaining structure in accordance with specification.
- Where the embankment is to be supported on a weak stratum it will be necessary to specially design the embankment and also adopt appropriate remedial / ground improvement measures.
- High embankments (height 6 m or above) in all soils will be designed from stability considerations. For design of high embankments, IRC:75-1979 and MORTH – Guidelines for Design of High Embankments may be referred to.

- The side slopes will be protected against erosion by providing turfing / vegetative cover, stone/C.C. block pitching, geo-synthetics, gabion walls or any other measures depending on the height of the embankment, type of soil involved and susceptibility of soil to erosion as per IRC:56-1974. Pitching works on slopes shall be as per MORTH Specifications.
- In high rainfall areas where soil is susceptible to erosion, before providing turfing on slopes and shoulders, a coir or jute blanket shall be placed on such slopes and shoulders immediately after completion of work.
- Pond ash is used for embackment construction in pursurance of the instructions of Ministry of Environment and Forests or otherwise, the embackment shall be designed and constructed in accordance with IRC:SP:58.

7.8 Pavement Design

7.8.1 Flexible Pavement

Flexible pavement shall be designed in accordance with IRC:37-2018 for a minimum design period of 15 years or operation period, whichever is more. Stage construction will be permissible subject to the requirements specified below:

Alternative strategies or combination of initial design, strengthening and maintenance can be developed by the concessionaire to provide the specified level of pavement performance over the operation period subject to satisfying the following minimum design requirements.

- The thickness of sub-base and base of pavement sections is designed for a minimum design period of 15 years and the initial bituminous surfacing for a minimum design period of 10 years.
- The pavement shall be strengthened by bituminous overlay as and when required to extend the pavement life to full operation period.

7.8.2 RIGID PAVEMENT

- Rigid pavement shall be designed in accordance with IRC:58-2015 for a minimum design period of 30 years. Stage construction shall not be permitted.
- PQC shall rest of DLC sub-base of 150 mm thickness.
- Separation membrane shall be used between PQC and DLC as per clause 602.5 of MORTH specifications
- DLC shall meet minimum strength requirements as per IRC:SP:49 and shall extend beyond PQC by 0.75 m on either side.
- Below DLC layer, properly designed drainage layer GSB of 150 mm shall be provided throughout road width.

7.8.3 Design Traffic

- The design traffic shall be estimated in terms of cumulative number of standard axles (8160 kg) to be carried by the pavement during the design period.
- Initial daily average traffic flow shall be based on at least 7 days, 24 hr classified traffic counts. IRC: 9-1972 may be used as guidance for carrying out the traffic census. Any likely change in traffic due to proposed improvement of the facility and/or future development plans, land use, shall be duly considered in estimating the design traffic.
- The design traffic for service roads shall be ten million standard axles respectively. The crust composition shall be provided accordingly.

7.8.4 Sub-grade

Sub-grade whether in cut or fill shall meet the requirements stipulated in clause 305 of MORTH specifications. The thickness of sub-grade shall not be less than 500 mm.

7.9 Drainage Design

Design and construction of surface and subsurface drains for highway drainage and drainage of structures shall be carried out in accordance with the requirements of IRC SP:87-2019, Clause 309 of MORTH specifications, IRC SP:42, IRC SP:50 and IRC SP:90.

- Selection of type of roadside drains shall be based on the magnitude and duration of flow. The road side drains shall be designed based on principles of Open Channel flow. Longitudinal slope shall not be less than 0.3% for lined drains and 1% for unlined drains.
- In case of depressed median, longitudinal drain shall be provided to drain off water.
- In super elevation sections, covered longitudinal and cross drains shall be provided.
- The side slopes of unlined drains shall be as flat as possible and shall not be steeper than 2H:1V
- RCC/CC Drains are provided in builtup areas where if flow velocity is more than 1 m/s in silt and more than 1.5 m/s in stiff clay

DRAINAGE WHERE EMBANKMENT HEIGHT IS MORE THAN 6m

- In embankments where height exceeds 6.0m, special arrangement for protection of embankment slopes shall be essential in order to ensure that embankment slopes maintain their shape during monsoon season.
- Drainage arrangement shall include a system consisting of providing kerb with channel at the edge of the paved shoulders and provision of chute drains along the slopes at designed intervals with energy dissipation basin and protection of side channels by turfing or vegetation.
- Catch water drains shall be provided on hill slopes, if any, above cutting in trapezoidal shape with stone lining.
- Sub base shall be extended across the shoulders for efficient internal drainage of pavement
- Suitable filter or granular material or geo textiles to act as filtration and separation layer shall be incorporated, wherever necessary, between the subgrade and sub base to prevent clogging.
- Effective drainage shall be provided both longitudinally and transversely for structures. Transverse drainage shall be secured by means of suitable camber in the roadway surface. Longitudinal drainage shall be secured by means of scuppers, inlets, or other suitable means of sufficient size and numbers to drain the run off efficiently.

- When highway runs parallel to existing channels, adequate measures shall be taken in the form of bank protection and channel alignment to avoid water build up or stagnation against the highway slope endangering the pavement drainage.

7.10 Design of Structures

7.10.1 General

The data collected from the detailed surveys and investigations and the results derived from analysis of the data forms the basis of all the engineering designs. The designs would be developed within the parameters of the design criteria and standards specified herein.

The engineering designs covering all the elements of construction of new bridges and widening are included in the Detailed Project Report (DPR). The salient features and methodology of the design are explained in the following paragraphs.

7.10.2 General Arrangement of Proposed New Bridges

A. SPAN ARRANGEMENT

The span arrangements of the new bridges is kept same as those of the existing bridges except where increase in waterway is required. Increasing spans by omitting piers results in increase in depth of superstructure, thereby causes reduction in the vertical clearance above HFL unless the formation level is raised. It is important to maintain adequate free board above HFL.

The inventory of the existing bridges, topographic survey, hydrological investigation and geo-technical investigation formed the basis for the development of the general arrangement of the bridges proposed for reconstruction.

B. FORMATION LEVEL

In fixing the profile of the existing road, the top levels of minor bridges and slab culverts have been considered as obligatory points. However, the vertical clearance above HFL for each of the bridges is checked against the hydrological analysis before finalising the finished formation level of proposed bridges.

C. TYPE AND DEPTH OF FOUNDATION

Type and depth of foundation is decided based on geotechnical investigation and report. Wherever rock or suitable soil for foundation is found at shallow depth, open foundations are provided. Pile foundation or other suitable deep foundation are provided where rock or suitable soil is found at a greater depth.

D. TYPE OF SUPERSTRUCTURE

RCC Solid Slabs, RCC T-beam and slab, PSC T- Beam and Slab and PSC Box girder superstructure will be considered based on the span lengths. The following criteria,

in general, is followed while deciding type of superstructure for various bridges:

Type of Superstructure	Span Length
i) RCC solid slab	5m to 10m
ii) RCC T-beam and slab	11m to 25m
iii) PSC T- beam and Slab	25m to 35m
iv) PSC Box girder	>35m

The depth of superstructure is decided based on structural considerations and also keeping in view the minimum free board above HFL and the road formation levels.

E. MISCELLANEOUS DETAILS

For the design of superstructure elements, flexure and shear checks are carried out as per IRC Codes of practices.

The minimum cross sectional dimensions of each component are provided so as to satisfy the requirements specified in relevant IRC Code.

7.10.3 Design Codes and Criteria

Design Codes of Practices that will be used for this project are mentioned below:

- IRC: 5-1998- Standard Specification and Code of Practice for Road Bridges, Section I- General Features of Design
- IRC: 6-2014- Standard Specification and Code of Practice for Road Bridges, Section II- Loads and Stresses
- IRC: 112-2011- Code of Practice for Concrete Road Bridges
- IRC: 78-2014- Standard Specification and Code of Practice for Road Bridges, Section VII- Foundations and Substructure
- IRC: 83-1987 (Part II)- Standard Specification and Code of Practice for Road Bridges, Section IX- Bearings, Part- II: Elastomeric Bearings
- IRC: 83-2002 (Part III)- Standard Specification and Code of Practice for Road Bridges, Section IX- Bearings, Part- III: POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings.
- IRC: SP-87:2019- Manual of Specifications and Standards for Six Laning of Highways through Public Private Partnership.
- IRC: SP-13-1988- Guidelines for the Design of Small Bridges and Culverts
- IRC: SP-40-1993- Guidelines on Techniques for Strengthening and Rehabilitation of Bridges
- IRC: 89-1997- Guidelines for Design and Construction of River Training and Control Works for Road Bridges
- IS: 2911-1979- Code of Practice for Design and Construction of Pile Foundations.

7.10.4 Design Considerations

7.10.4.1 GENERAL

- The design loads and load combinations are considered in accordance with IRC:6-2014 appropriate for the width of carriageway, type and properties of stream, location, altitude, etc.
- All concrete structural elements will be designed in accordance with IRC: 112- 2011.
- All composite steel structures for Road over Bridges (ROBs) are designed in accordance with RDSO guidelines and pertinent IRC standards.
- Where footpaths are provided on bridges, the live load intensity on load carrying members is taken as maximum of that with and without the footpaths. Also design must be checked for the condition when footpath is used as carriageway.

- Construction of structures shall conform to Fifth Edition of MORTH specifications for Road and Bridge Works.
- The design has taken into account long term durability, serviceability, constructability, construction methodology and environmental factors.
- All the components of structures are designed for a service life of 100 years except appurtenances like crash barriers, wearing surface and rubberised components in expansion joints and elastomeric bearings.
- All the structures will have adequate waterway, not less than that of existing bridge. The design discharge is evaluated for 50-year return period.
- Subsequent articles deal with various considerations for design of bridges comprising materials, loads and load combinations, exposure condition, reference codes and standards, cover to reinforcement, design methodology, etc.

7.10.4.2 MATERIALS

A. CONCRETE

All RCC members are of grade M25 and M30; PCC members are of M25/M15 and PSC members are of M35/M45.

Cofficient of Thermal Expansion	11.7x 10-6/°C as per IRC: 6- 2014
Poisson's Ratio	0.2
Modulus of Elasticity	As per Table A4.2 of IRC: 112- 2011 for RCC members
Creep & Shrinkage	As per IRC: 112- 2011 for Coefficient & time effects

B. REINFORCEMENT

The reinforcement conforms to the following specifications:

- Cold-twisted bars conforming to IS: 1786 – 1979 (Grade Designation S 500)
- Pre- stressing Steel System
- All ducts and anchorages shall be suitable for 19T13 stress relieved low relaxation strands conforming to IS: 14268 – 95.
- Structural Steel
- Structural steel shall conform to IS: 226 with yield stress of 23.6 Kg/cm^2.

Cover to Reinforcement shall conform to Clause 14.3.2 of IRC: 112- 2011, corresponding to moderate exposure condition.

- Foundation: 75mm
- Sub-structure: 50mm
- Superstructure: 40 mm

C. BEARINGS

POT–PTFE, Elastomeric or Tar Paper bearings are provided depending upon the requirement of new bridges

- Expansion Joints
- Strip Seal type of expansion joint (40mm) is proposed for RCC T- Girder and PSC T-girder type superstructures;
- Compressible Filler Board type of expansion joint (20mm) is proposed for RCC Box type structure.

D. BUOYANCY

100% buoyancy is considered while checking stability of foundations irrespective of their resting on soil/weathered rock/ hard rock. However, the maximum base pressure is checked under an additional condition with 50% buoyancy in cases where foundation is embedded into hard rock. Pore pressure uplift is limited to 15% while checking stresses of the substructure elements.

E. EXPOSURE CONDITIONS

Moderate exposure condition is considered in design of structures.

F. DURABILITY AND MAINTENANCE CONSIDERATIONS

In order to keep maintenance to a minimum during the operation, materials resistant to aggressive conditions are utilised. Access to critical points of the structure shall be facilitated. Provision for replacement of bearings, expansion joints and parts having reduced design life shall be ensured. Quick collection and disposal of water shall be ensured.

7.10.4.3 LOADS AND LOAD COMBINATIONS

A. DEAD LOADS

Following unit weights are considered for dead load computations in the design:

- Reinforced Concrete: 25.0 kN/m^3

- Pre-stressed Concrete: 25.0 kN/m^3
- Plain Concrete: 22.0 kN/m^3
- Structural Steel: 78.5 kN/m^3
- Wearing Coat: 22.0 kN/m^3

B. SUPER IMPOSED DEAD LOADS

WEARING COAT

Cement concrete wearing coat shall be laid over the bridge deck. The thickness of wearing coat shall be 75mm. The concrete shall be of M30 grade. Steel reinforcement of 8mm diameter at 150mm spacing in both directions shall be provided at mid depth of the wearing coat. In a length of 1.0m near the expansion joint additional reinforcement of 8mm diameter bars shall be provided in both directions to make the spacing as 75mm. Loading is considered accordingly.

CRASH BARRIER

Concrete crash barriers are 500 mm wide and are provided adjacent to the carriageway on either side. Loading will be considered accordingly.

C. CARRIAGEWAY LIVE LOADS

Bridges are designed for the worst effect of the following carriageway live loads:

- One/ Two/ Three lanes of IRC Class A loading; and
- One lane of IRC Class 70R loading (Wheeled/ Tracked).
- One lane of 70R loading with one lane of Class A loading

D. PEDESTRIAN LIVE LOADS

The pedestrian live load is taken as per Clause 206 of IRC: 6 – 2014 where required. The basic intensity of live load is considered as 500 Kg/m^2. However for design of bridges, the vehicular live load is considered on footpath to get the worst effect on structure.

E. LONGITUDINAL FORCES DUE TO BEARING FRICTION

Longitudinal force due to bearing friction is considered as per Clause 211 of IRC: 6 – 2014.

F. HORIZONTAL FORCES DUE TO WATER CURRENTS

The water current forces are taken as per Clause 210 of IRC: 6– 2014.

G. SEISMIC LOADING

The bridges come under Seismic Zone- II as well as III as per the relevant IRC code. As per the code, seismic force needs to be considered only for those bridges having span greater than 15m or overall length of the bridge is more than 60m. However, for design of structures seismic forces are considered for all the bridges.

H. WIND LOADING

Wind loading is considered as per Clause 209 of IRC: 6– 2014.

I. TEMPERATURE LOADING

The superstructure is designed for effect of distribution of temperature across the depth of superstructure as given in Clause 215 of IRC: 6– 2014.

J. LOAD COMBINATIONS

All members are designed to sustain safely the most critical combination of various loads and forces that can co-exist. The various load combinations and corresponding permissible increase in stresses is as per Clause 202 of IRC: 6 – 2014 and Clause 706 of IRC: 78 – 2014.

7.10.5 Width of Structures

- The width of the culverts shall be equal to roadway width of the approaches. The outer most face of railing/ parapet shall be in line with the outer most edge of shoulder.
- All bridges shall have a footpath on left side of the traffic direction. The overall width of new bridges with a footpath on left side shall be same as the roadway width of approaches. The crash barrier shall be provided at the edge of the paved shoulders with 0.25m shy distance.

7.11 Traffic Control Devices

7.11.1 Road Signs

- Three types of road signs *viz*., Mandatory, cautionary and Informatory shall be provided and guidelines given in IRC 67-2012, clause 800 of MORTH specifications shall be kept in view.
- All signs are placed on the left hand side of the road. Where extra emphasis is warranted, they may be duplicated on the right hand side as well.
- On non-kerb side, the extreme edge of the sign is 1.5 m – 2.0 m from the edge of the carriageway. On kerb portion, it shall not be less than 60 cm from the edge of the kerb.

7.11.2 Road Marking

Provisions have been made for center and edge road marking with hot applied thermo plastic paint glass reflectorizing beads as per relevant specification. This would help reduce road accidents. Road studs shall also be provided in addition to pavement marking for better visibility during night. Guidelines given in IRC 35 shall be used for providing these facilities.

7.11.3 Road Delineators

These are roadway indicators, hazard markers and object markers. The design shall conform to the recommendation made in IRC-79 and IRC 67. Reflective Chevron signs at curves shall also be provided.

7.12 Toll Plaza

Toll Plaza shall be designed to permit the provision of toll lanes for a projected peak hour traffic of 20 years subject to a minimum number of 16 toll lanes including all other buildings and structures to be accommodated.

Specifications given in IRC SP:87-2019 for layout and design of toll plaza shall be followed.

7.13 Project Facilities

7.13.1 Pedestrian facilities

There shall be no pedestrian crossings across the carriageway. Facility for crossing the carriageway by the pedestrians shall be provided through pedestrian underpasses/FOB as per the guidelines given in IRC SP:87-2019. Sidewalks wherever provided, width shall not be less than 1.5m.

7.13.2 Busbays

Busbays shall be located only near pedestrian underpass/ overpass locations. The layout and design of bus bays with shelters shall be as per the specifications given in IRC SP:87-2019

7.13.3 Truck Laybyes

Truck laybyes, in general, shall be located near check barriers, interstate borders, places of conventional stops of the truck operators etc. The places shall be identified on the basis of field survey. Adequate space for facilities and future growth shall be allocated.

7.13.4 Rest Areas

Rest Areas with minimum facilities shall be provided keeping in view the expected peak hour traffic, Conccesionaire on lands included in site and procured by authority.

7.14 Design Standards Adopted:

S.No	Description	Details for Project road
1	Design Speed	100 Kmph

<table>
<tr><th>S.No</th><th colspan="2">Description</th><th colspan="2">Details for Project road</th></tr>
<tr><td>2</td><td colspan="2">Right of Way</td><td colspan="2">70 m- 6 lane Greenfield Alignment
150m – Tunnel Location</td></tr>
<tr><td>3</td><td colspan="2">Lane width</td><td colspan="2">3.5 m</td></tr>
<tr><td>4</td><td colspan="2">Median including Shyness</td><td colspan="2">5.00 m</td></tr>
<tr><td>5</td><td colspan="2">6-Lane carriageway</td><td colspan="2">21.00 m</td></tr>
<tr><td>6</td><td colspan="2">Paved Shoulder (Plain and Rolling Terrain)/Edge Strip</td><td colspan="2">Nil / 0.5m on Either Side</td></tr>
<tr><td>7</td><td colspan="2">Earthen Shoulder</td><td colspan="2">3.5 m</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Camber</td><td>C/W & PS</td><td colspan="2">2.50%</td></tr>
<tr><td>Earthen shoulder</td><td colspan="2">3%</td></tr>
<tr><td>9</td><td colspan="2">Utility Corridor</td><td colspan="2">4.00 m</td></tr>
<tr><td>10</td><td colspan="2">Maximum super-elevation</td><td colspan="2">5.00%</td></tr>
<tr><td>11</td><td colspan="2">Safe Stopping Sight Distance (SSD)</td><td colspan="2">180 m</td></tr>
<tr><td>12</td><td colspan="2">Desirable Minimum Sight Distance (ISD)</td><td colspan="2">360 m</td></tr>
<tr><td>13</td><td colspan="2">Desirable minimum radius of horizontal curve</td><td colspan="2">400 m</td></tr>
<tr><td rowspan="2">14</td><td rowspan="2">Min. longitudinal slope for Drain</td><td>Lined</td><td colspan="2">0.2%</td></tr>
<tr><td>Unlined</td><td colspan="2">0.3%</td></tr>
<tr><td>15</td><td colspan="2">Ruling gradient</td><td colspan="2">2.5%</td></tr>
<tr><td>16</td><td colspan="2">Minimum length of vertical curve</td><td colspan="2">60 m</td></tr>
<tr><td>17</td><td colspan="2">Minimum Height of Embankment</td><td colspan="2">Top of Sub-grade is minimum 1.5 m above the High Flood Level/Water Table/Pond Level.</td></tr>
<tr><td rowspan="5">18</td><td colspan="4">clearance</td></tr>
<tr><td colspan="2">Type of Underpass</td><td>Vertical Clearance(m)</td><td>Horizontal Clearance(m)</td></tr>
<tr><td colspan="2">SVUP</td><td>4.0</td><td>7</td></tr>
<tr><td colspan="2">LVUP</td><td>4.0</td><td>12</td></tr>
<tr><td colspan="2">VUP</td><td>5.5</td><td>20</td></tr>
</table>

8.TRAFFIC SURVEY AND DEMAND ASSESMENT

8.1 General

An accurate estimate of the traffic that is likely to use the project road is very important as it forms the basic input in planning, design, operation and financing. A thorough knowledge of the travel characteristics of the traffic likely to use the project road as well as other major roads in the influence area of the study corridor is essential for future traffic estimation. The estimation of revenue through toll collection is important to assess the financial viability of the project and to finalize the financial covenants for the concession agreement. Thus, accurate assessment of the existing traffic and forecasting attains utmost importance in the project planning phase. Hence, detailed traffic surveys were carried out to assess the baseline traffic characteristics on the project road. This chapter deals with the traffic studies undertaken and the analysis conducted thereafter.

8.2 Location of the Project

The project corridor Surat-Nasik-Ahmednagar is chosen as one of the direct connectivity routes of Indian Cities. The Green field alignment starts from proposed Vadodara – Mumbai Expressway of Navsari District near to Toli village in the state of Gujarat with start Design chainage Km.0+000 and ends at road connecting NH-61 near Sarolabaddi village in Ahmednagar District (Des. Ch 290+700) in the State of Maharashtra. The Proposed Alignment passes through rural, semi urban and urban sections such as Sarpor, Dabhalal, Surkhai, kukeri, Mama bacha, Bendwal, Ambedgoan, Adgoan, Telegoan, Rahuri, Khadambe Bk, Vambori etc. with fair geometrics. All the built-up locations are densely populated consisting of residential and commercial structures abutting to proposed alignment. Major part of the stretch traverses through plain terrain with a mixed land use of agricultural, barren, residential and commercial. The project corridor passes through rural, urban and semi urban areas. The Index map of the project stretch is shown in the Appendix -1.

Table-8.1: Details of the Project stretch

S. No	Design Chainage (Km)		Length (Km)	Stretch
	From	To		
1	0.000	290.700	290.700	Surat – Nashik - Ahmednagar

Table-8.2: Location and Chainage of the Project stretch

S.No	Stretch Name	Chainage (Km)		Geographic Coordinates(UTM)	
		From	To	Start	End
1	Surat-Nashik-Ahmednagar Greenfield stretch	0.000	290.700	20°55'17.68"N 73° 3'47.52"E	19° 4'27.69"N 74°50'51.80"E

8.3 Objectives

The primary objectives of these traffic studies are to:

- Determine characteristics of traffic movement and to establish base year traffic demand
- Identify zones of influence for the project stretch and extent of influence based on O-D Survey.
- Determine travel pattern as well as type and weight of commodities carried by goods vehicles.
- Capacity assessment and recommendation for number of lanes based on demand forecast and evolving suitable design there for
- Geometric design of intersections
- Determination of Vehicle Damage Factor as an aid to pavement design
- Cost benefit and financial analysis
- Environmental impact assessment
- Enable preliminary design of the project facilities

8.4 Scope of the Study

The scope of traffic study includes the analysis of the primary data collected from traffic surveys and collection of secondary sources including petrol sales data, to determine the seasonal variation and truck parking surveys. Vehicle Damage Factor is assessed from the Axle Load Survey to design of pavement layers. To determine the capacity and level of service of the project corridor, the following parameters are assessed:

- Average Daily Traffic, Annual Average Daily Traffic, Peak Hour Factor and Seasonal
- Correction Factor of the Base Year
- Traffic Growth Rates
- Travel pattern, major origin and destinations, and influencing zones
- Axle load survey

8.5 Traffic Surveys Planning Schedule

During the reconnaissance survey, the existing road network was studied. As per the details given in TOR mid-block sections were identified for carrying out traffic surveys and all other locations of traffic surveys were finalized in consultation with the Authority. Traffic Surveys Planning Schedule is presented in **Table-8.3.**

Table-8.3: Schedule and Location of Traffic surveys

S.No	Type Of Survey	Location	Chainage (km)	Highway	Duration Of Survey	Date Of Survey
1	Classified Traffic Volume Counts	Vapi	359.600	NH-48	7 Days	03-12-2018 to 09-12-18
		Manekpore	75.800	NH-53		02-12-2018 to 08-12-18
		Tankal	6.400	SH-177		03-12-2018 to 10-12-2018
		Sinnar	178.400	NH-60		02-12-2018 to 08-12-2018
		Pimpri Nirmal	106.800	NH-160	3 Days	06-12-2018 to 08-12-2018
2	OD Survey	Bagwadi	356.900	NH-48	24 Hours	08-12-2018
		Manekpore	75.800	NH-53		11-12-2018
		Tankal	6.400	SH-177		07-12-2018
		Sinnar	178.400	NH-60		04-12-2018
		Pimpri Nirmal	106.800	NH-160		05-12-2018
3	Axle Load Survey	Bagwadi	356.900	NH-48	24 Hours	08-12-2018
		Manekpore	75.800	NH-53		11-12-2018
		Tankal	6.400	SH-177		07-12-2018
		Sinnar	178.400	NH-60		04-12-2018
		Pimpri Nirmal	106.800	NH-160		05-12-2018
4		Bagwadi	356.900	NH-48	24 Hours	10-12-2018

S.No	Type Of Survey	Location	Chainage (km)	Highway	Duration Of Survey	Date Of Survey
	Number Plate Survey	Manekpore	75.800	NH-53		11-12-2018
		Tankal	6.400	SH-177		10-12-2018
		Sinnar	178.400	NH-60		07-11-2018
		Pimpri Nirmal	106.800	NH-160		05-12-2018

The Automatic Classified Traffic Volume Count (ATCC) surveys were conducted at 5 strategic points, i.e., at Km 359.600 (Bhagwadi toll plaza of Surat-Mumbai Stretch) on NH-48, at Km 75.800 (Manekpore of Surat-Bajipura Stretch) on NH-53, at Km 6.400(Tankal of Tankal-Rankuva Stretch) on SH-177, at km 178.400 (Sinnar of Pune-Nashik Stretch) on NH-60 for 7 days and at km 106.800 (Pimpri Nirmal of Shiridi- Ahmednagar Stretch) on NH-160 for 3 days. The surveys were conducted using Pneumatic tubes and video graphic methods.

Axle load Survey and Origin-Destination & Commodity Movement Survey by Road Side Interview (RSI) method were conducted at Five locations i.e., at Km 356.900 (Bhagwadi toll plaza of Surat-Mumbai Stretch) on NH-48, at Km 75.800 (Manekpore of Surat-Bajipura Stretch) on NH-53, at Km 6.400 (Tankal of Tankal-Rankuva Stretch) on SH-177, at km 178.400(Sinnar of Pune-Nashik Stretch) on NH-60 and at km 106.800 (Pimpri Nirmal of Shiridi-Ahmednagar Stretch) on NH-160 for 24 hrs.

Traffic Locations are presented in below mentioned Map.

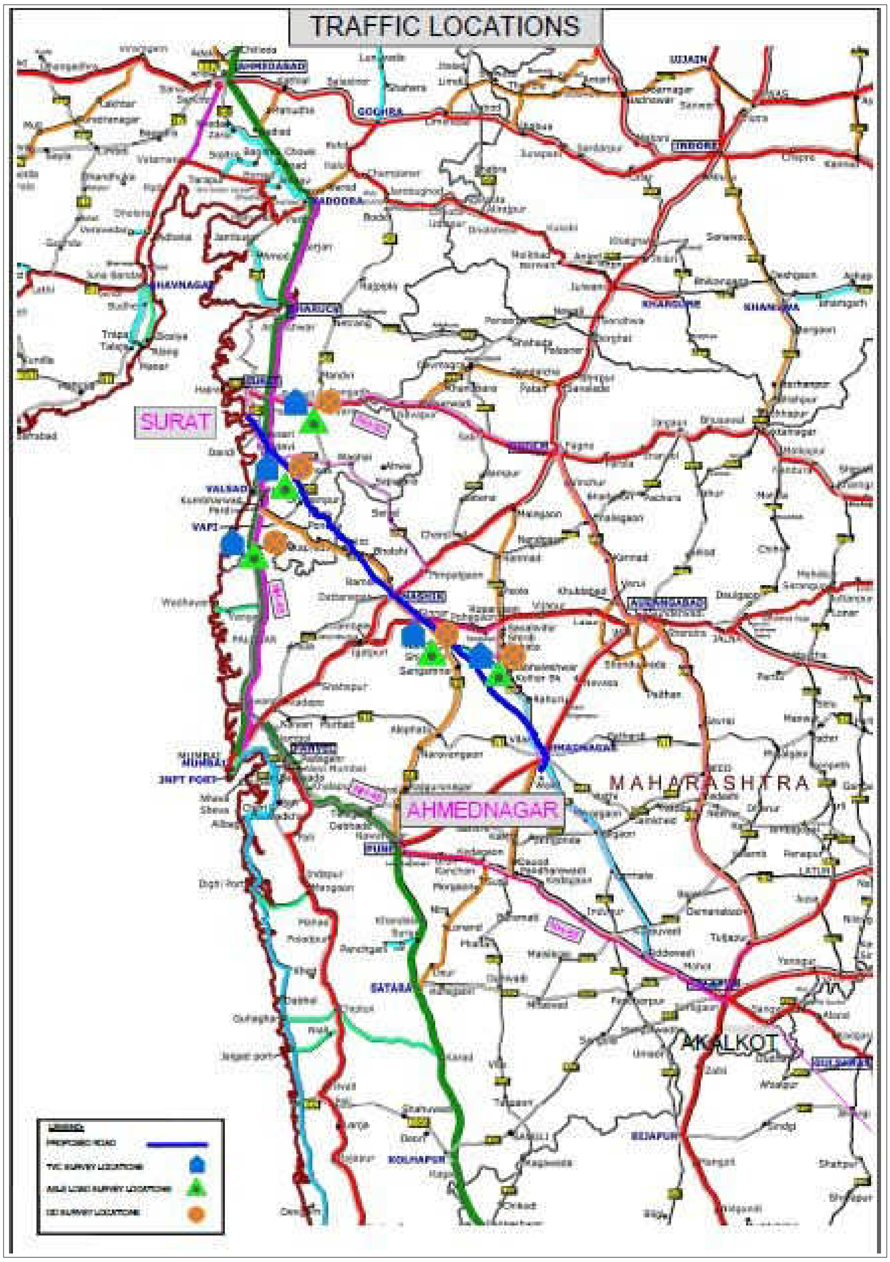


Figure-8.1 (a): TVC locations

8.6 Homogeneous Traffic Sections

Traffic homogeneous sections were identified based on the major traffic generating and diversion locations(i.e., Inter changes) along the project corridor. As per the observed patterns of commercial vehicle distribution, and also the passenger traffic volume that varies with the presence of important towns, habitations and educational institutions along the corridor, the project stretch was divided into 11 legs based on Interchange Proposals.

Based on the calculated diverted traffic PCUs/Day on each The Total project stretch is divided into 2 Homogeneous Sections (HS-1 from Surat to Nashik & HS-2 Nashik to Ahmednagar Sections)

Table-8.4: Homogeneous Sections

S.No	Homogeneous Section	From (Km)	To (Km)	Length (Km)
1	HS-1 (Surat-Nashik Section)	0.000	139.000	139.000
2	HS-1 (Nashik-Ahmedngar Section)	139.000	290.700	151.700

Homogeneous Sections represented in below mentioned figure.

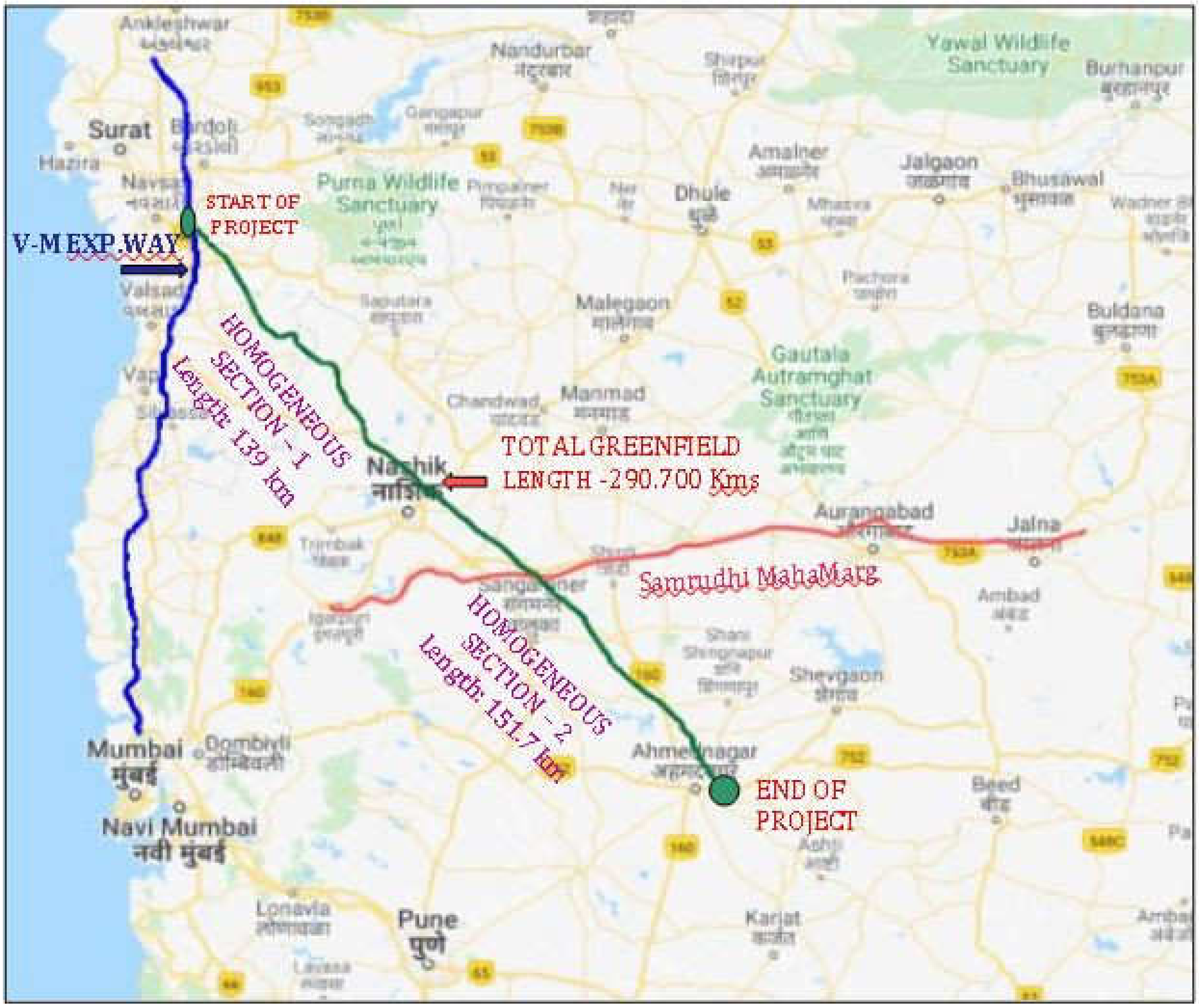


Figure-8.1 (b): Homogeneous Sections

8.7 Average Daily Traffic (ADT)

The various vehicle types having different sizes and characteristics were converted into a standard unit called passenger car unit (PCU). Passenger Car equivalents for various vehicles were adopted based on recommendations of Indian Road Congress prescribed in "Guidelines for Capacity of Roads in Rural areas", IRC:64-1990. The passenger car unit values (PCU) which were adopted are presented in **Table-8.4**. The information derived from the surveys was utilized to obtain traffic intensity, traffic composition, hourly variation and daily variations and peak hour characteristics.

Table-8.5: Passenger Car Unit Factors for various vehicle types*

Vehicle Type	Equivalent PCU factors	Vehicle Type		Equivalent PCU factors
Two Wheelers	0.5	Two Axle		3
Three Wheelers	1	Three Axle		3
Car / Jeep / Van	1	Multi Axle		4.5
Car (Yellow Board)	1	Heavy Earth Moving		4.5
Tata Magic	1	LCV/ LGV		1.5
RTC Bus	3	Mini LCV		1
Private Bus	3	Tractor		1.5
School Bus	3	Tractor with trailer		4.5
College Bus	3	Non Motorised	Cycle	0.5
Mini Bus	1.5		Cycle Rickshaw	2
Three Wheeler (Goods)	1		Animal Drawn	8

***Source: IRC:64-1990**

Figure-8.1: Automatic Traffic Classifier and Counter installed at TVC locations

The Average Daily Traffic (ADT) was obtained from the Classified Traffic Volume Count to determine the characteristics of traffic movement and to establish base year traffic demand on the project corridor. The data collected from primary and secondary sources were recorded in worksheets, compiled, checked and corrected before further proceeding for analysis. Traffic data analysis was carried out, to understand the traffic characteristics and travel pattern in the study area and to provide basic input for pavement design. Average Daily Traffic(ADT) for two Classified Traffic Volume locations are given in Table-8.5. The detailed calculations are presented in Annexures – I(a),I(b),I(c),I(d)&I(e).

Table-8.6: ADT for the Five survey locations of TVC

Vehicle Type	(Surat-Mumbai) Km 356.900 NH-48	(Surat-Bajipura) Km 75.800 NH-53	(Tankal-Rankuva) Km 6.400 SH-177	(Pune-Nashik) Km 178.400 NH-60	(Shiridi - Ahmednagar) Km 106.800 NH-160
Two Wheelers	24230	4637	4774	6904	1107
Three Wheelers (Passenger)	4319	227	143	50	328
Car	25500	6386	2781	7057	7031
Tata Magic	21	9	7	10	266
RTC Bus	236	321	22	520	378
Private Bus	798	259	53	189	337
Mini Bus	249	49	16	60	235
School/ College Bus	99	3	5	13	30
Two Axle	2967	660	199	1128	424
Three Axle	3129	804	82	780	591
Multi Axle	7735	2070	91	680	1788
HEM	32	2	2	2	4
LCV	5983	668	402	1562	421
Mini LCV	2547	664	448	1819	1112
Tractor	15	12	13	11	20

Vehicle Type		(Surat-Mumbai) Km 356.900 NH-48	(Surat-Bajipura) Km 75.800 NH-53	(Tankal-Rankuva) Km 6.400 SH-177	(Pune-Nashik) Km 178.400 NH-60	(Shiridi - Ahmednagar) Km 106.800 NH-160
Tractor with Trailer		51	11	19	121	50
Three Wheeler (Goods)		396	57	28	47	117
Bicycle		256	78	200	9	322
Cycle Rickshaw		13	7	2	0	0
Animal Drawn		4	0	2	0	0
Government Exempted		61	11	13	15	15
Vehicles	Motorised	78368	16870	9177	20968	24254
	Non Motorised	273	85	204	9	322
	Total Traffic	78641	16955	9381	20977	24576
	Tollable Traffic	49296	11915	4108	13820	12627
PCU	Motorised	111255	26309	8407	26417	29025
	Non Motorised	186	53	120	5	161
	Total Traffic	111441	26362	8527	26422	29186
	Tollable Traffic	94057	23622	5368	22282	22754

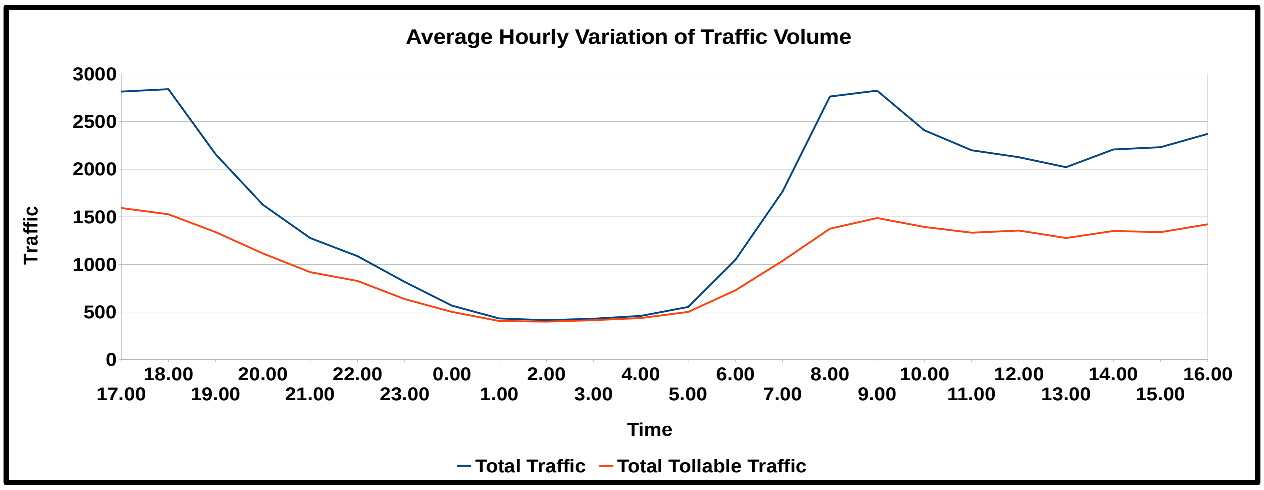


Figure-8.2: Average Hourly Traffic Variation at Km 356.900 on NH-48 at Vapi

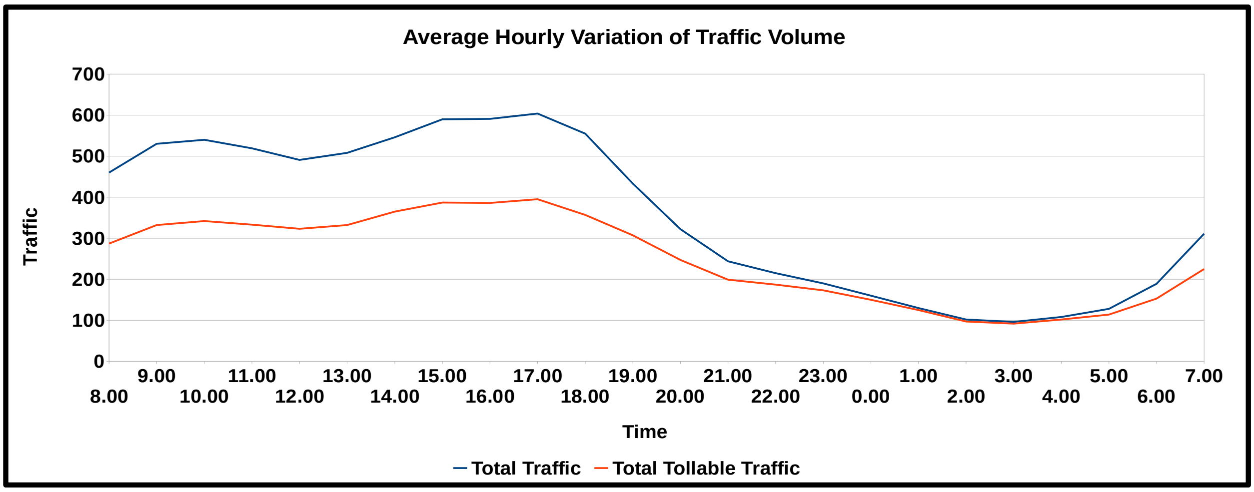


Figure-8.3: Average Hourly Traffic Variation at Km 75.800 on NH-53 at Manekpore

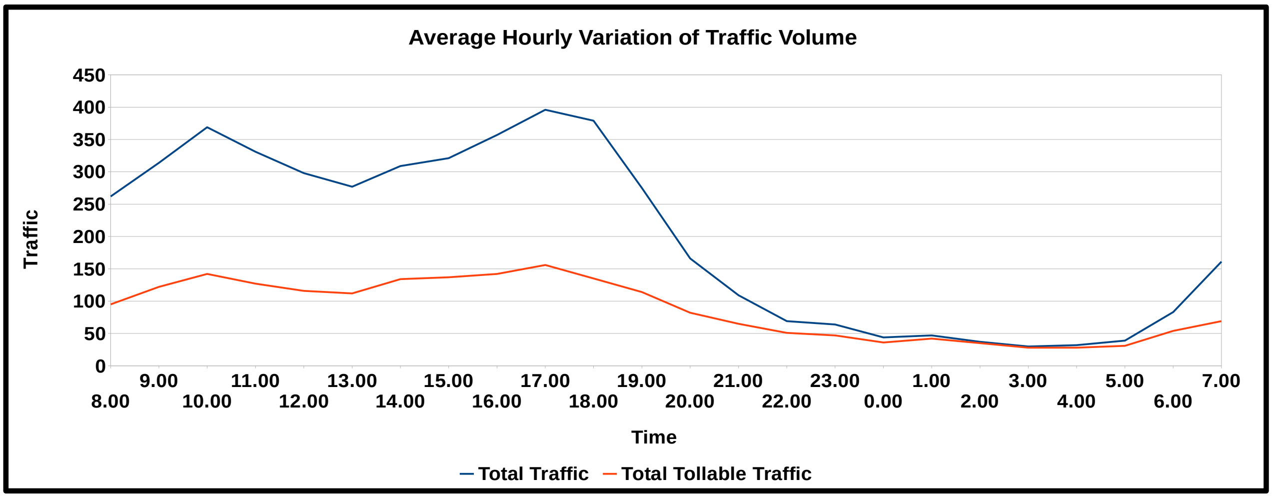


Figure-8.4: Average Hourly Traffic Variation at Km 6.400 on SH-177 at Tankal

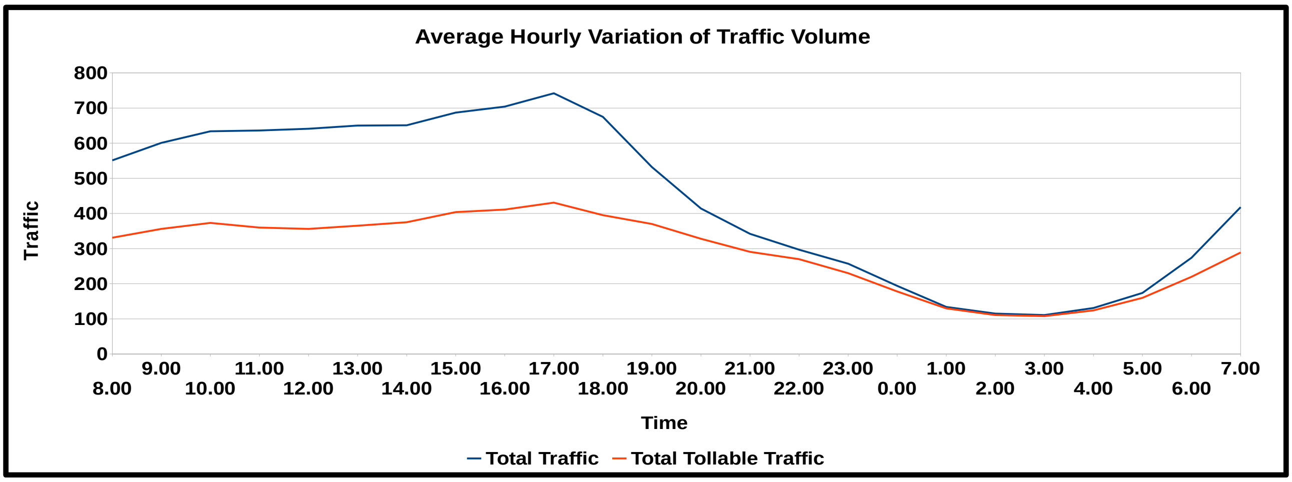


Figure-8.5: Average Hourly Traffic Variation at Km 178.400 on SH-60 at Sinnar

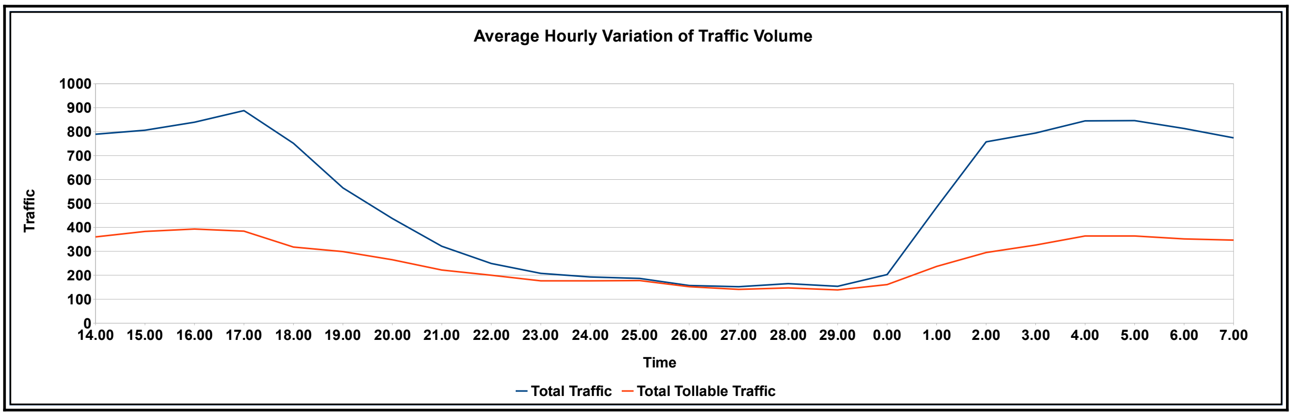


Figure-8.6: Average Hourly Traffic Variation at Km 106.800 on SH-160 at Pimpri Nirmal

8.8 Seasonal correction Factor

Monthly sales data from the fuel stations located on the project corridor were collected to estimate the Seasonal Correction Factor (SCF). The SCF was applied to the vehicular traffic volume of ADT to obtain the Annual Average Daily Traffic (AADT) and it was later converted to PCU's. The factor is calculated based on the month of survey conducted, i.e., December 2018, was applied to the ADT to determine the AADT. The average Seasonal Correction Factor for the survey locations were obtained as 1 for MS and 1 for HSD.

Table-8.7: Average Seasonal Variation Factors(SVF)

S.No.	Section	Motor Spirit	High Speed D
1	Surat - Nashik	1.000	1.000

8.9 Annual Average Daily Traffic Volume (AADT)

The Annual Average Daily Traffic (AADT) at each of the survey location was obtained by multiplying the Average Daily Traffic (ADT) with the Seasonal Correction Factor. The AADT for the year 2018 at survey locations are calculated and tabulated in the below Table-8.7. The AADT values represented in the following table are actual values obtained from the survey. The detailed calculations are presented in Annexures-I(a),I(b),I(c),I(d)&I(e).

Table-8.8:AADT Volume for Five TVC locations along the Project Stretch

Vehicle Type	(Surat-Mumbai) Km 356.900 NH-48	(Surat-Bajipura) Km 75.800 NH-53	(Tankal-Rankuva) Km 6.400 SH-177	(Pune-Nashik) Km 178.400 NH-60	(Shiridi - Ahmednagar) Km 106.800 NH-160
Two Wheelers	24230	4637	4774	6904	1107
Three Wheelers (Passenger)	4319	227	143	50	328
Car	25500	6386	2781	7057	7031
Tata Magic	21	9	7	10	266
RTC Bus	236	321	22	520	378
Private Bus	798	259	53	189	337
Mini Bus	249	49	16	60	235
School/ College Bus	99	3	5	13	30

Vehicle Type		(Surat-Mumbai) Km 356.900 NH-48	(Surat-Bajipura) Km 75.800 NH-53	(Tankal-Rankuva) Km 6.400 SH-177	(Pune-Nashik) Km 178.400 NH-60	(Shiridi - Ahmednagar) Km 106.800 NH-160
Two Axle		2967	660	199	1128	424
Three Axle		3129	804	82	780	591
Multi Axle		7735	2070	91	680	1788
HEM		32	2	2	2	4
LCV		5983	668	402	1562	421
Mini LCV		2547	664	448	1819	1112
Tractor		15	12	13	11	20
Tractor with Trailer		51	11	19	121	50
Three Wheeler (Goods)		396	57	28	47	117
Bicycle		256	78	200	9	322
Cycle Rickshaw		13	7	2	0	0
Animal Drawn		4	0	2	0	0
Government Exempted		61	11	13	15	15
Vehicles	Motorised	78368	16870	9177	20968	24254
	Non Motorised	273	85	204	9	322
	Total Traffic	78641	16955	9381	20977	24576
	Tollable Traffic	49296	11915	4108	13820	12627
PCU	Motorised	111255	26309	8407	26417	29025
	Non Motorised	186	53	120	5	161

Vehicle Type		(Surat-Mumbai) Km 356.900 NH-48	(Surat-Bajipura) Km 75.800 NH-53	(Tankal-Rankuva) Km 6.400 SH-177	(Pune-Nashik) Km 178.400 NH-60	(Shiridi - Ahmednagar) Km 106.800 NH-160
	Total Traffic	111441	26362	8527	26422	29186
	Tollable Traffic	94057	23622	5368	22282	22754

8.10 Peak Hour Proportion (PHP)

Peak Hour Proportion is defined as Traffic volume during Peak hour expressed as Percentage of AADT. Peak Hour Traffic is obtained as the highest Hourly traffic volume observed during a typical day (24 hours). Peak Hour proportions of all locations are presented in Table:8.8. It is observed that Peak Hour Proportion is in between 6&8.5.

Table: 8.9: Peak Hour Factor for Different Locations

	Surat -Nasik Section				
	(Surat-Mumbai) Km 356.900 NH-48	(Surat-Bajipura) Km 75.800 NH-53	(Tankal-Rankuva) Km 6.400 SH-177	(Pune-Nashik) Km 178.400 NH-60	(Shiridi - Ahmednagar) Km 106.800 NH-160
Peak Hour Volume (PCU)	5664	1205	784	1467	1865
AADT-(PCU)	78614	16958	9380	20980	29936
Peak Hour Proportion	7.2	7.11	8.36	6.99	6.23
Peak Hour Time	18:00 to 19:00	17.00 to 18.00	17.00 to 18.00	2.00 to 3.00	11:00 to 12:00

8.11 Origin-Destination & Commodity Movement Survey

Origin-Destination & Commodity Movement Survey by Road Side Interview (RSI) method were conducted at Five locations i.e., at Km 356.900 (Bhagwadi toll plaza of Surat-Mumbai Stretch) on NH-48, at Km 75.800 (Manekpore of Surat-Bajipura Stretch) on NH-53, at Km 6.400(Tankal of Tankal-Rankuva Stretch) on SH-177, at km 178.400(Sinnar of Pune-Nashik Stretch) on NH-60 and at km 106.800 (Pimpri Nirmal of Shiridi- Ahmednagar Stretch) on NH-160 for 24 hrs.

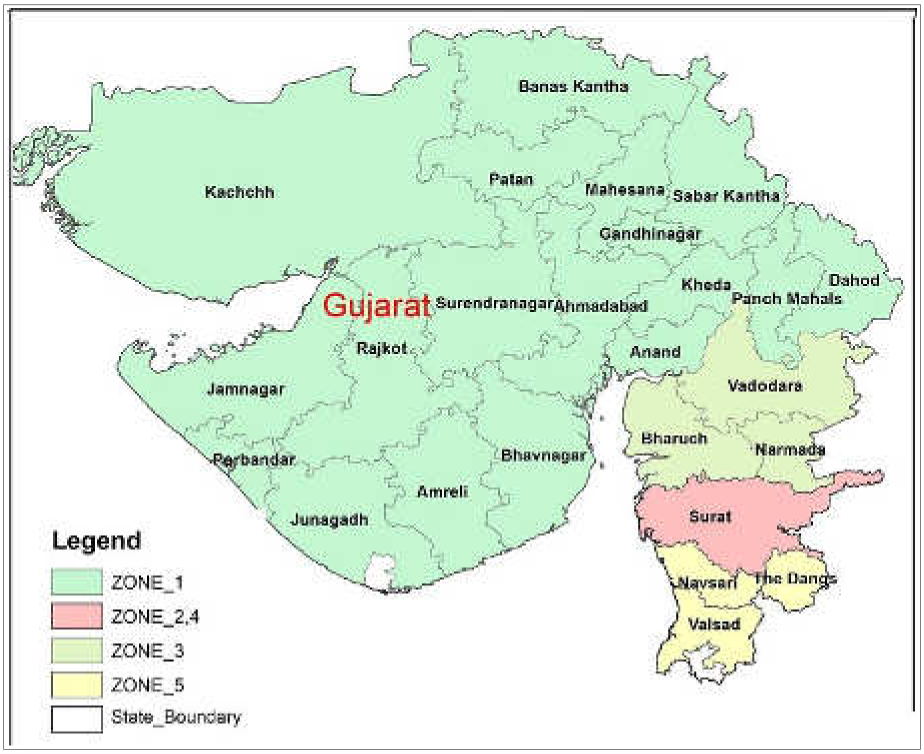
Origin Destination by Road Side Interview method was conducted by using Well-formatted questionnaire was framed containing information regarding origin, destination, distance, purpose and other various details. Separate queries were made for passenger vehicles and goods vehicles. The analysis of daily flow of classified volume counts was the basis for fixing the sample size of vehicles by type and direction. At the survey location, on an average the number of vehicles (both Passenger & Goods vehicles) interviewed are more than 30% as sample size. List of Zone number and corresponding zone area is mentioned in below table.

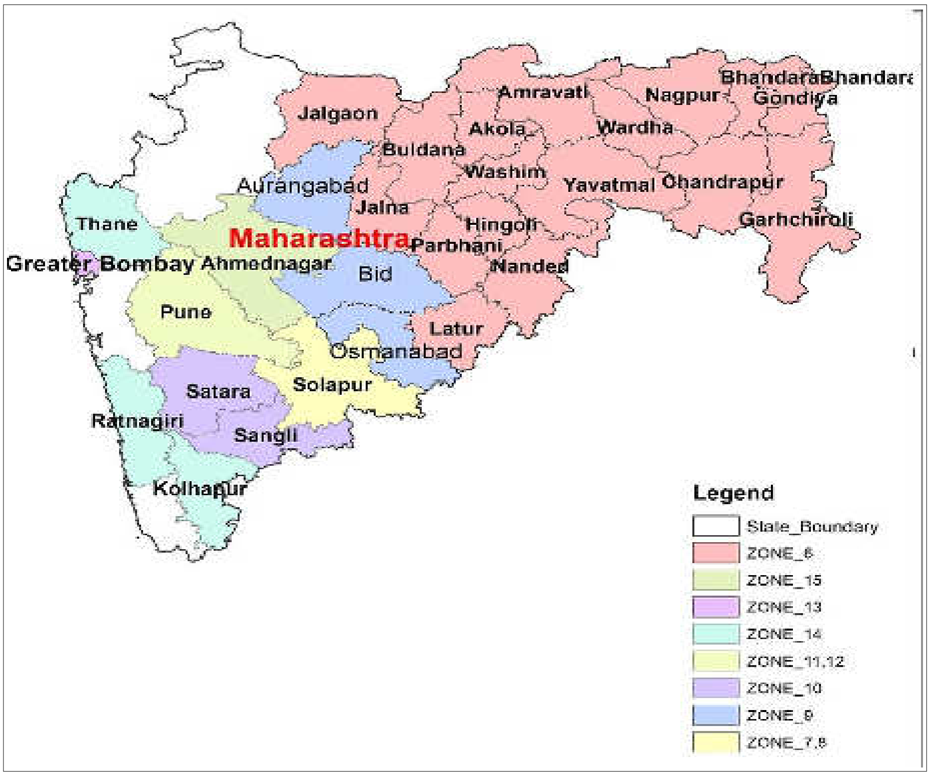
Zones Derived From Origin & Destination Commodity Survey		
Zones	**State**	**Place**
1	Gujarath	Kutch, Banaskhantha, Patan, Morbi, Jamnagar, Dev Bhoomi Dwaraka, Porbandar, Junagadh, Rajkot, Surendranagar, Patan, Gir somnath, Amreli, Botad, Ahmedabad, Gandhinagar, Mehsana,bhavnagar, Sabarkantha, Aravali, Kheda, Anand, Mahisagar, Dahod, Panchmahal, Chhotta Udaypur.
2		Surat
3		Vadodara, Baruch, Narmada, Kukarmunda, Baroda, Dahej
4		Rest of Surat
5		Navsari, Valsad, Vapi, Dang, Tapi, Daman, Dadra, Haveli, Silvassa, tankal, Rankuva, Ahwa
6	MH	Bandhara, Gadchirili, Nagpur, Waedha, Amaravati, Akola, Washi, Hingoli, Yavatmal, Chandrapur, Buldhana, Jalgoan, Jalna, Parbhani, Nanded, Latur, Nilanga
7		Solapur
8		Rest of Solapur, Mohol

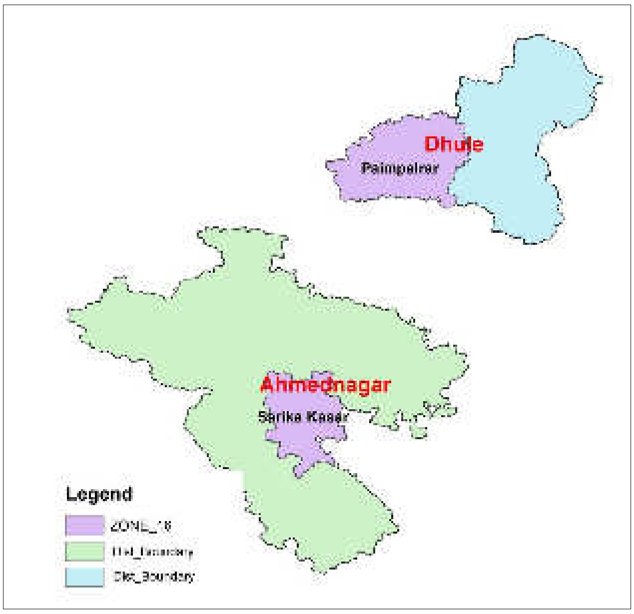
Zones Derived From Origin & Destination Commodity Survey		
9		Osmanabad, Beed, Aurangabad
10		Sangli, Satara
11		Pune
12		Rest of Pune
13		Mumbai
14		Thane, Pali, Ratnagiri, Kolhapur, Bhiwandi
15		Ahmednagar
16		Paimpalrar, Sarola Kasara
17		Nevasa, Shevgaon,Tisgoan, Koradgoan
18		Vambori, Takli, Rahata, Dhore, Shani Signapur,
19		Akole, Sangamner, Khetwadi, Pimpalgaon, Supe, Chincholi, Shirdi
20		Talegoan, Kopaurgaun, Loni, kolhar, Rahuri
21		Niphad, Devgaon, Yeola, Nangaon, Tarora, Naydongri, Vadangali, Chndwada, Sinnar, Devpur, Gulwanch
22		Satana, Kalvan, Waghad, Surgana, Saputara, Dindori, Jalgaon
23		Nashik
24		Pient, bhegu, Palasana, Karanjari, Igatpuri,
25		Pandhuri, Ambewadi, Karungwadi, Bhagur, Dhubere, Dapur, Gonde, Deolali
26		Goa
27		Karnataka, Banglore
28		Chikbalapur, Kolar
29		Hassan, Dakshan Kannada, Mandya, Koduru, Mysore, Chamarajannagar, Tumakuru

Zones Derived From Origin & Destination Commodity Survey		
30		Udipi, Chikmanglore, Uttarkannada
31		Chitradurga, Davangiri, Haveri, Dharwad, Belghar
32		Ballari, Koppal, Gadag, Bagarkot, Vijaypura
33		Raichur, Yadgir, Kalaburgi, Bidar
34		Kurnool, Anantapur, Kadapa, Chittoor
35		Rest of AP, Vijayawada, Vizag
36		Telangana, Chattisgarh, Orissa, Jarkhand, Bihar, West Bengal
37		Arunachal Pradesh, Nagaland, Meghalaya, Manipur, Mizoram
38		Jammu and Kashmir, Himachar Pradesh, Chandigarh, Haryana, Uttarkhand
39		Delhi
40	Rajasthan	Jaisalmar, Jodhpur, Jalore, Bikaner, Nagaur, Sirohi, Jalore, Pali, Ajmer
41		Sikhar, Junjhunun, Karauli, Dholpur, Kota, Baran
42		UP, MP
43		Kerala
44		Chennai
45		Kanyakumari, Tuticorin, Tiruchendur, Madurai, Tirunelveli, Dundigal, Ramanthapuram, Karur, Namakkal, Salem, Erode, Coimbatore, Sivaganga
46		Pudukottai, Thanjavur, Nagapattinam, Trichy, Cuddalore, Villupuram
47		Tiruvannamalai, Vellore, Kanchepuram, Tiruvallur

Zone wise Maps Shown below :



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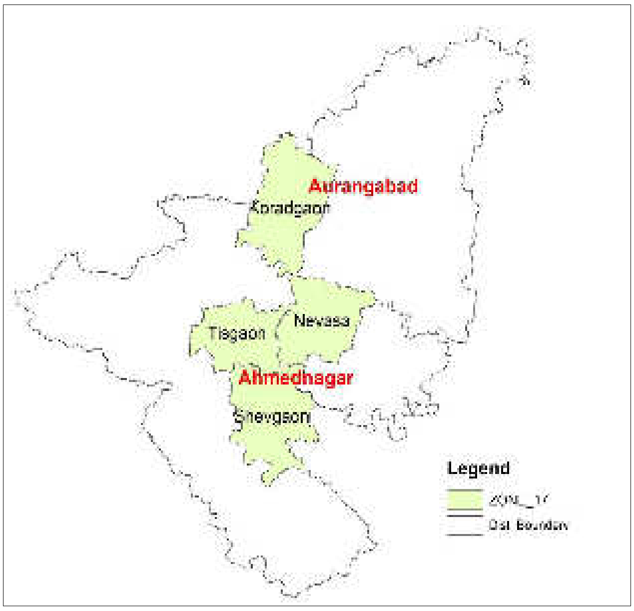
Ahmednagar
Legend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Tisgaon
Ahmednagar
Shevgaon
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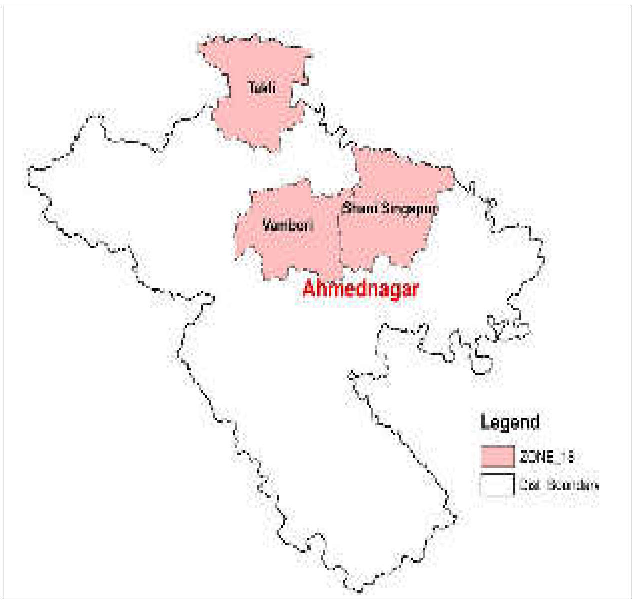
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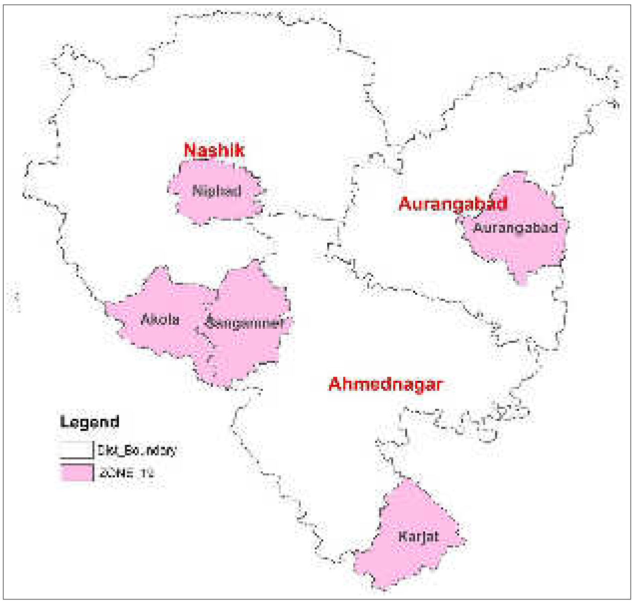
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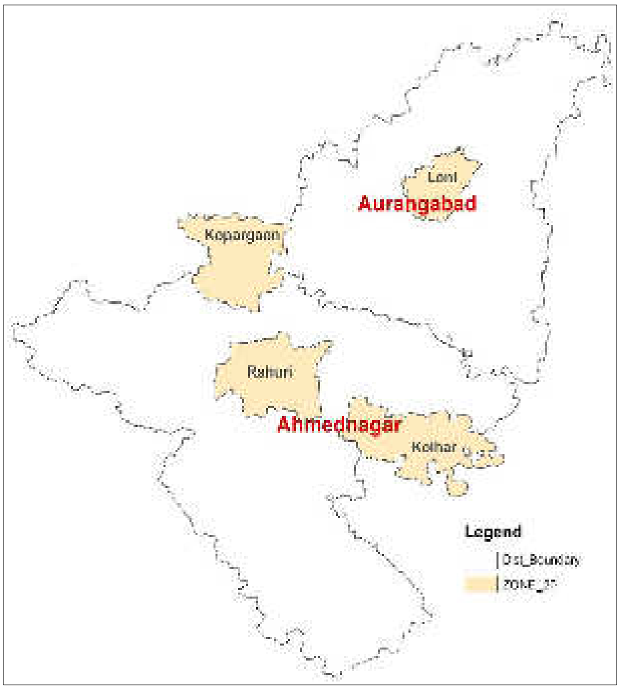
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Aurangabad
Kopargaon
Rahuri
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Chandvad
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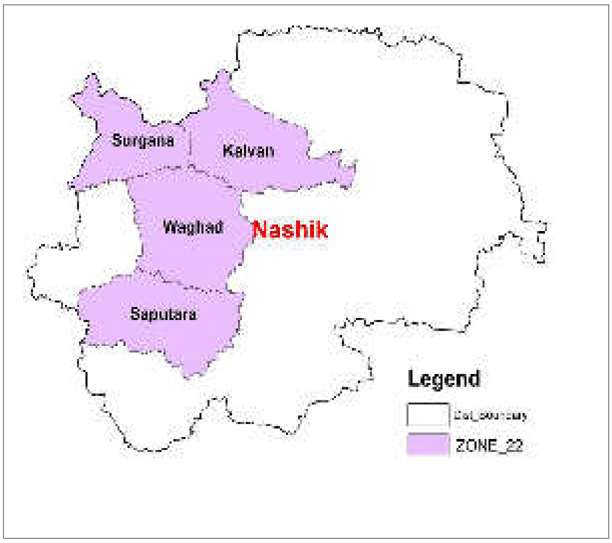
ZONE_21


Surgana
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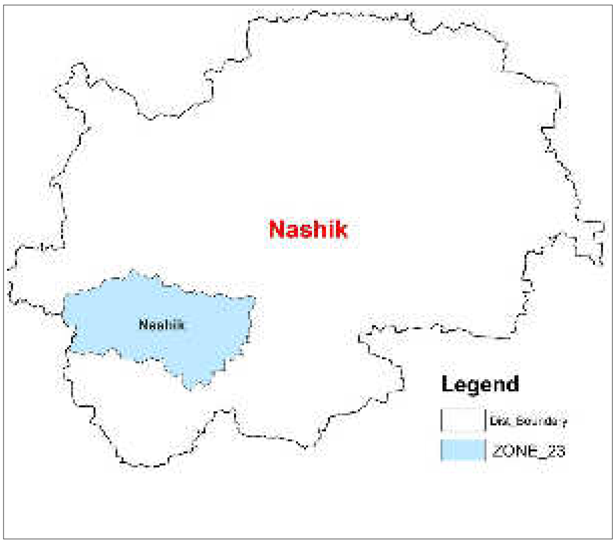
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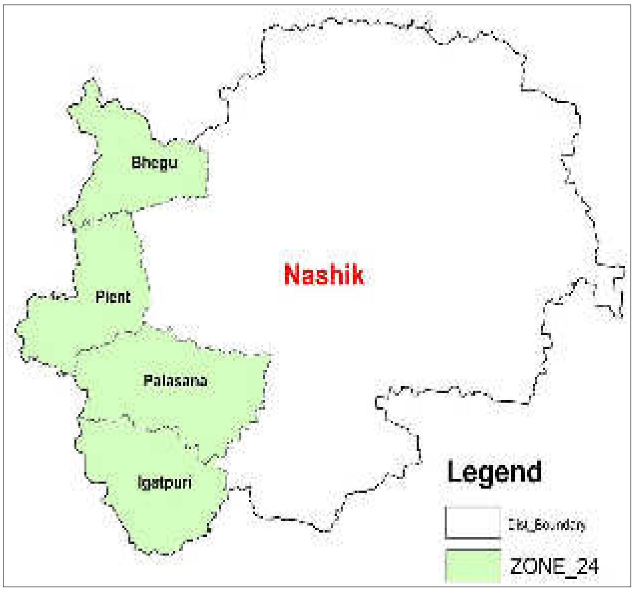
Bhegu
Nashik
Plent
Palasana
Igatpuri
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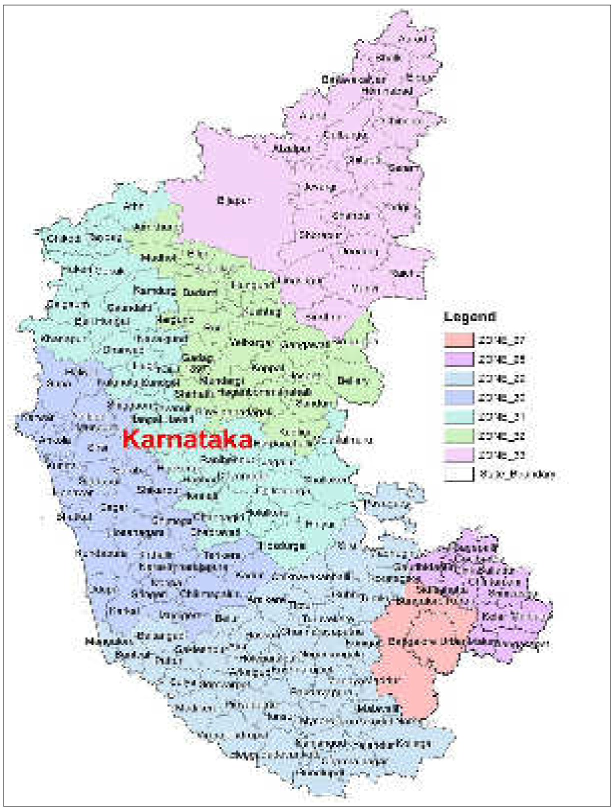
Dist_Boundary
ZONE_24


Nashik
Nashik
Sinnar
Igatpuri
Legend
Dist_Boundary
ZONE_25


Pernem
Mapuca
Dicholi
n.a. (1882)
Valpoy
Panaji
Sambaji
Ponda
Goa
Madgaon
Sanguem
Quepem
Chauri
Legend
ZONE_28
State_Boundary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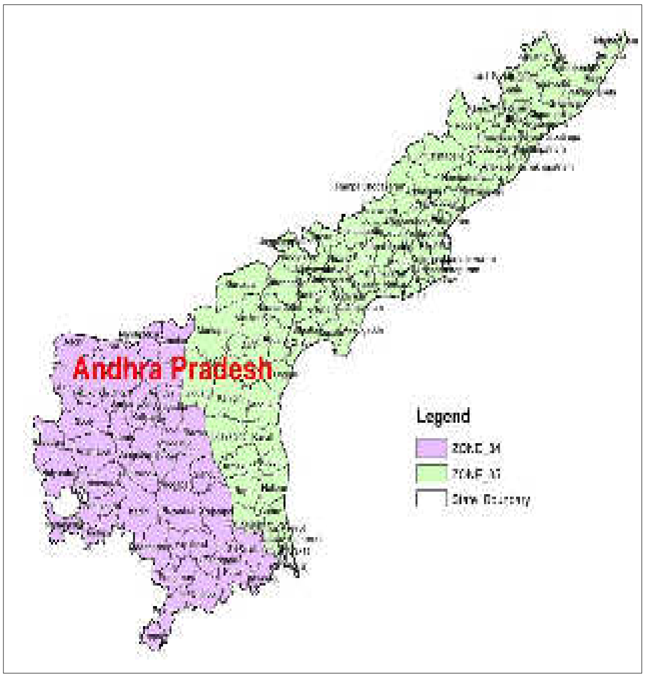

Andhra Pradesh
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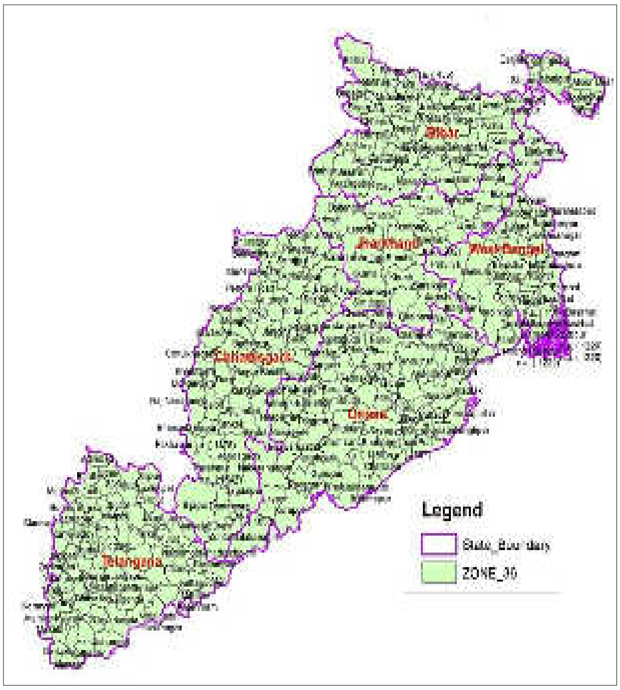

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West Bengal
Chhattisgarh
Orissa
Telangana
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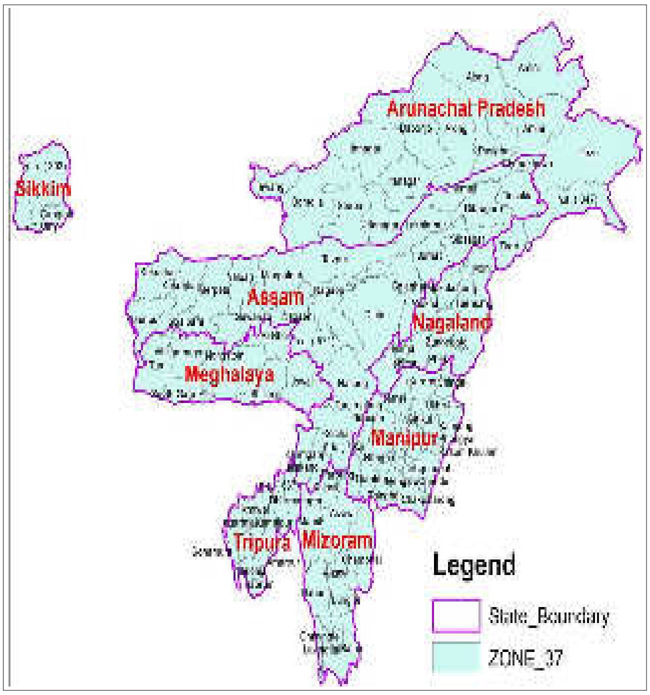
State_Boundary
ZONE_36



Sikkim
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Assam
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
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State_Boundary
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Jammu and Kashmir
Himachal Pradesh
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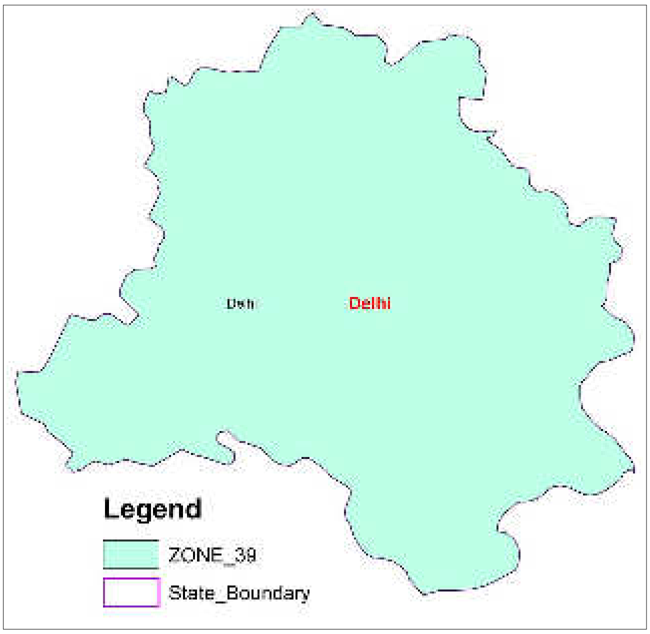
State_Boundary
ZONE_38
Chandigarh
Uttaranchal
Haryana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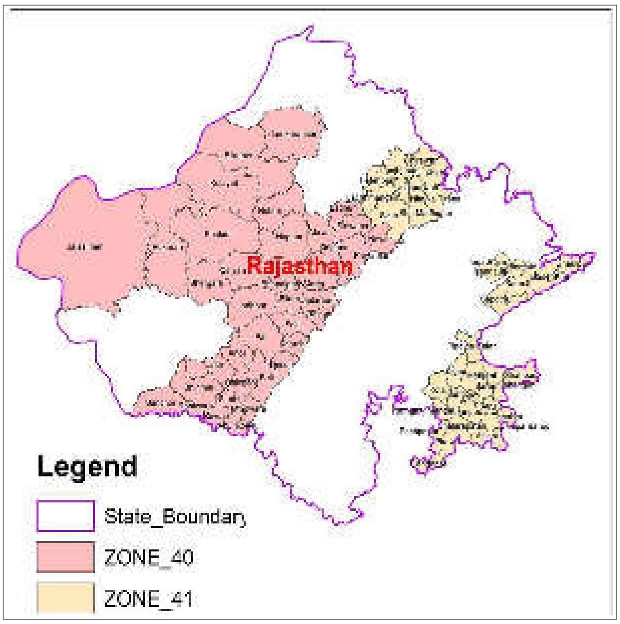
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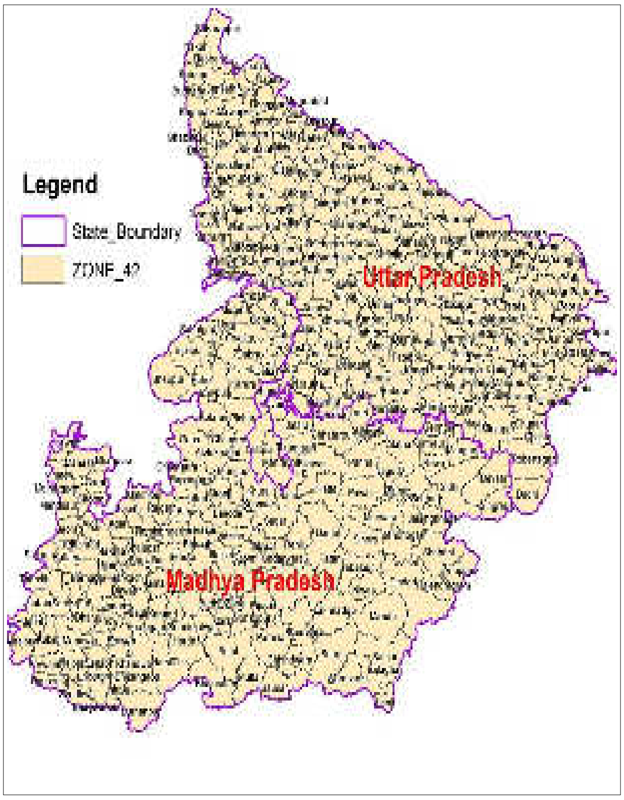
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Madhya Pradesh


Legend
State_Boundary
Kerala


Tamil Nadu
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State_Boundary
ZONE_44
ZONE_45
ZONE_46
ZONE_47

The sample data obtained for Origin-Destination Surveys(RSI) for the various locations are represented in the below tables.

Table 8.10: Sample Size of Vehicles at Km 356.900 on NH-48 at Bagwadi Toll Plaza

Mode	Towards Mumbai			Towards Surat			Both Directions		
	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)
LCV	3815	1238	32%	4310	1432	33%	8125	2670	33%
2 Axle	1475	463	31%	1547	578	37%	3022	1041	34%
3 Axle	1489	395	27%	1368	409	30%	2857	867	30%
M Axle	3972	1487	37%	3972	1284	32%	7944	2771	35%
Car	11825	2944	25%	14145	3573	25%	25970	6517	25%
Bus	511	202	40%	484	108	22%	995	310	31%
Mini Bus	129	50	39%	122	57	47%	251	107	43%
TataMagic	7	4	57%	5	3	60%	12	7	58%

Table 8.11: Sample Size of Vehicles at Km 75.800 on NH-53 at Manekpore

Mode	Towards Surat			Towards Bajipura			Both Directions		
	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)
LCV	723	240	33%	698	225	28%	1421	466	33%
2 Axle	357	129	36%	339	162	56%	696	291	42%
3 Axle	462	136	29%	341	112	35%	803	248	31%
M Axle	939	246	26%	1098	302	50%	2037	548	27%
Car	3012	983	33%	3020	938	31%	6032	1921	32%
Bus	287	11	40%	306	171	56%	593	286	48%
Mini Bus	24	12	50%	23	8	35%	47	20	43%
TataMagic	9	4	44%	2	1	50%	11	5	45%

Table 8.12: Sample Size of Vehicles at Km 6.400 on SH-177 at Tankal

Mode	Towards Tankal			Towards Rankuva			Both Directions		
	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)
LCV	443	139	31%	445	198	44%	888	337	38%
2 Axle	98	26	27%	105	64	61%	203	90	44%
3 Axle	45	29	64%	40	21	53%	85	50	59%
M Axle	34	14	41%	61	23	38%	95	37	39%
Car	1253	407	32%	1331	496	37%	2584	903	35%
Bus	42	28	67%	35	29	83%	77	57	74%
Mini Bus	5	3	60%	16	8	50%	21	11	52%
TataMagic	4	2	50%	2	1	50%	6	3	50%

Table 8.13: Sample Size of Vehicles at Km 178.400 on NH-60 at Sinnar

Mode	Towards Pune			Towards Nashik			Both Directions		
	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)
LCV	1822	496	27%	1746	470	27%	3568	966	27%
2 Axle	613	234	38%	544	297	55%	1157	531	46%
3 Axle	343	135	39%	423	194	46%	766	329	43%
M Axle	313	158	50%	405	198	49%	718	356	50%
Car	3055	874	29%	3221	857	27%	6276	1731	28%
Bus	335	109	33%	331	133	40%	666	242	36%
Mini Bus	35	28	80%	32	24	75%	67	52	78%
TataMagic	4	2	50%	6	3	50%	10	5	50%

Table 8.14: Sample Size of Vehicles at Km 106.800 on NH-160 at Pimpri Nirmal

Mode	Towards Shirdi			Towards Ahmednagar			Both Directions		
	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)	Total Volume	RSI	Sample (%)
LCV	787	192	24%	813	186	23%	1600	378	24%
2 Axle	192	79	41%	186	66	35%	378	145	38%
3 Axle	262	94	36%	270	75	28%	532	169	32%
M Axle	945	232	25%	703	297	42%	1648	529	32%
Car	3365	745	22%	3229	691	21%	6594	1436	22%
Bus	344	78	23%	350	101	29%	694	179	26%
Mini Bus	147	35	24%	115	44	38%	262	79	30%
TataMagic	143	32	22%	94	25	27%	237	57	24%

From the analysis of the OD-Commodity movement survey conducted at survey locations, the trip frequency distribution of traffic for all the directions are illustrated in the below tables.

Table 8.15: Percentage of Trip Frequency Distribution at Km 356.900 on NH-48 at Bagwadi Toll Plaza

Percentage Trip Frequency Distribution												
Vehicle Type	**Total No of Vehicles**	**Daily Once**	**Daily Twice**	**> Daily Twice**	**Weekly Once**	**Weekly Twice**	**> Weekly Twice**	**Monthly Once**	**Monthly Twice**	**> Monthly Twice**	**Yearly Once**	**>Yearly Once**
Car	6517	53.00%	2.59%	0.41%	5.36%	4.25%	0.29%	19.13%	13.83%	0.61%	0.52%	0.00%
Bus	310	71.29%	13.87%	0.00%	9.68%	0.00%	0.00%	3.55%	0.00%	1.61%	0.00%	0.00%
Mini Bus	107	60.75%	2.80%	0.00%	3.74%	2.80%	0.00%	14.95%	10.28%	1.87%	2.80%	0.00%
Tata Magic	7	85.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	14.29%	0.00%	0.00%	0.00%
LCV	2670	20.30%	4.31%	1.42%	6.93%	18.31%	5.24%	9.21%	15.17%	18.91%	0.19%	0.00%
2 Axle	1041	17.87%	2.31%	0.58%	7.97%	23.63%	3.94%	8.74%	16.62%	17.39%	0.58%	0.38%
3 Axle	867	17.53%	6.34%	0.58%	7.27%	16.72%	2.65%	8.65%	19.26%	20.30%	0.35%	0.35%
M Axle	2771	12.67%	1.26%	0.51%	8.77%	22.74%	3.32%	9.85%	16.13%	24.50%	0.07%	0.18%

Table 8.16: Percentage of Trip Frequency Distribution at Km 75.800 on NH-53 at Manekpore

Percentage Trip Frequency Distribution												
Vehicle Type	**Total No of Vehicles**	**Daily Once**	**Daily Twice**	**> Daily Twice**	**Weekly Once**	**Weekly Twice**	**> Weekly Twice**	**Monthly Once**	**Monthly Twice**	**> Monthly Twice**	**Yearly Once**	**>Yearly Once**
Car	1893	23.82%	1.00%	4.01%	0.85%	0.85%	0.00%	29.16%	26.73%	10.51%	2.38%	0.69%
Bus	286	38.11%	10.14%	5.24%	0.00%	0.00%	0.00%	24.83%	17.83%	3.85%	0.00%	0.00%
Mini Bus	20	45.00%	10.00%	30.00%	0.00%	0.00%	0.00%	15.00%	0.00%	0.00%	0.00%	0.00%
Tata Magic	5	20.00%	0.00%	0.00%	0.00%	0.00%	0.00%	80.00%	0.00%	0.00%	0.00%	0.00%
LCV	415	8.67%	0.48%	0.00%	20.24%	15.42%	0.00%	9.88%	34.22%	11.08%	0.00%	0.00%
2 Axle	259	13.13%	2.32%	0.00%	19.31%	12.74%	0.00%	11.20%	23.55%	17.76%	0.00%	0.00%
3 Axle	1277	1.17%	0.39%	0.00%	3.76%	2.27%	82.85%	2.66%	4.54%	2.35%	0.00%	0.00%
M Axle	638	2.04%	1.25%	0.00%	12.38%	9.40%	19.12%	13.01%	26.65%	16.14%	0.00%	0.00%

Table 8.17: Percentage of Trip Frequency Distribution at Km 6.400 on SH-177 at Tankal

Percentage Trip Frequency Distribution												
Vehicle Type	**Total No of Vehicles**	**Daily Once**	**Daily Twice**	**> Daily Twice**	**Weekly Once**	**Weekly Twice**	**> Weekly Twice**	**Monthly Once**	**Monthly Twice**	**> Monthly Twice**	**Yearly Once**	**>Yearly Once**
Car	903	12.62%	32.00%	3.10%	15.84%	7.53%	1.77%	19.38%	5.76%	1.99%	0.00%	0.00%
Bus	57	19.30%	54.39%	7.02%	5.26%	1.75%	1.75%	8.77%	1.75%	0.00%	0.00%	0.00%
Mini Bus	11	36.36%	45.45%	0.00%	0.00%	0.00%	0.00%	18.18%	0.00%	0.00%	0.00%	0.00%
Tata Magic	3	66.67%	0.00%	0.00%	0.00%	33.33%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LCV	297	19.53%	16.16%	4.71%	5.72%	9.09%	5.72%	9.43%	15.82%	13.13%	0.00%	0.67%
2 Axle	90	18.89%	8.89%	4.44%	5.56%	11.11%	8.89%	14.44%	16.67%	6.67%	0.00%	4.44%
3 Axle	50	20.00%	14.00%	4.00%	4.00%	4.00%	12.00%	16.00%	20.00%	6.00%	0.00%	0.00%
M Axle	37	0.00%	35.14%	21.62%	2.70%	5.41%	2.70%	18.92%	10.81%	2.70%	0.00%	0.00%

Table 8.18: Percentage of Trip Frequency Distribution at Km 178.400 on NH-60 at Sinnar

Percentage Trip Frequency Distribution												
Vehicle Type	**Total No of Vehicles**	**Daily Once**	**Daily Twice**	**> Daily Twice**	**Weekly Once**	**Weekly Twice**	**> Weekly Twice**	**Monthly Once**	**Monthly Twice**	**> Monthly Twice**	**Yearly Once**	**>Yearly Once**
Car	1731	13.58%	6.24%	8.49%	7.11%	3.64%	5.55%	18.49%	16.00%	12.31%	1.79%	6.82%
Bus	242	10.74%	21.90%	8.68%	5.37%	7.85%	4.96%	18.60%	9.92%	8.68%	0.00%	3.31%
Mini Bus	52	17.31%	7.69%	9.62%	7.69%	15.38%	13.46%	5.77%	9.62%	7.69%	1.92%	3.85%
Tata Magic	5	40.00%	0.00%	0.00%	0.00%	0.00%	0.00%	20.00%	0.00%	40.00%	0.00%	0.00%
LCV	966	41.20%	0.93%	0.00%	11.80%	19.98%	2.07%	8.59%	0.00%	7.25%	0.00%	8.18%
2 Axle	531	40.11%	0.00%	0.00%	21.09%	12.05%	3.39%	12.05%	0.00%	6.03%	0.00%	5.27%
3 Axle	329	37.39%	0.61%	0.00%	22.49%	8.21%	2.74%	13.98%	0.00%	10.33%	0.00%	4.26%
M Axle	357	35.85%	0.00%	0.00%	22.41%	6.44%	11.20%	10.92%	0.00%	7.00%	0.00%	6.16%

Table 8.19: Percentage of Trip Frequency Distribution at Km 106.800 on NH-160 at Pimpri Nirmal

Percentage Trip Frequency Distribution												
Vehicle Type	**Total No of Vehicles**	**Daily Once**	**Daily Twice**	**> Daily Twice**	**Weekly Once**	**Weekly Twice**	**> Weekly Twice**	**Monthly Once**	**Monthly Twice**	**> Monthly Twice**	**Yearly Once**	**>Yearly Once**
Car	1326	0.00%	0.98%	36.50%	0.75%	0.45%	23.98%	0.83%	1.43%	26.85%	1.81%	6.41%
Bus	179	3.35%	0.00%	39.11%	6.70%	1.68%	17.32%	8.38%	0.00%	13.97%	1.12%	8.38%
Mini Bus	118	0.00%	0.00%	22.88%	0.00%	2.54%	24.58%	0.85%	0.00%	45.76%	0.85%	2.54%
Tata Magic	84	0.00%	0.00%	35.71%	2.38%	0.00%	19.05%	0.00%	13.10%	29.76%	0.00%	0.00%
LCV	377	15.12%	5.04%	0.80%	12.20%	20.95%	4.51%	10.88%	9.28%	20.16%	0.00%	1.06%
2 Axle	145	23.45%	1.38%	0.00%	4.14%	17.24%	2.07%	13.10%	11.03%	24.14%	1.38%	2.07%
3 Axle	168	3.57%	2.98%	0.60%	8.33%	10.12%	0.00%	21.43%	21.43%	29.76%	0.00%	1.79%
M Axle	529	1.13%	0.76%	0.57%	11.15%	7.56%	2.27%	25.71%	26.28%	23.06%	1.51%	0.00%

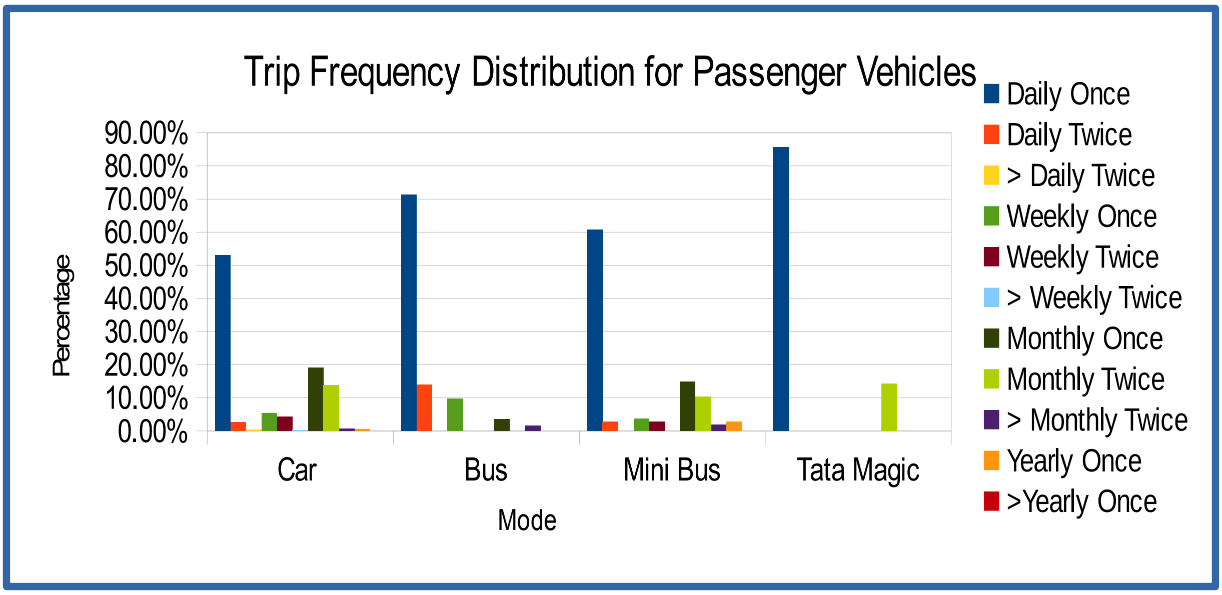


Figure 8.7: Trip distribution of Passengers vehicles at Km 356.900 on NH-48 at Bagwadi Toll Plaza

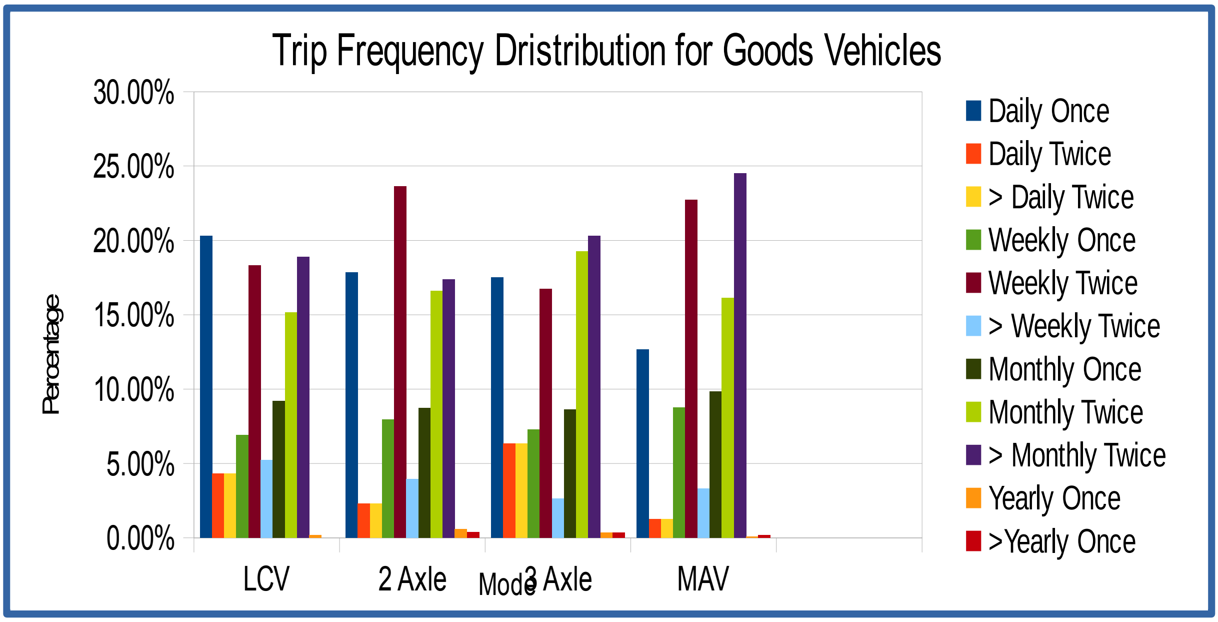


Figure 8.8: Trip distribution of Goods vehicles at Km 356.900 on NH-48 at Bagwadi Toll Plaza

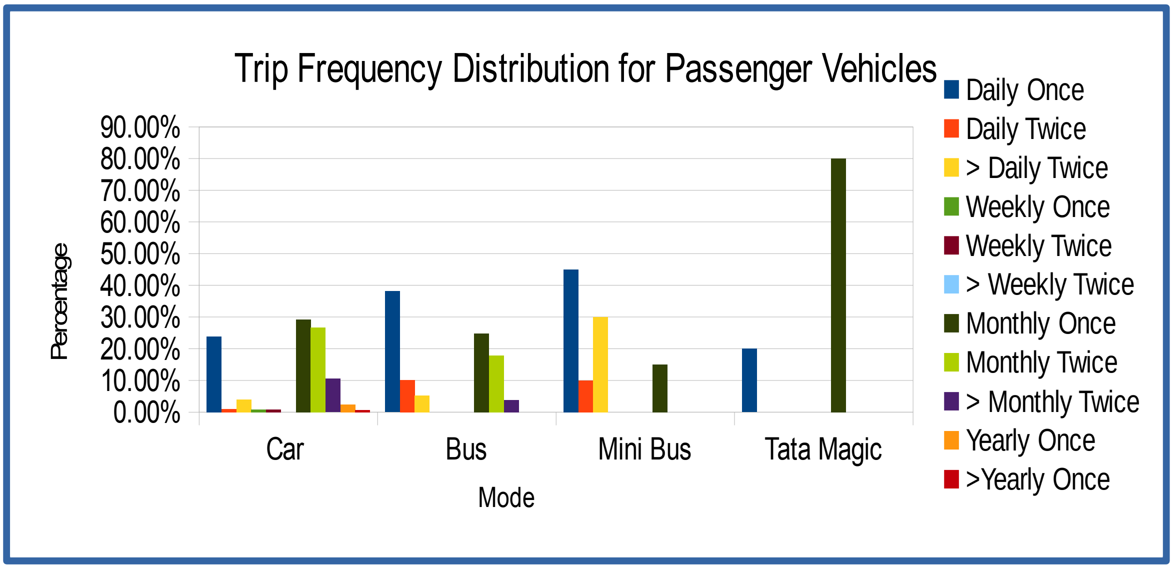


Figure 8.9: Trip distribution of Passengers vehicles at Km 75.800 on NH-53 at Manekpore

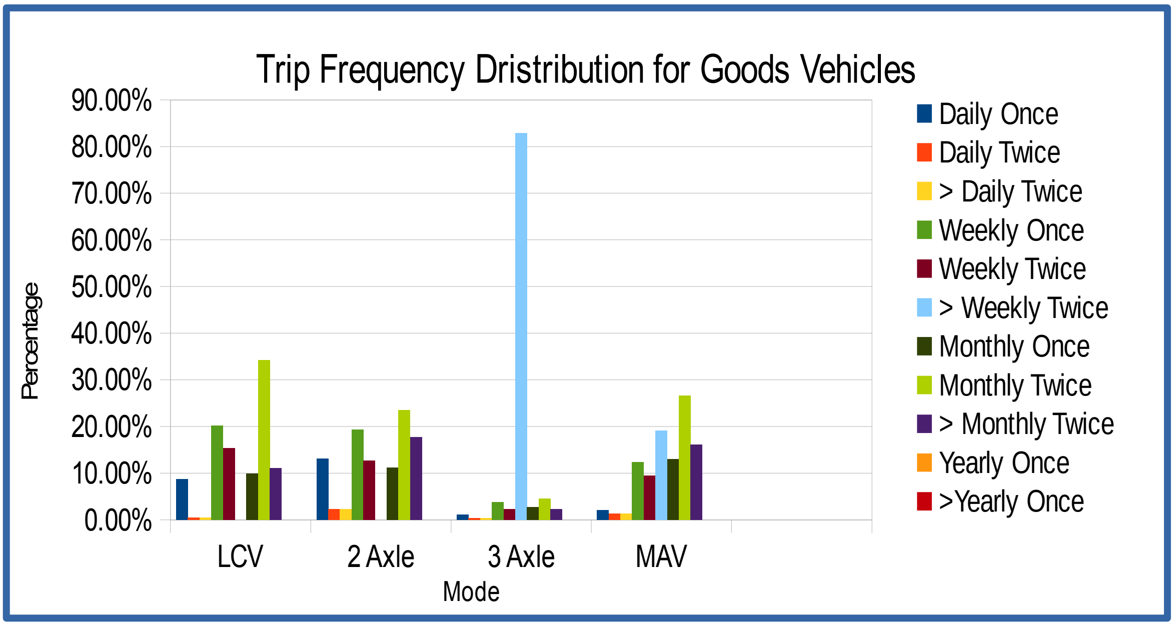


Figure 8.10: Trip distribution of Goods vehicles at Km 75.800 on NH-53 at Manekpore

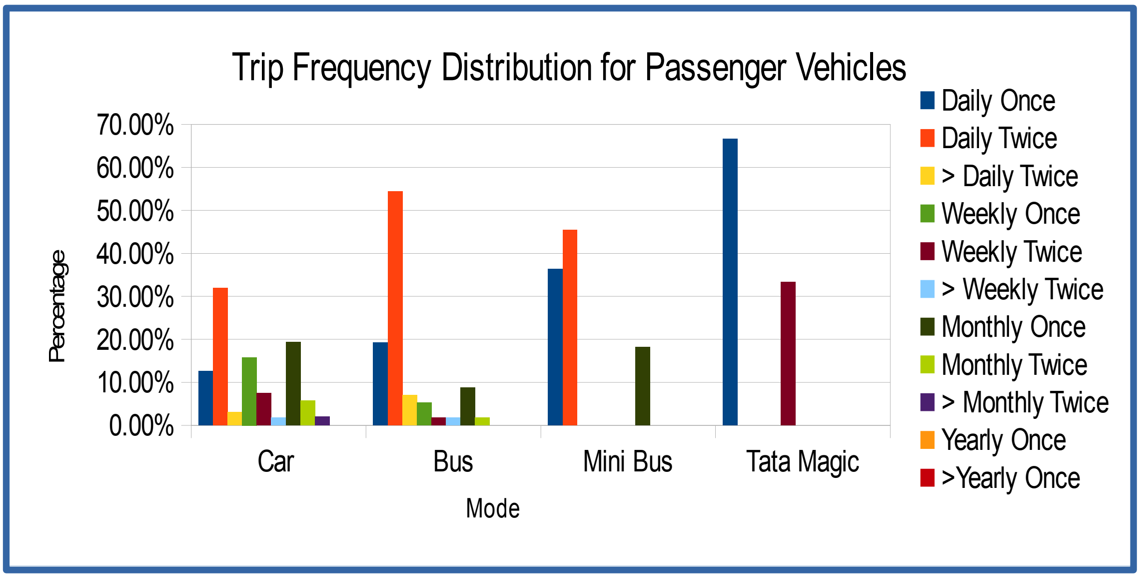


Figure 8.11: Trip distribution of Passengers vehicles at Km 6.400 on SH-177 at Tankal

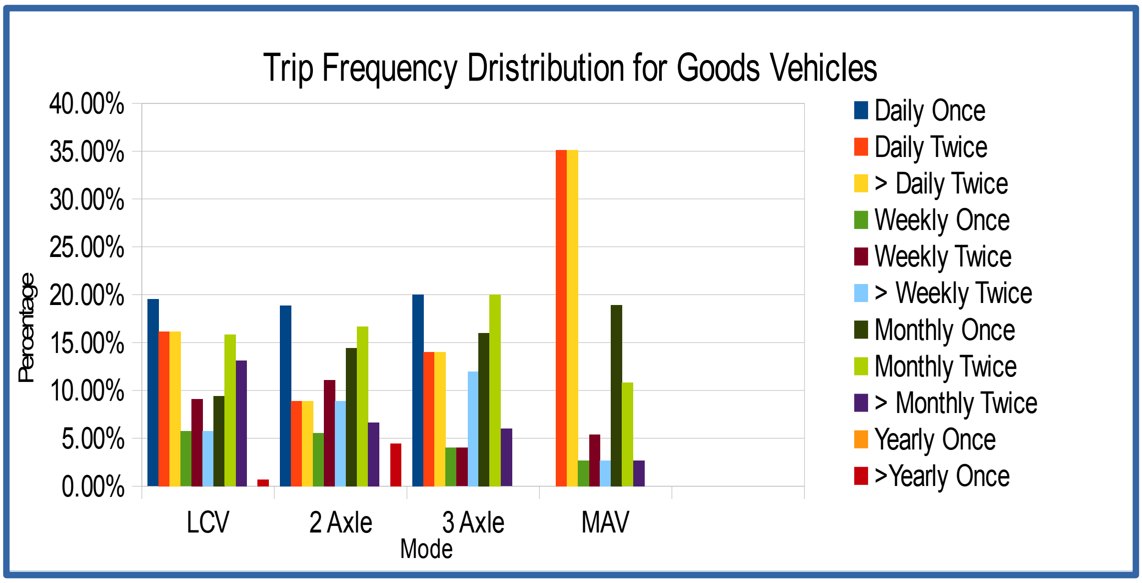


Figure 8.12: Trip distribution of Goods vehicles at Km 6.400 on SH-177 at Tankal

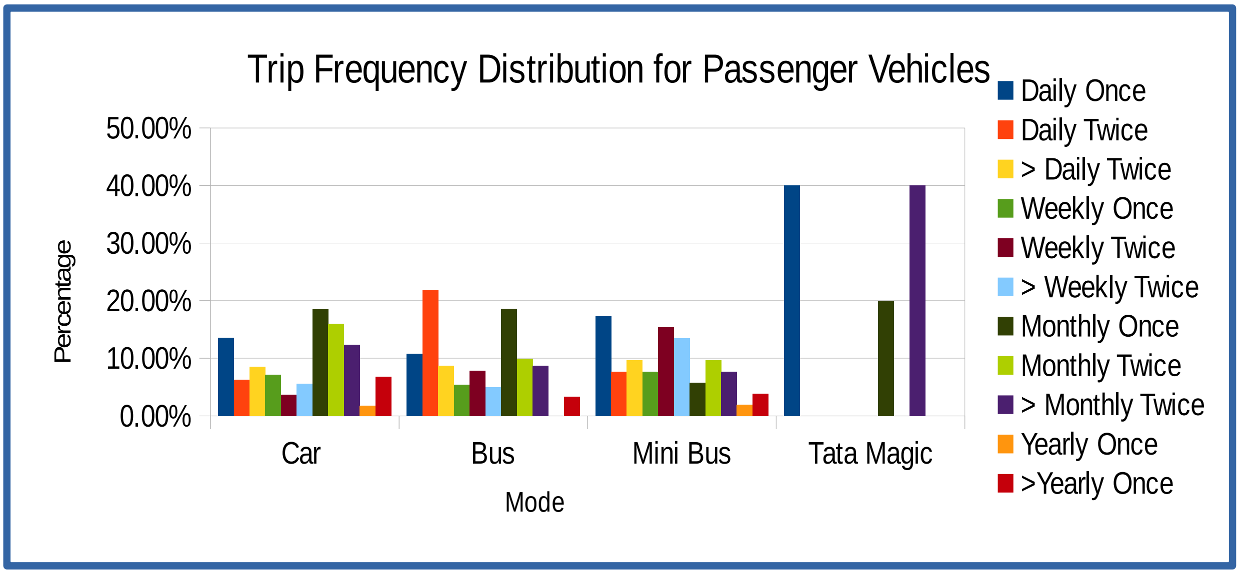


Figure 8.13:Trip distribution of Passengers vehicles at Km 178.400 on NH-60 at Sinnar

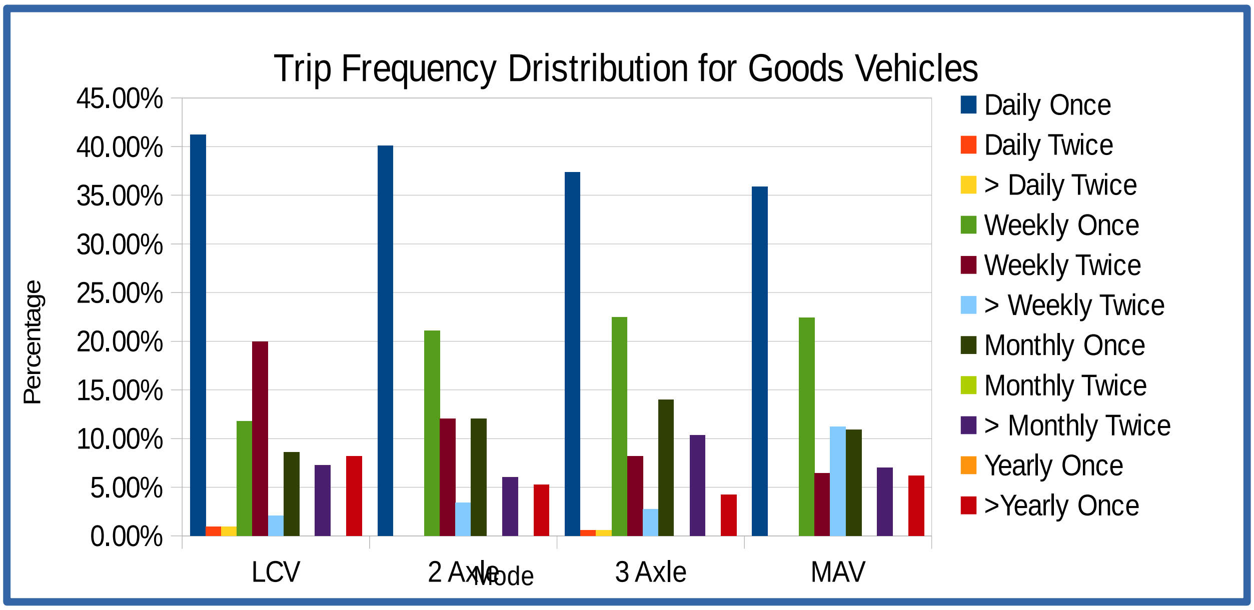


Figure 8.14 Trip distribution of Goods vehicles at Km 178.400 on NH-60 at Sinnar

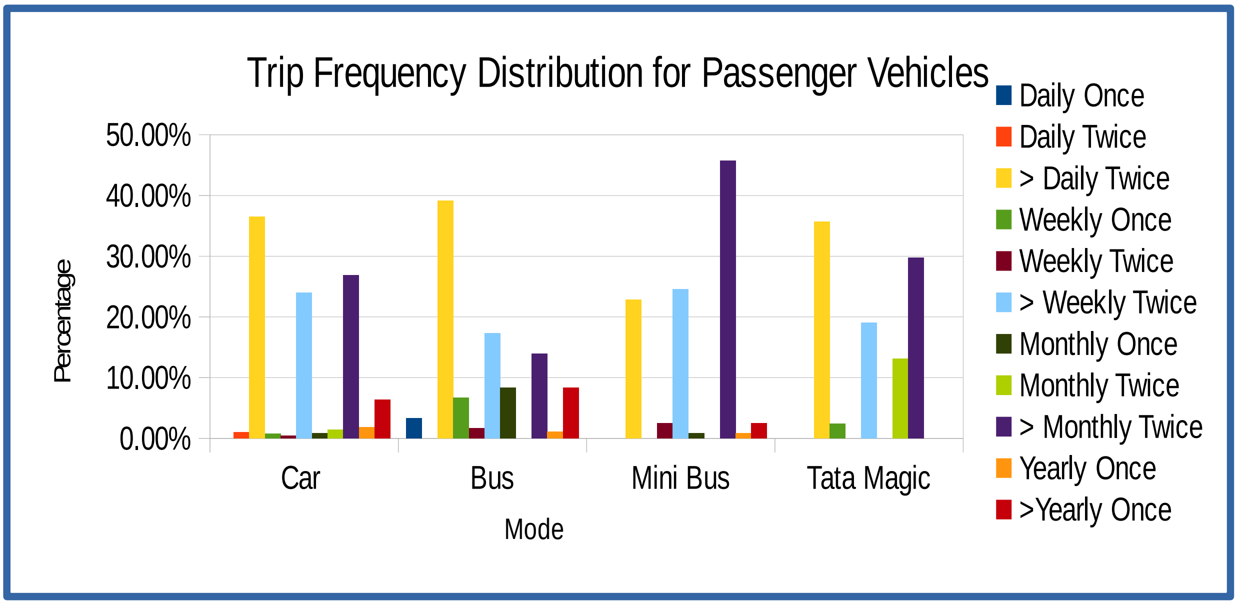


Figure 8.15:Trip distribution of Passengers vehicles at Km 106.800 on NH-160 at Pimpri Nirmal

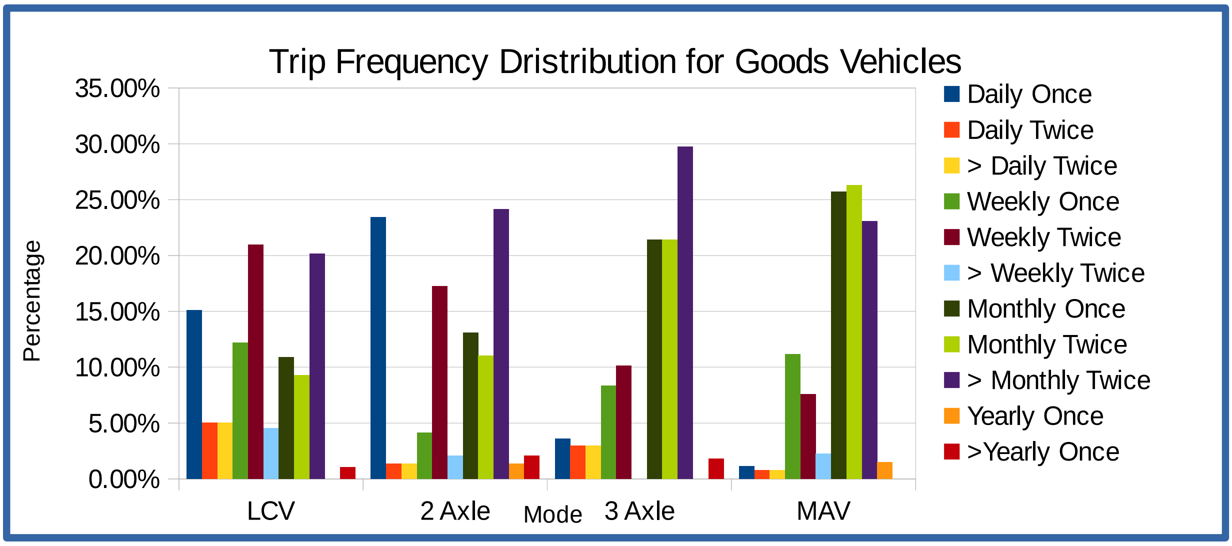


Figure 8.16:Trip distribution of Goods vehicles at Km 106.800 on NH-160 at Pimpri Nirmal

Table 8.20: Goods Composition at Km 356.900 on NH-48 at Bagwadi Toll Plaza

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Food grains and pulses	2%	3%	1%	1%
Cash crops	1%	1%	1%	1%
Vegetables and Fruits	3%	3%	1%	1%
Processed Food Items	1%	0%	0%	0%
Packed Food Items	4%	5%	2%	4%
Fishery, Poultry and Animal feed	1%	2%	1%	1%
Building Materials	6%	9%	12%	8%
Industrial Raw Materials	5%	4%	5%	6%
Consumer Goods	12%	12%	12%	13%
Fertilisers, chemicals and Pharmaceuticals	2%	3%	4%	5%
Machinery and Automobiles	8%	7%	7%	8%
Petroleum Products	6%	3%	8%	10%
Parcel Goods	18%	17%	16%	12%
Empty	27%	26%	25%	23%
Industrial Outputs	5%	4%	3%	6%
Liquor and Cooldrinks	1%	0%	2%	1%

Table 8.21: Goods Composition at Km 75.800 on NH-53 at Manekpore

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Food grains and pulses	10%	4%	5%	4%
Cash crops	8%	10%	6%	3%
Vegetables and Fruits	4%	2%	1%	1%
Processed Food Items	4%	1%	1%	1%
Packed Food Items	7%	2%	2%	2%
Fishery, Poultry and Animal feed	9%	3%	2%	2%
Building Materials	3%	10%	12%	12%
Industrial Raw Materials	5%	4%	5%	21%
Consumer Goods	12%	9%	8%	7%
Fertilisers, chemicals and Pharmaceuticals	2%	3%	2%	4%

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Machinery and Automobiles	0%	3%	4%	2%
Petroleum Products	12%	13%	21%	14%
Parcel Goods	3%	7%	6%	5%
Empty	17%	18%	19%	18%
Industrial Outputs	5%	9%	6%	4%
Liquor and Cooldrinks	0%	1%	0%	0%

Table 8.22: Goods Composition at Km 6.400 on SH-177 at Tankal

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Food grains and pulses	9%	3%	4%	3%
Cash crops	4%	2%	0%	5%
Vegetables and Fruits	1%	7%	14%	0%
Processed Food Items	1%	2%	0%	0%
Packed Food Items	2%	2%	2%	3%
Fishery, Poultry and Animal feed	0%	1%	0%	0%
Building Materials	13%	8%	14%	35%
Industrial Raw Materials	5%	6%	14%	14%
Consumer Goods	4%	7%	4%	0%
Fertilisers, chemicals and Pharmaceuticals	0%	1%	0%	0%
Machinery and Automobiles	0%	6%	0%	3%
Petroleum Products	6%	1%	6%	0%
Parcel Goods	21%	23%	2%	22%
Empty	30%	31%	36%	16%
Industrial Outputs	1%	0%	4%	0%
Liquor and Cooldrinks	1%	0%	0%	0%

Table 8.23: Goods Composition at Km 178.400 on NH-60 at Sinnar

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Food grains and pulses	1%	3%	2%	1%
Cash crops	2%	0%	0%	1%
Vegetables and Fruits	9%	7%	9%	5%
Processed Food Items	15%	13%	11%	16%
Packed Food Items	5%	5%	7%	7%

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Fishery, Poultry and Animal feed	0%	0%	0%	0%
Building Materials	8%	6%	5%	6%
Industrial Raw Materials	1%	1%	2%	3%
Consumer Goods	10%	8%	8%	13%
Fertilisers, chemicals and Pharmaceuticals	2%	3%	2%	3%
Machinery and Automobiles	5%	4%	4%	3%
Petroleum Products	1%	4%	2%	3%
Parcel Goods	15%	23%	19%	17%
Empty	22%	21%	28%	23%
Industrial Outputs	2%	3%	0%	2%
Liquor and Cooldrinks	0%	0%	0%	0%

Table 8.24: Goods Composition at Km 106.800 on NH-160 at Pimpri Nirmal

Commodity	LCV	2 Axle	3 Axle	Multi Axle
Food grains and pulses	7%	8%	1%	4%
Cash crops	4%	1%	4%	4%
Vegetables and Fruits	16%	9%	2%	5%
Processed Food Items	4%	5%	6%	1%
Packed Food Items	7%	7%	1%	5%
Fishery, Poultry and Animal feed	2%	2%	0%	1%
Building Materials	3%	2%	8%	12%
Industrial Raw Materials	3%	5%	10%	7%
Consumer Goods	15%	8%	10%	10%
Fertilisers, chemicals and Pharmaceuticals	2%	4%	3%	4%
Machinery and Automobiles	1%	5%	19%	13%
Petroleum Products	3%	8%	9%	5%
Parcel Goods	15%	10%	8%	12%
Empty	16%	17%	15%	11%
Industrial Outputs	2%	8%	4%	4%
Liquor and Cooldrinks	3%	3%	1%	2%

Fig 8.17: OD Survey at various survey locations

8.12 Axle load surveys & Analysis

Axle load Surveys were conducted at Five locations i.e., at Km 356.900 (Bhagwadi toll plaza of Surat-Mumbai Stretch) on NH-48, at Km 75.800 (Manekpore of Surat-Bajipura Stretch) on NH-53, at Km 6.400(Tankal of Tankal-Rankuva Stretch) on SH-177, at km 178.400(Sinnar of Pune-Nashik Stretch) on NH-60 and at km 106.800 (Pimpri Nirmal of Shiridi- Ahmednagar Stretch) on NH-160 for 24 hrs. The surveys were conducted for all the commercial vehicles (weighing more than 3.0 Tonnes) on a normal weekday in both the directions. The vehicles were selected randomly for axle load measurement, ensuring suitable sample for each category of commercial vehicles consisting of overloaded and empty vehicles to calculate VDF.

The Vehicle Damage Factor (VDF) is an index characterizing the traffic loading for a highway and is defined as a multiplier for converting the number of commercial vehicles of different axle loads to Standard Axle Loads (SAL). Equivalency factor (EF) is normally worked out by using the Fourth Power Rule derived by AASHTO and approved by CRRI.

Equivalency Factor:

Table-8.25: Standard Axle Loads of Different vehicles

Type of Axle	Standard Axle loads(in kN)
Single Axle with single wheel on either side	65
Single Axle with dual wheel on either side	80
Tandem Axle with dual wheel on either side	148
Tridem Alxe with dual wheel on either side	224

By using Fourth Power Rule, Equivalency Factor can be determined. With the help of equivalency factors and frequency distribution of axle loads, Equivalent Axle Loads (EAL) were computed.

Equivalency Factor	**(Axle load / Standard Axle Load)^4**
VDF	**Total EAL/ Number of Vehicles Weighed**

Table-8.26: Axle Load Survey Sample Size at Km 356.900 on NH-48 at Bagwadi Toll Plaza

	Towards Surat			Towards Vapi			Both Directions		
Vehicle type	**TVC**	**Axle load veh.**	**% Sample**	**TVC**	**Axle load veh.**	**% Sample**	**TVC**	**Axle load veh.**	**% Sample**
LCV	2998	561	18.7	2687	597	22.2	5685	1158	20.37
2 Axle	1547	390	25.2	1475	312	21.2	3022	702	23.23
3 Axle	1368	283	20.7	1489	408	27.4	2857	691	24.19
M Axle	3972	796	20.0	3568	737	20.7	7540	1533	20.33
Others	1312	284	21.6	1128	234	20.7	2440	518	21.23

Table-8.27: Axle Load Survey Sample Size at Km 75.800 on NH-53 at Manekpore

	Towards Surat			Towards Bajipura			Both Directions		
Vehicle type	**TVC**	**Axle load veh.**	**% Sample**	**TVC**	**Axle load veh.**	**% Sample**	**TVC**	**Axle load veh.**	**% Sample**
LCV	330	112	33.9	337	118.0	35	667	230	34.48
2 Axle	357	128	35.9	339	100.0	29	696	228	32.76
3 Axle	462	149	32.3	341	84.0	25	803	233	29.02
M Axle	939	275	29.3	1098	298.0	27	2037	573	28.13
Others	402	92	22.9	366	92.0	25	768	184	23.96

Table-8.28: Axle Load Survey Sample Size at Km 6.400 on SH-177 at Tankal

Vehicle type	Towards Rankuva			Towards Tankal			Both Directions		
	TVC	Axle load veh.	% Sample	TVC	Axle load veh.	% Sample	TVC	Axle load veh.	% Sample
LCV	205	55	26.8	203	130	64.0	408	185	45.34
2 Axle	105	44	41.9	98	66	67.3	203	110	54.19
3 Axle	40	17	42.5	45	26	57.8	85	43	50.59
M Axle	61	15	24.6	34	25	73.5	95	40	42.11
Others	240	59	24.6	240	96	40.0	480	155	32.29

Table-8.29: Axle Load Survey Sample Size at Km 178.400 on NH-60 at Sinnar

Vehicle type	Towards Nashik			Towards Pune			Both Directions		
	TVC	Axle load veh.	% Sample	TVC	Axle load veh.	% Sample	TVC	Axle load veh.	% Sample
LCV	789	283	35.9	891	288	32.3	1680	571	33.99
2 Axle	544	117	21.5	613	280	45.7	1157	397	34.31
3 Axle	423	139	32.9	343	112	32.7	766	251	32.77
M Axle	405	165	40.7	313	142	45.4	718	307	42.76
Others	957	36	3.8	931	3	0.3	1888	39	2.07

Table-8.30: Axle Load Survey Sample Size at Km 106.800 on NH-160 at Pimpri Nirmal

Vehicle type	Towards Ahmednagar			Towards Shirdi			Both Directions		
	TVC	Axle load veh.	% Sample	TVC	Axle load veh.	% Sample	TVC	Axle load veh.	% Sample
LCV	203	96	47.3	189	81	42.9	392	177	45.15
2 Axle	188	102	54.3	151	70	46.4	339	172	50.74
3 Axle	212	101	47.6	290	135	46.6	502	236	47.01
M Axle	677	421	62.2	707	314	44.4	1384	735	53.11
Others	607	187	30.8	585	127	21.7	1192	314	26.34

Table 8.31: VDF values for various commercial Vehicles

Type of Vehicle	at Km 356.900 on NH-48 at Bagwadi Toll Plaza			at Km 75.800 on NH-53 at Manekpore			at Km 6.400 on SH-177 at Tankal			at Km 178.400 on NH-60 at Sinnar			at Km 106.800 on NH-160 at Pimpri Nirmal		
	Towards Surat	Towards Vapi	preffered	Towards Surat	Towards Bhajipura	preffered	Towards Rankuva	Towards Tankal	preffered	Towards Nashik	Towards Pune	preffered	Towards Ahmednagar	Towards Shirdi	preffered
2 Axle	2.507	2.857	2.857	2.320	2.259	2.320	1.973	2.120	2.120	2.118	1.665	2.118	3.464	0.993	3.464
3 Axle	5.415	4.256	5.415	3.210	2.120	3.210	2.120	2.230	2.230	3.640	4.240	4.240	5.454	4.265	5.454
M Axle	8.420	5.578	8.420	6.230	5.230	6.230	5.634	3.607	5.634	5.443	4.906	5.443	7.478	4.721	7.478
LCV	1.028	0.878	1.028	1.100	1.200	1.200	1.100	1.200	1.200	1.100	0.950	1.100	1.200	0.900	1.200
Others	0.915	0.401	0.915	0.139	0.186	0.186	0.829	0.107	0.829	0.605	0.820	0.820	0.203	0.687	0.687

Fig 8.18: Axle load Survey at various survey locations

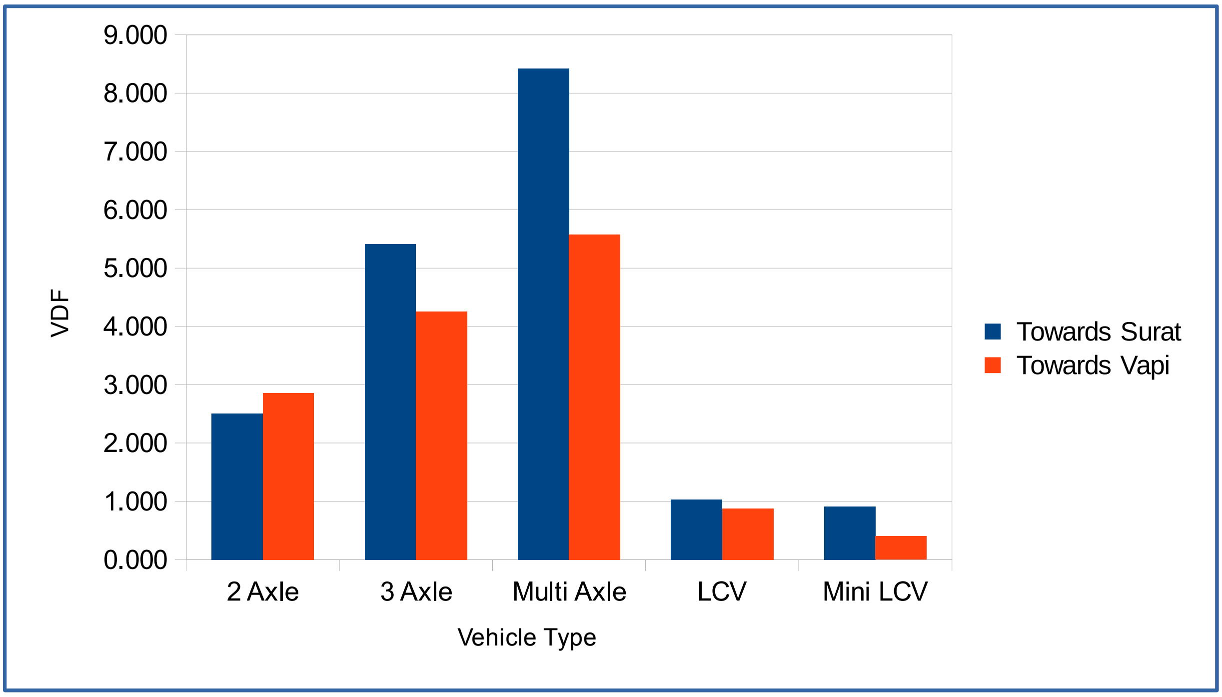


Fig 8.19: Chart showing comparison of VDF values in Both Directions at Km 356.900 on NH-48 at Bagwadi Toll Plaza

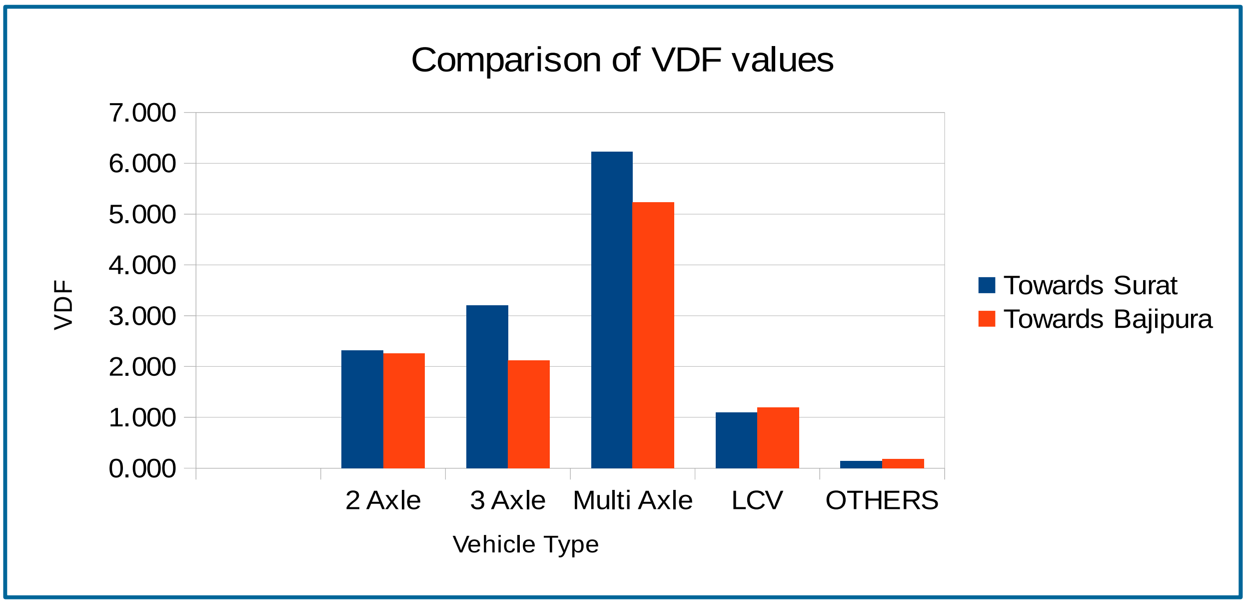


Fig 8.20: Chart showing comparison of VDF values in Both Directions at Km 75.800 on NH-53 at Manekpore

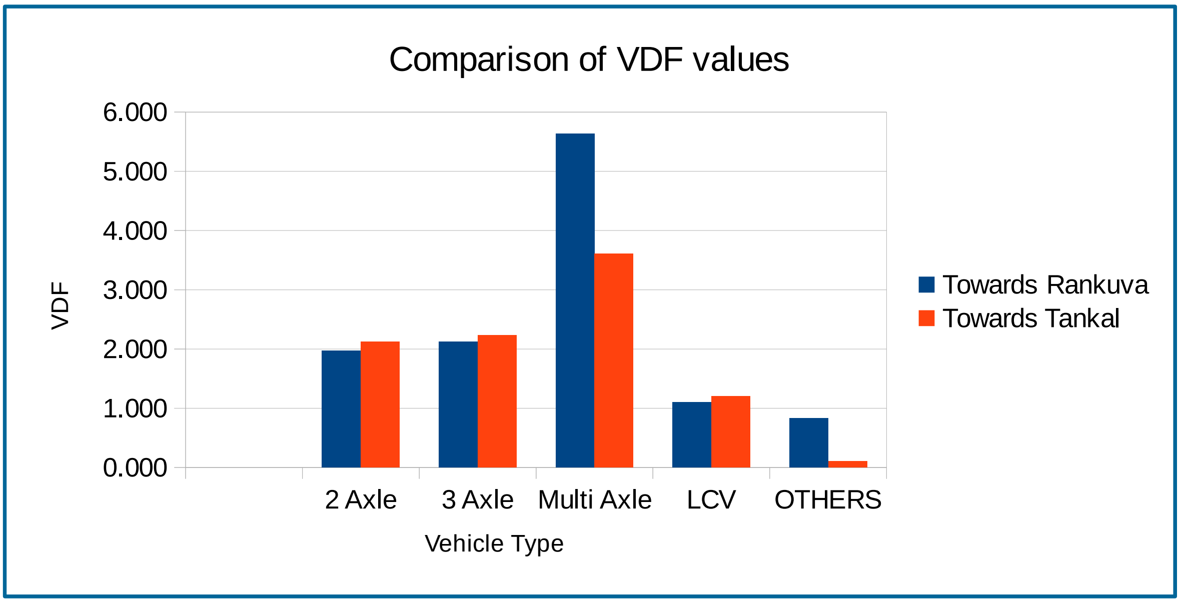


Fig 8.21: Chart showing comparison of VDF values in Both Directions at Km 6.400 on SH-177 at Tankal

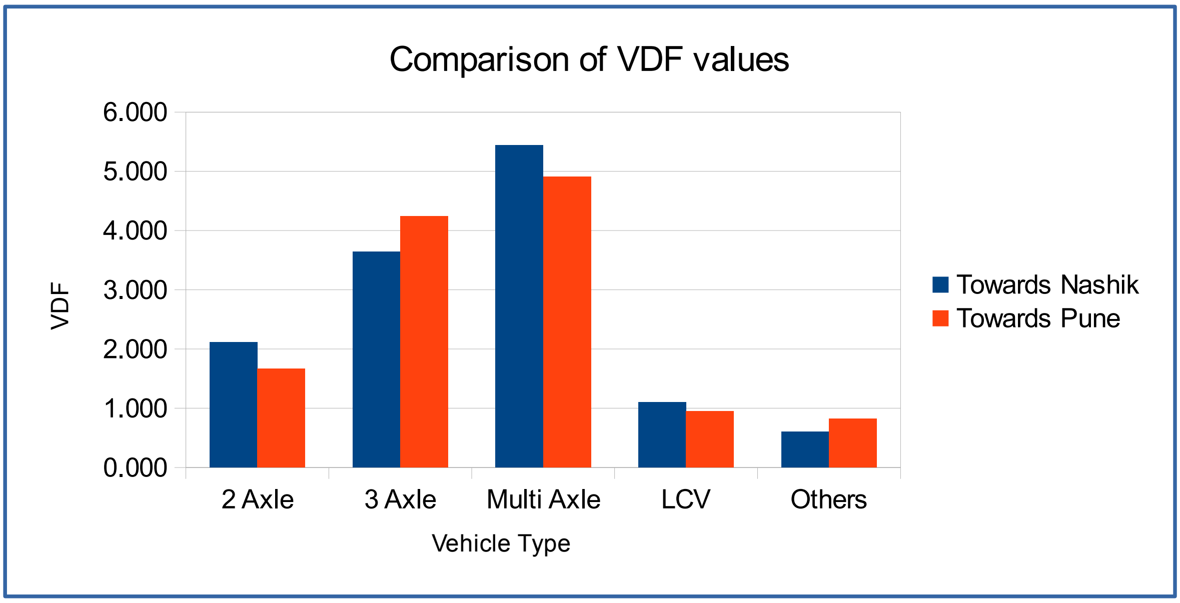


Fig 8.22: Chart showing comparison of VDF values in Both Directions at Km 178.400 on NH-60 at Sinnar

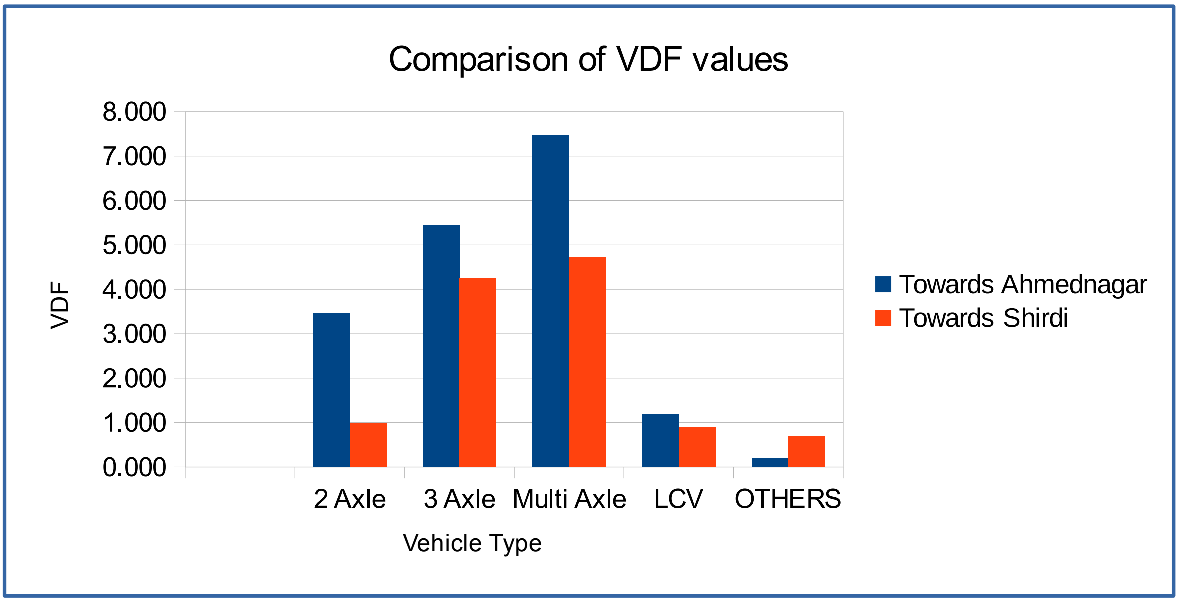


Fig 8.23: Chart showing comparison of VDF values in Both Directions at Km 106.800 on NH-160 at Pimpri Nirmal

8.13 Registration Number Plate Method

To arrive at the contribution of single trip, return trip and monthly trips of vehicles in the toll revenue analysis, O-D surveys in Number Plate method are conducted. Registered numbers of all vehicles passing through a point are noted including the state and district code. The traffic on the project corridor is classified as passenger and goods transport vehicles.

Passenger traffic includes car (including jeep, taxi and van), Bus (standard and mini) and goods traffic includes Light commercial vehicles (LCV and Mini LCV), 2, 3 and M Axle vehicles. The results were analysed and the percentage of bypassable traffic etc. have been suggested based on judgment and the results are presented in Tables–8.19 & 8.20 as shown below and the detail calculations are presented in Annexures-IV(a) & IV(b),IV(c),IV(d),IV(e).

Table-8.32: Number Plate sample size at Various Locations

Vehicle type	at Km 356.900 on NH-48 at Bagwadi Toll Plaza			at Km 75.800 on NH-53 at Manekpore			at Km 6.400 on SH-177 at Tankal			at Km 178.400 on NH-60 at Sinnar			at Km 106.800 on NH-160 at Pimpri Nirmal		
	NP Volume	TVC	Sample Size	NP Volume	TVC	Sample Size	NP Volume	TVC	Sample Size	NP Volume	TVC	Sample Size	NP Volume	TVC	Sample Size
Car	14202	27683	51.3	4312	6032	71.49	1788	2245	79.64	5008	6256	80.05	5608	6594	85.05
Bus	28	34	82.35	8	11	72.73	4	5	80.00	8	10	80.00	191	237	80.59
Mini Bus	926	1168	79.28	486	593	81.96	57	72	79.17	535	666	80.33	556	694	80.12
Tata Magic	322	405	79.51	38	47	80.85	22	27	81.48	55	67	82.09	213	262	81.30
LCV	2909	4616	63.02	480	667	71.96	353	434	81.34	1345	1680	80.06	332	405	81.98
2 Axle	1881	2420	77.73	530	696	76.15	168	211	173.00	929	1157	80.29	304	378	0.80
3 Axle	1972	2485	79.36	661	803	82.32	46	55	83.64	613	766	80.03	424	532	79.70
M Axle	4835	6546	73.86	1588	2038	77.92	85	106	80.19	574	714	80.39	1328	1648	80.58
MiniLCV	1624	2273	71.45	631	754	83.69	328	421	77.91	1521	1888	80.56	972	1195	81.34

Table–8.33: Percentage of Registered Vehicles at Km 356.900 on NH-48 at Bagwadi Toll Plaza

Type of Vehicle	Through Traffic	Daily Pass	Monthly Pass	Total
Car	50%	16%	34%	100%
Car Yellow	100%	0%	0%	100%
Bus	89%	8%	3%	100%
Mini Bus	85%	7%	8%	100%
Tata Magic	100%	0%	0%	100%
LCV	97%	3%	0%	100%
2 Axle	78%	19%	4%	100%
3 Axle	60%	31%	9%	100%
MAV	91%	9%	0%	100%
Mini LCV	96%	4%	0%	100%

Table–8.34: Percentage of Registered Vehicles at Km 75.800 on NH-53 at Manekpore

Type of Vehicle	Through Traffic	Daily Pass	Monthly Pass	Total
Car	96%	4%	0%	100%
Car Yellow	96%	3%	1%	100%
Bus	100%	0%	0%	100%
Mini Bus	100%	0%	0%	100%
Tata Magic	99%	1%	0%	100%
LCV	84%	15%	1%	100%
2 Axle	77%	5%	18%	100%
3 Axle	99%	1%	0%	100%
MAV	99%	1%	0%	100%
Mini LCV	33%	67%	0%	100%

Table–8.35: Percentage of Registered Vehicles at Km 6.400 on SH-177 at Tankal

Type of Vehicle	Through Traffic	Daily Pass	Monthly Pass	Total
Car	68%	30%	2%	100%
Bus	82%	18%	0%	100%
Mini Bus	100%	0%	0%	100%
Tata Magic	100%	0%	0%	100%
LCV	67%	32%	1%	100%
2 Axle	74%	15%	11%	100%
3 Axle	52%	30%	17%	100%
MAV	72%	28%	0%	100%
Mini LCV	58%	21%	21%	100%

Table–8.36: Percentage of Registered Vehicles at Km 178.400 on NH-60 at Sinnar

Type of Vehicle	Through Traffic	Daily Pass	Monthly Pass	Total
Car	88%	11%	1%	100%
Bus	90%	8%	3%	100%
Mini Bus	100%	0%	0%	100%
Tata Magic	100%	0%	0%	100%
LCV	95%	4%	0%	100%
2 Axle	98%	2%	0%	100%
3 Axle	96%	3%	0%	100%
MAV	100%	0%	0%	100%
Mini LCV	96%	4%	0%	100%

Table–8.37: Percentage of Registered Vehicles at Km 106.800 on NH-160 at Pimpri Nirmal

Type of Vehicle	Through Traffic	Daily Pass	Monthly Pass	Total
Car	84%	13%	3%	100%
Bus	90%	5%	4%	100%
Mini Bus	92%	5%	4%	100%
Tata Magic	98%	2%	0%	100%
LCV	73%	25%	2%	100%
2 Axle	45%	53%	1%	100%
3 Axle	98%	2%	0%	100%
MAV	97%	2%	0%	100%
Mini LCV	98%	2%	0%	100%

8.14 Traffic Forecast

For forecasting the traffic in future, it is essential to estimate different components of traffic *viz*., normal traffic, induced traffic, diverted traffic and developmental traffic.

Normal Traffic: Normal traffic is that traffic which would pass along the proposed expressway. The growth of traffic is normally estimated based on past and envisaged future growth trend of traffic around the project influence area. However, as the proposed expressway is a green field project, this component of traffic on project stretch is considered as nil and can be ignored.

Diverted Traffic: Generated traffic is defined as auxiliary traffic that occurs in response to the road investment. The proposed expressway will attract trips from other routes and modes. Diverted traffic is the proportion of traffic on existing road network, around the project influence area, which tends to make a shift in route as well as mode to the proposed expressway. As the project stretch provides more attractive options to commuters along the existing roads in the form of reduced travel distance, reduced travel time, savings in vehicle operating costs, savings in toll and value of time, significant segment of traffic opts to ply on proposed expressway. This component of attracted traffic is considered as Diverted traffic.

Developmental Traffic: Provision of an expressway provides immense opportunities for development of influential areas. Development is augmented by investment in various sectors like industrial, commercial, real estate, tourism etc. This in turn generates notable quantity of traffic volume which is often termed as Developmental traffic. Such component contributes significantly to the future traffic volumes along the project corridor.

"*The projected traffic on project stretch is arrived by summing up the different components of traffic as discussed above giving due diligence to future investments and respective developments for different time horizons*"

8.14.1 Traffic Assignment Methodology

The proposed highway is assumed to come into operation in the year 2025. It is expected that due to construction of access-controlled highway, traffic on existing roads will completely utilize the facility. Hence the traffic that is most likely to use the project stretch is completely diverted on to the proposed highway. Methodology adopted for assigning the traffic on proposed stretch is explained as under:

Step 1: The entire project stretch has been divided into 11 Legs based on entry and exit points in the form of interchanges proposed. The entry/ exit points along the project stretch have been chosen at such locations where possible diversion of existing traffic is expected on to the proposed stretch from National/ State Highways/ MDRs. Section-wise (*leg-wise)* breakup of project stretch is shown in ***Figure-8.24***. Description of individual sections (*legs*) is given as under:

Table–8.38: Leg Deatails with Chainage

Leg No.	Design Chainage(Km)		Village		Length (Km)
	From	To	From	To	
1	0.000	20.145	Toli	Kukeri	20.145
2	20.145	35.923	Kukeri	Pipalkhed	15.778
3	35.923	107.051	Pipalkhed	Ambegaon	71.128
4	107.051	139.000	Ambegaon	Adgaon	31.743
5	139.000	147.340	Adgaon	Varhe Davna	8.546
6	147.340	185.108	Varhe Davna	Fulenagar	37.768
7	185.108	198.393	Fulenagar	Talegaon	13.285
8	198.393	217.592	Talegaon	Chinchpur Kh.	19.199
9	217.592	251.275	Chinchpur Kh.	Rahuri Kh	33.683
10	251.275	275.901	Rahuri Kh	Shendi	24.626

Leg No.	Design Chainage(Km)		Village		Length (Km)
	From	To	From	To	
11	275.901	290.700	Shendi	Sarolabaddi	14.799

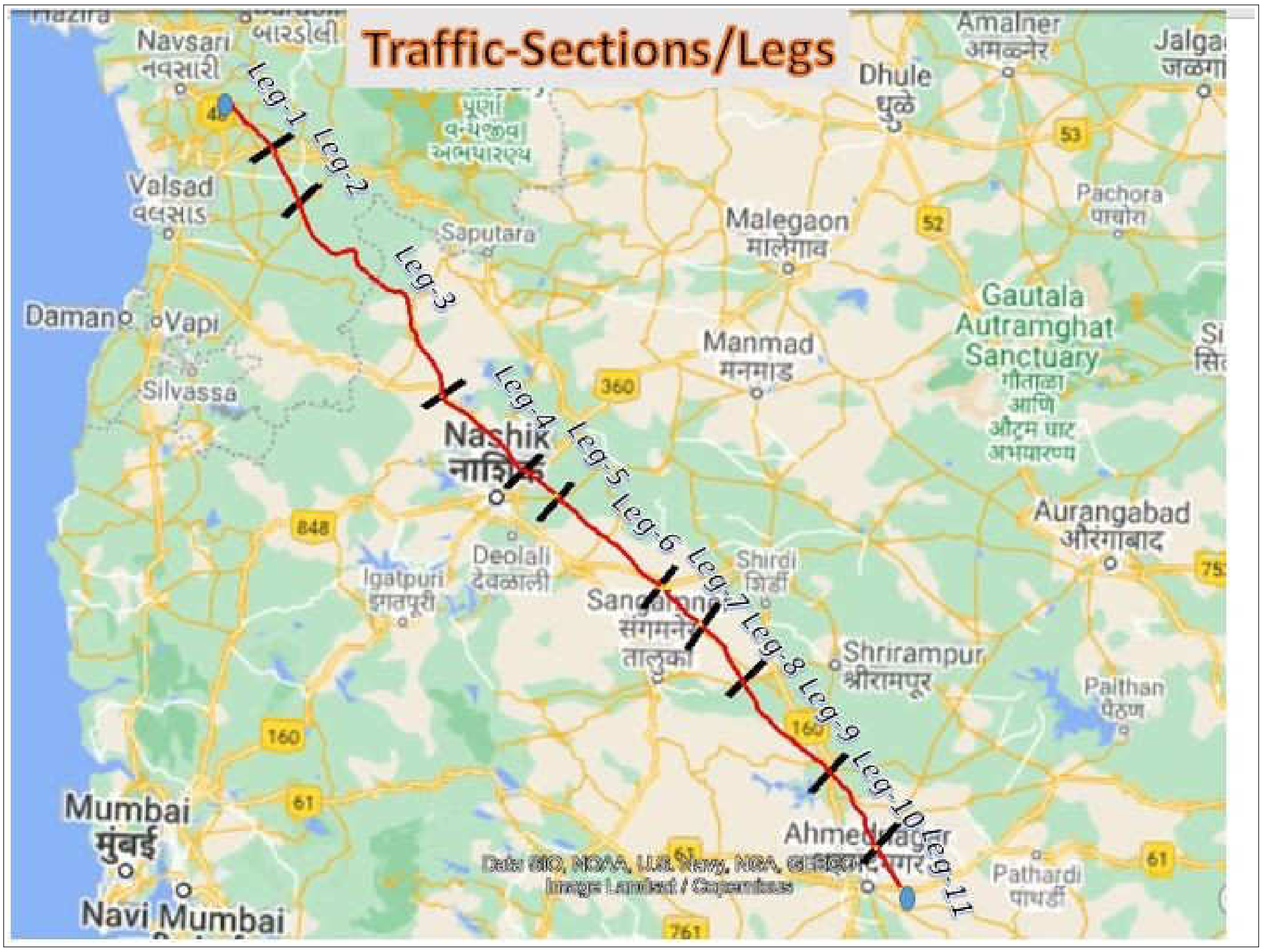


Figure-8.24: *Section-wise (leg-wise) breakup of project stretch*

- **Step 2:** Influential zones were identified for individual sections (*legs)* from where traffic is expected to get diverted. Such section-wise zones have been marked up and grouped together. This aids in arriving at traffic figures expected to ply on individual sections of project stretch.

Step 3: It is assumed that the existing traffic prefers to travel at shorter (*reduced*) distances in shorter times. Hence traffic travelling on existing routes from influential zones is completely assigned to corresponding sections of proposed highway without any precipitates.

Step 4: Upon arriving the traffic on individual sections, total traffic on project stretch is calculated by cumulative summation of applicable section-wise traffic figures. Care has been taken to segregate sections and assign traffic depending upon their origin and destination characteristics. Total diverted traffic on proposed highway for the year 2018-19 is shown from ***Table-8.38.***

Table-8.39: Potential Diverted Traffic on Proposed highway in the year 2018-2019

Vehicle Mode	Homogeneous Section-1				Homogeneous Section-2						
	Leg 1	Leg 2	Leg 3	Leg 4	Leg 5	Leg 6	Leg 7	Leg 8	Leg 9	Leg 10	Leg 11
Car	8201	4923	6140	6640	6849	4652	2358	3396	3503	3272	3530
Bus	469	309	387	437	315	328	318	316	284	358	351
LCV	1568	1086	1435	1277	1263	1141	1026	1152	871	765	966
2 Axle	1922	1316	2329	3205	2532	1566	1178	1433	1398	1251	1165
3 Axle	2128	1566	2070	1645	1437	1788	1906	1823	2169	1842	1748
Multi Axle	3250	1782	1684	1766	1966	1598	1552	2188	2049	2469	2465
Total (Vehicles)	17538	10982	14045	14970	14362	11073	8338	10308	10274	9957	10225
Total (PCU)	38735	24144	30229	32364	30443	24601	21087	25686	25584	25884	25864

From above table the maximum of Leg-1, Leg-2, Leg-3 and Leg-4's diverted traffic is assigned on Homogeneous Section-1 which is 38,735 PCUs/Day and assigned traffic on Homogeneous Section-2 is the maximum of Leg-5, Leg-6, Leg-7, Leg-8, Leg-9, Leg-10 and Leg-11 which is 30,443 PCUs/Day for the Year 2018.

S.No	Homogeneous Section	From (Km)	To (Km)	Length (Km)	Diverted Traffic (PCUs/Day)
1	HS-1 (Surat-Nashik Section)	0.000	139.000	139.000	38,735
2	HS-1 (Nashik-Ahmedngar Section)	139.000	290.700	151.700	30,443

8.15 Estimation of Growth rates

The past motor vehicle registration data at the state level provides a valuable indication regarding the trends in the traffic growth and presents a dependable tool for estimating future growth rates in different categories of vehicles. A more rational method will be able to establish a relationship between the socio-economic variables such as Population, Net State Domestic Product (NSDP) and Per-Capita Income (PCI) on one hand and the past motor vehicle registration data of different vehicle categories of vehicles on the other to determine the elasticity of transport demand with respect to different categories of vehicles. The Estimated growth rates for Gujarat and Maharastra are given in the Table-8.40 and Table-8.41 respectively. Adopted growth rates are given in Table-8.42.

Table–8.40: Projected Growth Rates Of Gujarat

Year	2w	3w	Car	Car(Y)	Goods	Bus	Tractor	Tractor with Trailor	Mini Bus
2018	13%	5%	13%	13%	9%	6%	5%	5%	10%
2022	13%	5%	13%	13%	9%	6%	5%	5%	10%
2027	13%	5%	14%	13%	9%	7%	5%	5%	11%
2032	13%	5%	13%	13%	9%	6%	5%	5%	10%
2037	12%	5%	13%	12%	8%	6%	5%	5%	10%
2042	12%	5%	12%	12%	8%	5%	5%	5%	9%
2047	11%	5%	12%	11%	7%	5%	5%	5%	9%
2052	11%	5%	11%	11%	7%	4%	5%	5%	8%

Table–8.41: Projected Growth Rates Of Maharashtra

Year	2w	3w	Car	Car(Y)	Goods	Bus	Tractor	Tractor with Trailor	Mini Bus
2018	10%	5%	15%	9%	8%	12%	9%	5%	3%
2022	10%	5%	15%	9%	8%	12%	9%	5%	3%
2027	11%	5%	15%	9%	9%	12%	10%	6%	3%
2032	10%	5%	15%	9%	8%	12%	9%	5%	3%
2037	10%	4%	14%	8%	8%	11%	9%	5%	2%
2042	9%	4%	14%	8%	7%	11%	8%	4%	2%
2047	9%	3%	13%	7%	7%	10%	8%	4%	1%
2052	8%	3%	13%	7%	6%	10%	7%	3%	1%

Table 8.42: Adopted Traffic growth rates

Year	Car	Car(Y)	Goods	Bus	Mini Bus
2018- 2023	5%	5%	5%	5%	5%
2023-2028	4.5%	4.5%	4.5%	4.5%	4.5%
2028-2033	4.0%	4.0%	4.0%	4.0%	4.0%
2034-2039	3.5%	3.5%	3.5%	3.5%	3.5%
2040-2045	3.0%	3.0%	3.0%	3.0%	3.0%
2046-2045	3.0%	3.0%	3.0%	3.0%	3.0%
Beyond 2045	3.0%	3.0%	3.0%	3.0%	3.0%

8.16 Projected Traffic On Project Corridor

The proposed highway is assumed to commence its operations from year 2025. Total traffic expected on the project stretch is arrived as the summation of diverted traffic, induced traffic and developmental traffic. The growth rates suggested in **Table-8.41** have been considered in calculating the forecasted traffic volume. **Table-8.42** provides Forecast traffic of Homogeneous Sections till the year 2049.

Table 8.43: Projections of Traffic on Homogeneous Sections

Year	HS-1		HS-2	
	Volume	PCUs	Volume	PCUs
2019	17538	38735	14362	30443
2020	18415	40672	15080	31965

Year	HS-1		HS-2	
	Volume	PCUs	Volume	PCUs
2021	19336	42705	15834	33563
2022	20302	44841	16626	35241
2023	21318	47083	17457	37003
2024	22334	49387	18288	38812
2025	23339	51609	19111	40558
2026	24389	53932	19971	42383
2027	25486	56359	20870	44290
2028	26633	58895	21809	46284
2029	27770	61483	22739	48314
2030	28880	63942	23648	50247
2031	30036	66500	24594	52257
2032	31237	69160	25578	54347
2033	32487	71926	26601	56521
2034	33710	74728	27602	58719
2035	34890	77343	28568	60774
2036	36111	80050	29568	62901
2037	37375	82852	30603	65103
2038	38683	85752	31674	67381
2039	39948	88664	32708	69665
2040	41218	91432	33747	71842
2041	42530	94288	34820	74088
2042	43886	97236	35929	76407
2043	45286	100278	37074	78800
2044	46732	103418	38257	81270
2045	48226	106658	39478	83819

Year	HS-1		HS-2	
	Volume	PCUs	Volume	PCUs
2046	49769	110003	40741	86450
2047	51364	113455	42045	89166
2048	53011	117019	43392	91970
2049	54713	120697	44783	94864

8.17 Capacity and Level of Service Analysis

The capacity of a facility is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of the lane or roadway during a given time period under prevailing roadway, traffic and control conditions. By comparing the present traffic volume with the capacity of existing highways, their adequacy or deficiency can be assessed. Improvements and changes in the geometric features, intersection features, traffic control devices and traffic management measures can be planned if capacity studies are considered.

The Highway Capacity Manual has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating conditions and traffic volumes. It is defined as a qualitative measure describing the operational conditions with in a traffic stream and their perception by motorists. The level of service for rural roads can be related to speed and travel time, freedom to maneuver, traffic interruptions, comfort and safety. Project corridors in rural areas are normally designed for LOS B for Urban Road and LOC C for Rural Roads, based on level of service criteria (IRC 64:1990).

8.17.1.1 Capacity analysis with 5% growth rates

Table 8.44: Capacity analysis for homogeneous section 1 (HS-1)

Year	Volume (PCUs/Day)	Capacity Criteria			Recommended Lane Configuration
		Capacity (PCU/day)	V/C Ratio	LOS	
2019	38735	80000	0.48	B	4-Lane
2020	40672	120000	0.34	B	6-Lane
2021	42705	120000	0.36	B	6-Lane
2022	44841	120000	0.37	B	6-Lane
2023	47083	120000	0.39	B	6-Lane

Year	Volume (PCUs/Day)	Capacity Criteria			Recommended Lane Configuration
		Capacity (PCU/day)	V/C Ratio	LOS	
2024	49387	120000	0.41	B	6-Lane
2025	51609	120000	0.43	B	6-Lane
2026	53932	120000	0.45	B	6-Lane
2027	56359	120000	0.47	B	6-Lane
2028	58895	120000	0.49	B	6-Lane
2029	61483	120000	0.51	C	6-Lane
2030	63942	120000	0.53	C	6-Lane
2031	66500	120000	0.55	C	6-Lane
2032	69160	120000	0.58	C	6-Lane
2033	71926	120000	0.60	C	6-Lane
2034	74728	120000	0.62	C	6-Lane
2035	77343	120000	0.64	C	6-Lane
2036	80050	120000	0.67	C	6-Lane
2037	82852	120000	0.69	C	6-Lane
2038	85752	180000	0.48	B	8-Lane
2039	88664	180000	0.49	B	8-Lane
2040	91432	180000	0.51	C	8-Lane
2041	94288	180000	0.52	C	8-Lane
2042	97236	180000	0.54	C	8-Lane
2043	100278	180000	0.56	C	8-Lane
2044	103418	180000	0.57	C	8-Lane
2045	106658	180000	0.59	C	8-Lane
2046	110003	180000	0.61	C	8-Lane
2047	113455	180000	0.63	C	8-Lane
2048	117019	180000	0.65	C	8-Lane

Year	Volume (PCUs/Day)	Capacity Criteria			Recommended Lane Configuration
		Capacity (PCU/day)	V/C Ratio	LOS	
2049	120697	225000	0.54	C	10-Lane

8.17.2.2 Capacity analysis for homogeneous section 2 (HS-2)

Table 8.45:Capacity analysis for homogeneous section 2 (HS-2)

Year	Volume (PCUs/Day)	Capacity Criteria			Recommended Lane Configuration
		Capacity (PCU/day)	V/C Ratio	LOS	
2019	30443	80000	0.38	B	4-Lane
2020	31965	120000	0.27	A	6-Lane
2021	33563	120000	0.28	A	6-Lane
2022	35241	120000	0.29	A	6-Lane
2023	37003	120000	0.31	B	6-Lane
2024	38812	120000	0.32	B	6-Lane
2025	40558	120000	0.34	B	6-Lane
2026	42383	120000	0.35	B	6-Lane
2027	44290	120000	0.37	B	6-Lane
2028	46284	120000	0.39	B	6-Lane
2029	48314	120000	0.40	B	6-Lane
2030	50247	120000	0.42	B	6-Lane
2031	52257	120000	0.44	B	6-Lane
2032	54347	120000	0.45	B	6-Lane
2033	56521	120000	0.47	B	6-Lane
2034	58719	120000	0.49	B	6-Lane
2035	60774	120000	0.51	C	6-Lane
2036	62901	120000	0.52	C	6-Lane
2037	65103	120000	0.54	C	6-Lane
2038	67381	120000	0.56	C	6-Lane

Year	Volume (PCUs/Day)	Capacity Criteria			Recommended Lane Configuration
		Capacity (PCU/day)	V/C Ratio	LOS	
2039	69665	120000	0.58	C	6-Lane
2040	71842	120000	0.60	C	6-Lane
2041	74088	120000	0.62	C	6-Lane
2042	76407	120000	0.64	C	6-Lane
2043	78800	120000	0.66	C	6-Lane
2044	81270	120000	0.68	C	6-Lane
2045	83819	120000	0.70	C	8-Lane
2046	86450	180000	0.48	B	8-Lane
2047	89166	180000	0.50	B	8-Lane
2048	91970	180000	0.51	C	8-Lane
2049	94864	225000	0.53	C	8-Lane

8.17.3 Conclusions

As per the traffic survey data, the present proposed lane configuration(6 Lane configuration) is sufficient and sustainable upto 2037 and 2045 for HS-1 and HS-2 respectively.

Based on the analysed traffic data and capacity demand, the year of lane up-gradation to 8 lane from proposed 6 lane for normal growth rate is tabulated below **Table-8.46.**

Table 8.46: Year of Lane Upgradation

Homogeneous Sections	Year of lane up-gradation (to 8 Lane)
	With adopted Growth rate
HS-1 (Surat- Nashik)	2038
HS-2 (Nashik – Ahmednagar)	2046

9. PAVEMENT DESIGN REPORT

9.1 Introduction

9.1.1 General

The design of pavement i.e., calculating the total crust thickness depends on mainly two factors Viz. total cumulative repetitions of standard axle loads for the design life and the strength of sub-grade soils(CBR).

The total cumulative repetitions of standard axles is in turn, a function of the annual average daily traffic (AADT) and applicable growth rate (r) of vehicles for forecasting the traffic after a certain period and Vehicle Damage Factor (VDF) for converting the mixed volume of traffic in terms of standard axle load repetitions. Further, lane distribution factor is applied to account for the vehicle load distribution across the width of pavement depending on the available carriageway width.

9.1.2 Design Guide Lines

a) Clause 5.3 of "Manual of Specifications and Standards for Six laning of Highways through Public Private Partnership by – IRC:SP:87-2019" states that "new pavements shall be designed in accordance with IRC:37(flexible).

b) Clause 5.4.1 of IRC:SP:87-2019, states that "Flexible pavement shall be designed for a minimum design period of 15 years or operation period, whichever is more. Stage construction will be permissible subject to the requirements specified below:

Alternative strategies or combination of initial design, strengthening and maintenance can be developed by the concessionaire to provide the specified level of pavement performance over the operation period subject to satisfying the following minimum design requirements.

I. The thickness of sub-base and base of pavement sections is designed for a minimum design period of 15 years or the operation period, whichever is more and the initial bituminous surfacing for a minimum design period of 10 years.

II. The pavement shall be strengthened by bituminous overlay as and when required to extend the pavement life to full operation period. The thickness of bituminous overlay shall be determined on the basis of relevant IRC codes.

It is a common phenomenon in Indian Roads that the road requires a functional overlay every 5 years, even if the pavement is designed for 15 years. The initial pavement thickness designed for 15 years is left underutilized. It is wise to follow the stage construction rather than total construction.

c) Clause 5.5.4 of IRC: SP:87-2019, states that "the concessionaire shall adopt a realistic value of the rate of traffic growth, provided that annual rate of growth of commercial vehicles shall not be less than 5 per cent."

9.2 PRELIMINARY INVESTIGATIONS

9.2.1 Soil Investigations

a) Soil Classification:

The sub-grade soil along the proposed project corridor generally consists of Sandy soil and Clayey soil.

b) CBR of Borrow area soils:

Soaked CBR tests were conducted at MDD and OMC on the samples collected from borrow areas. It was observed that the soaked CBR varies from 5% to 20% for the project road. The following table presents the detail of borrow material.

S. No	Type of work	Maximum Laboratory dry unit weight when tested as per IS: 2720(Part 8)
1	Embankments up to 3metres height, not subjected to extensive flooding	Not less than 15.2 KN/cum
2	Embankments exceeding 3 meters height or embankments of any height subject to long periods of inundation	Not less than 16.0 KN/cum
3	Sub grade and earthen shoulders/verges/back fill	Not less than 17.5 KN/cum

Table-9.1: Test results of Borrow Area

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
1	km. 00+000, RHS,	BA 01	3.0	1.4	3.3	22.4	69.9	MI	38	25	13	18	1.82	16.50	16	SUB
2	km. 2+300, LHS,	BA 02	3.50	3.30	4.67	11.90	76.60	CI	38	20	18	40.0	1.82	15.00	14	SUB
3	km. 4+800, LHS,	BA 03	12.10	5.40	5.37	11.30	65.80	CI	43	19	24	18.2	1.83	14.00	16	SUB
4	km. 8+150, RHS,	BA 04	12.10	5.40	5.37	11.30	65.80	CI	43	19	24	18.2	1.83	14.00	15	SUB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
5	km. 12+800, LHS,	BA 05	7.1	7.0	10.6	14.0	61.3	CI	43	18	25	40	1.76	16.10	12	SUB
6	km. 15+700, LHS,	BA 06	7.2	5.6	20.4	32.1	34.7	SC	30	22	08	10	1.94	13.40	18	SUB
7	km. 19+100, LHS,	BA 07	18.9	29.7	24.5	9.7	17.2	SM	45	30	15	17	1.69	21.20	9	SUB
8	km. 26+200, LHS,	BA 08	22.5	20.2	18.3	10.3	28.7	SC	43	25	18	17	1.69	18.50	8	EMB
9	km. 30+700, LHS,	BA 09	14.0	7.6	12.6	10.7	55.1	MI	45	28	17	8	1.68	19.00	8	EMB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
10	km. 35+900, LHS,	BA 10	8.6	25.7	36.1	12.7	16.9	SC	46	21	25	8	1.74	18.20	10	SUB
11	km. 41+800, RHS,	BA 11	46.6	19.5	7.6	3.4	22.9	GM	47	28	19	17	2.13	11.60	22	SUB
12	km. 45+400, LHS,	BA 12	9.9	10.7	22.1	19.1	38.2	SM	45	28	17	15	1.66	20.20	8	EMB
13	km. 81+700, RHS,	BA 13	14.3	14.2	19.6	13.8	38.1	SM	47	30	17	8	1.62	22.60	6	NS
14	km. 91+700, LHS,	BA 14	18.9	8.8	13.8	9.2	49.3	SM	50	32	18	17	1.55	23.50	5	NS

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
15	km. 95+700, LHS,	BA 15	12.0	14.6	27.0	12.5	33.9	SM	55	32	23	17	1.44	26.00	5	NS
16	km. 100+600, LHS	BA 16	16.6	3.0	5.5	8.3	66.6	CI	44	25	19	20	1.69	20.40	9	SUB
17	km. 103+700, RHS	BA 17	22.5	8.4	9.9	9.5	49.7	SM	57	31	26	17	1.57	22.50	6	NS
18	km. 107+000, RHS	BA 18	13.1	15.6	31.9	10.6	28.8	SM	55	32	23	8	1.55	23.00	5	NS
19	km. 115+400, LHS	BA 19	6.6	15.0	38.8	12.2	27.4	SC	50	28	22	25	1.65	20.00	6	NS

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
20	km. 118+000, LHS	BA 20	16.3	18.1	21.3	7.6	36.7	SM	46	28	18	8	1.83	15.30	17	SUB
21	km. 124+000, RHS	BA 21	7.2	17.4	41.4	11.7	22.3	SM	45	27	18	20	1.64	21.00	8	EMB
22	km. 128+500, LHS	BA 22	18.2	21.9	27.9	8.8	23.2	SC	41	23	18	18	1.91	14.80	19	SUB
23	km. 138+200, LHS	BA 23	23.3	26.6	29.0	7.3	13.8	SC	45	26	19	27	1.91	15.00	20	SUB
24	km. 152+200, RHS	BA 24	33.1	16.2	25.7	11.9	13.1	SM	NP	NP	NP	10	2.06	12.70	23	SUB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
25	km. 163+000, RHS	BA 25	47.0	23.1	23.3	6.3	0.3	SP	38	24	14	18	2.00	13.30	20	SUB
26	km. 174+000, RHS	BA 26	23.6	21.1	26.0	7.3	22.0	SC	49	25	24	27	1.85	16.00	16	SUB
27	km. 185+100, RHS	BA 27	35.7	17.0	15.2	5.7	26.4	SC	49	26	23	50	1.90	12.90	19	SUB
28	km. 195+100, RHS	BA 28	35.7	19.4	25.9	8.6	10.4	SP-SC	36	24	12	9	2.02	12.10	21	SUB
29	km. 204+300, RHS	BA 29	4.7	6.8	16.5	10.9	61.1	CI	49	26	23	40	1.71	18.00	12	SUB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
30	km. 211+000, RHS	BA 30	6.3	7.9	14.7	22.8	48.3	SC	39	25	14	0	1.85	17.30	15	SUB
31	km. 217+600, RHS	BA 31	38.0	19.6	21.0	7.8	13.6	SC	36	23	13	0	2.00	12.60	21	SUB
32	km. 225+900, RHS	BA 32	26.5	20.8	24.3	12.0	16.4	SM	42	27	15	40	1.88	15.00	15	SUB
33	km. 230+700,RHS,	BA 33	39.2	13.6	17.4	9.6	20.2	SC	45	26	19	20	1.92	14.80	18	SUB
34	km. 230+700, LHS	BA 34	16.1	14.0	16.6	9.4	43.9	SM	48	28	20	40	1.80	16.50	14	SUB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
35	km. 240+600, LHS	BA 35	29.0	13.8	15.0	12.7	29.5	SM	42	33	09	30	1.87	16.00	16	SUB
36	km. 243+300, LHS	BA 36	8.4	18.0	43.0	16.4	14.2	SM	NP	NP	NP	20	1.95	13.40	18	SUB
37	km. 245+000, RHS	BA 37	29.2	21.7	33.4	8.7	7.0	SP-SM	37	25	12	20	1.92	15.00	18	SUB
38	km. 251+300, RHS	BA 38	23.7	16.0	17.7	15.2	27.4	SM	37	25	12	20	1.92	13.40	17	SUB
39	km. 267+800, LHS	BA 39	0.9	2.8	9.7	42.9	43.7	SM	NP	NP	NP	0	1.93	14.00	18	SUB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
40	km. 272+600, LHS	BA 40	19.3	10.3	17.0	26.5	26.9	SM	38	25	13	30	1.92	14.70	19	SUB
41	km. 274+700, RHS	BA 41	20.5	11.8	20.0	13.7	34.0	SM	41	26	15	18	1.90	14.40	18	SUB
42	km. 275+900, LHS	BA 42	10.8	6.3	9.6	8.2	65.1	MH	61	32	29	45	1.66	18.20	12	SUB
43	km. 280+900, RHS	BA 43	10.1	9.3	24.5	24.8	31.3	SM	NP	NP	NP	10	1.87	15.40	15	SUB
44	km. 285+700, RHS	BA 44	10.7	9.2	25.9	15.0	39.2	SM	61	35	26	18	1.89	26.00	14	SUB

S.no	Chainage & side	Borrow area no.	Grain Size Analysis					IS Classification	Atterberg Limits			FSI (%)	Modified Proctor Tests		Soaked CBR %	Suitability
			Gravel %	Coarse sand(%)	Medium Sand %	Fine Sand %	Fines %		Liquidity Limit	Plastic Limit %	PI %		MDD (g/cc)	OMC (%)		
45	km. 287+900,LHS,	BA 45	43.7	18.2	23.0	7.2	7.9	SP-SM	42	28	14	18	1.90	15.50	19	SUB

Note: Emb – Embankment, Sub – Subgrade, N.S – Not Suitable, N.A – Not Applicable

9.2.2 Traffic Surveys

The classified Traffic Volume Count(TVC) Survey in each direction have been carried out at 5 locations i.e., at Km.359.600 near Vapi on NH-48, at Km.75.800 near Manekpore on NH-53, at Km.6.400 near Tankal on SH-177, at Km.178.400 near Sinnar on NH-60 & at Km.106.800 near Pimpri Nirmal on NH-160 (old SH-10) by trained personnel.

OD & Axle Load surveys have been conducted at Km.356.900 near Bagwadi Toll Plaza on NH-48, at Km.75.800 near Manekpore on NH-53, at Km.6.400 near Tankal on SH-177, at Km.178.400 near Sinnar on NH-60 & at Km.106.800 near Pimpri Nirmal on NH-160 (old SH-10). Further secondary economic data such as population, Net State Domestic Product (NSDP) and Per Capita Income (PCI) was used along with vehicle registration data to infer likely growth rates.

IRC: SP: 87-2019 states that a minimum of 5% growth rate to be adopted for pavement design. So the calculations were made taking the growth rates inferred subject to a minimum value of 5%. However, Terms of Reference (TOR) stated the use of a uniform growth rate of 5%. So design is done based on both the inferred as well as uniform growth rates. Following Tables shows the various inputs that are considered for pavement design.

9.2.2.1 Base Year Traffic (AADT)

For the purpose of the pavement design, commercial vehicles of laden weight more than 3 tonnes has been considered. Such vehicles consisted of LCV's, Mini LCVs, 2 Axle trucks, 3 Axle trucks and Multi Axle Trucks. The summary of AADT of commercial vehicles considered for pavement design is given below.

Axle load survey was conducted at Km.156.900 near Bagwadi on NH-48, at Km.75.800 near Manekpore on NH-53, at Km.6.400 near Tankal on SH-177, at Km.178.400 near Sinnar on NH-60 & at Km.106.800 near Pimpri Nirmal on NH-160 (old SH-10) respectively with trained personnel.

9.2.2.2 Axle Load Surveys

The Vehicle Damage Factor (VDF) is an index characterizing the traffic loading for a highway and is defined as a multiplier for converting the number of commercial vehicles of different axle loads to Standard Axle Loads (SAL). Equivalency Factor (EF) is normally worked out by using the Fourth Power Rule derived by AASHTO. With the help of equivalency factors and frequency distribution of axle loads, Equivalent Axle Loads (EAL) are computed as:

VDF = Total EAL/Number of Vehicles weighed.

The standard axle loads and the legal axle loads considered while calculating the equivalency factors for various axles are furnished below.

S.No.	Type of Axles	Standard Load (KN)	Legal Load (KN)
1	Single Axle (Single Wheel)	65	75
2	Single Axle (Dual Wheel)	80	115
3	Tandem Axle (Dual Wheel)	148	210
4	Tridem Axle (Dual Wheel)	224	270

*legal load is as per new MORTH circular IHMCL/ETC/Operations/2017

Axle load surveys were conducted at Km.156.900 near Bagwadi on NH-48, at Km.75.800 near Manekpore on NH-53, at Km.6.400 near Tankal on SH-177, at Km.178.400 near Sinnar on NH-60 & at Km.106.800 near Pimpri Nirmal on NH-160 (old SH-10). This survey was conducted for 1 normal day in both directions of traffic simultaneously with volume count of commercial vehicles (Trucks and LCV). The random selection of vehicles for axle load measurement was done, ensuring suitable sample for each category of commercial vehicles consisting of overloaded and empty vehicles. The distribution of sample by commodity type is presented below.

Table – 9.2: Distribution of Sample by Commodity at Km 356.900 on NH-48 at Bagwadi Toll Plaza

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Vapi	Towards Surat	Towards Vapi	Towards Surat	Towards Vapi	Towards Surat	Towards Vapi	Towards Surat	Towards Vapi	Towards Surat
1	Food grains and pulses	0	1	2	4	0	2	1	1	0	0
2	Cash crops	1	1	2	1	2	2	6	2	0	0
3	Vegetables and Fruits	2	3	3	3	1	1	3	3	2	3
4	Processed Food Items	0	0	0	0	0	0	0	1	3	3
5	Packed Food Items	0	1	2	2	0	0	0	1	0	0
6	Fishery, Poultry and Animal feed	0	1	5	6	1	1	1	2	0	0
7	Building Materials	15	19	14	14	19	16	2	3	0	0
8	Industrial Raw Materials	2	2	11	7	8	9	10	6	1	3
9	Consumer Goods	4	4	6	7	10	8	4	5	0	1
10	Fertilisers, chemicals and Pharmaceuticals	2	2	4	4	8	8	1	2	0	0
11	Machinery and	7	5	4	4	10	9	1	3	0	1

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Vapi	Towards Surat	Towards Vapi	Towards Surat	Towards Vapi	Towards Surat	Towards Vapi	Towards Surat	Towards Vapi	Towards Surat
	Automobiles										
12	Petroleum Products	4	3	4	4	11	8	1	1	0	1
13	Parcel Goods	16	14	12	12	7	9	17	19	2	2
14	Empty	35	38	21	19	15	19	45	40	89	80
15	Industrial Outputs	10	7	11	13	7	8	6	11	2	5
16	Liquor and Cooldrinks	1	1	0	0	0	0	0	1	0	0
	Total	100	100	100	100	100	100	100	100	100	100

Table – 9.3: Distribution of Sample by Commodity at Km 75.800 on NH-53 at Manekpore

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat
1	Food grains and pulses	0	0	0	4	0	8	3	3	0	3
2	Cash crops	3	2	13	10	2	11	7	4	0	0
3	Vegetables and Fruits	4	2	0	0	2	2	2	1	2	17
4	Processed Food Items	0	2	0	1	0	0	0	0	3	3
5	Packed Food Items	0	0	0	0	0	0	0	0	0	0
6	Fishery, Poultry and Animal feed	0	0	7	1	2	0	0	0	0	2
7	Building Materials	6	40	13	17	21	12	2	1	0	7
8	Industrial Raw Materials	2	5	2	14	4	25	7	4	0	2
9	Consumer Goods	0	20	0	7	13	12	3	3	0	5
10	Fertilisers, chemicals and Pharmaceuticals	0	0	0	0	8	4	0	0	0	5

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat	Towards Bajipura	Towards Surat
11	Machinery and Automobiles	6	0	5	0	14	0	0	0	0	0
12	Petroleum Products	4	1	10	3	14	9	2	2	0	0
13	Parcel Goods	19	8	8	14	3	5	17	26	2	10
14	Empty	40	22	37	27	9	11	58	56	91	32
15	Industrial Outputs	10	1	1	1	6	3	0	0	1	7
16	Liquor and Cooldrinks	6	0	2	0	1	0	0	0	0	7
	Total	100	100	100	100	100	100	100	100	100	100

Table 9.4: Distribution of Sample by Commodity at Km 6.400 on SH-177 near Tankal

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal
1	Food grains and pulses	2	8	6	4	0	0	16	8	3	1
2	Cash crops	0	2	0	0	0	0	0	1	0	15
3	Vegetables and Fruits	5	23	0	15	0	32	5	24	17	5
4	Processed Food Items	0	0	0	0	0	0	2	0	3	0
5	Packed Food Items	0	0	0	0	0	0	2	0	0	0
6	Fishery, Poultry and Animal feed	0	0	0	8	0	4	0	0	2	2
7	Building Materials	18	18	24	31	60	24	15	6	7	10
8	Industrial Raw Materials	2	17	6	12	7	16	0	16	2	0
9	Consumer Goods	11	0	0	0	7	0	2	0	5	0
10	Fertilisers, chemicals	2	0	0	0	0	0	2	0	5	0

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal	Towards Rankuva	Towards Tankal
	and Pharmaceuticals										
11	Machinery and Automobiles	7	10	0	8	0	4	4	21	0	0
12	Petroleum Products	5	7	0	0	0	0	0	2	0	1
13	Parcel Goods	16	0	12	0	7	0	24	0	10	0
14	Empty	25	15	53	23	7	20	24	22	32	66
15	Industrial Outputs	5	0	0	0	13	0	4	0	7	0
16	Liquor and Cooldrinks	2	0	0	0	0	0	2	0	7	0
	Total	100	100	100	100	100	100	100	100	100	100

Table 9.5: Distribution of Sample by Commodity at Km 178.400 on NH-60 near SINNAR

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Nashik	Towards Pune	Towards Nashik	Towards Pune	Towards Nashik	Towards Pune	Towards Nashik	Towards Pune	Towards Nashik	Towards Pune
1	Food grains and pulses	6	4	9	9	8	4	5	1	6	0
2	Cash crops	4	1	6	0	4	1	1	1	14	0
3	Vegetables and Fruits	5	2	6	4	5	2	7	3	6	0
4	Processed Food Items	3	0	2	0	6	0	7	1	0	0
5	Packed Food Items	1	1	4	6	2	0	3	1	3	0
6	Fishery, Poultry and Animal feed	2	4	4	13	1	1	5	2	6	33
7	Building Materials	8	14	5	29	11	41	5	17	6	33
8	Industrial Raw Materials	6	1	1	1	3	1	3	0	3	0
9	Consumer Goods	5	1	2	4	4	6	5	8	0	0
10	Fertilisers, chemicals and Pharmaceuticals	3	0	4	0	4	2	4	2	3	0
11	Machinery and Automobiles	4	2	4	4	4	15	7	1	8	0

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Nashik	Towards Pune	Towards Nashik	Towards Pune	Towards Nashik	Towards Pune	Towards Nashik	Towards Pune	Towards Nashik	Towards Pune
12	Petroleum Products	0	0	1	5	4	0	0	0	0	0
13	Parcel Goods	20	15	15	13	7	8	10	23	11	0
14	Empty	27	54	32	12	28	17	28	40	33	33
15	Industrial Outputs	4	0	2	0	8	0	8	0	3	0
16	Liquor and Cooldrinks	2	0	3	0	1	0	2	0	0	0
	Total	100	100	100	100	100	100	100	100	100	100

Table 9.6: Distribution of Sample by Commodity at Km 106.800 on NH-160 near PIMPRI NIRMAL

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi
1	Food grains and pulses	6	0	5	0	7	1	3	5	6	2
2	Cash crops	2	0	3	0	1	0	0	0	1	0
3	Vegetables and Fruits	2	11	0	16	3	8	3	14	1	6
4	Processed Food Items	0	9	1	10	1	3	0	4	1	4
5	Packed Food Items	0	6	1	6	1	3	0	4	1	4
6	Fishery, Poultry and Animal feed	1	0	3	1	3	1	1	0	1	0
7	Building Materials	5	7	7	4	14	4	4	4	3	3
8	Industrial Raw Materials	1	0	14	0	11	5	4	0	6	6
9	Consumer Goods	0	10	4	13	7	22	3	4	4	13
10	Fertilisers, chemicals and Pharmaceuticals	0	0	5	1	8	2	0	5	2	3

Commodity Code	Commodity	2 Axle Truck		3 Axle Truck		Multi Axle Truck		LCV		Others	
		Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi	Towards Ahmednagar	Towards Shiridi
11	Machinery and Automobiles	8	6	7	2	11	19	2	4	4	4
12	Petroleum Products	15	6	2	0	13	4	0	0	6	2
13	Parcel Goods	15	20	18	28	10	17	25	16	24	22
14	Empty	33	20	20	7	5	5	42	36	29	25
15	Industrial Outputs	7	4	11	11	4	7	13	5	9	6
16	Liquor and Cooldrinks	6	1	0	0	0	0	0	0	2	1
	Total	100	100	100	100	100	100	100	100	100	100

The VDF calculated for different categories of commercial vehicles are shown below and the detailed analysis is presented in Traffic Report.

Table 9.7: Vehicle Damage Factor (VDF) at Km 156.900 near Bagwadi on NH - 48

S.No	Mode	Adopted VDF
1	2 Axle Truck	2.857
2	3 Axle Truck	3.875
3	Multi Axle Truck	8.420
4	LCV	1.028

Table 9.8: Vehicle Damage Factor (VDF) at Km 75.800 near Manekpore on NH – 53

S.No	Mode	Adopted VDF
1	2 Axle Truck	2.320
2	3 Axle Truck	3.210
3	Multi Axle Truck	6.230
4	LCV	1.200

Table 9.9: Vehicle Damage Factor (VDF) at Km 66.400 near Tankal on SH – 177

S.No	Mode	Adopted VDF
1	2 Axle Truck	2.120
2	3 Axle Truck	2.230
3	Multi Axle Truck	5.634
4	LCV	1.200

Table 9.10: Vehicle Damage Factor (VDF) at Km 178.400 near Sinnar on NH – 60

S.No	Mode	Adopted VDF
1	2 Axle Truck	2.118
2	3 Axle Truck	4.240
3	Multi Axle Truck	5.443
4	LCV	1.100

Table 9.11: Vehicle Damage Factor (VDF) at Km 106.800 near Pimpri Nirmal on NH-160

S.No	Mode	Adopted VDF
1	2 Axle Truck	3.464
2	3 Axle Truck	5.454
3	Multi Axle Truck	7.478
4	LCV	1.200

9.2.2.3 Traffic Homogeneous Sections

The project road has two homogeneous sections on the basis of traffic generation and dispersal nodes located along the project road.

Table-9.12: Traffic Homogeneous section (HS)

S.No.	HS	From (Km)	To (Km)	Length (Km)
1	HS-1	0.000	139.000	139.000
2	HS-2	139.000	290.700	290.700

9.2.2.4 Million Standard Axles (MSA)

Design traffic in terms of Million Standard Axles has been determined at one location based on traffic homogeneous sections, where volume count and axle load surveys were conducted.

The traffic loading in terms of the cumulative number of standard axles for the given period has been computed using the following relationship.

N = 365 * [(1+r) n – 1] * A * D * L * F / r

Where,

N : The cumulative number of standard axles to be catered for in the design in terms of MSA.

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

L : Lane Distribution Factor (0.75)

D :Directional Distribution Factor(0.50)

n :Design Life in years

r : Annual Growth rate of commercial vehicles.

F : Vehicle Damage Factor

The above said traffic parameters and VDF for individual vehicles have been used for the computations of cumulative million standard axles.

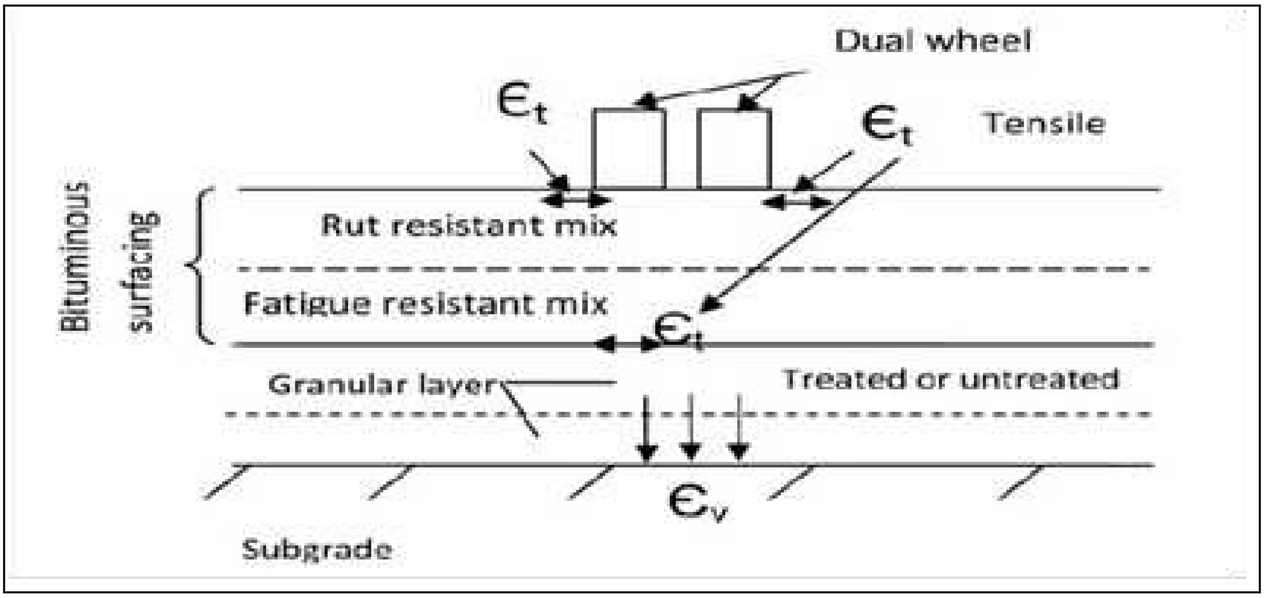
100 MSA is adopted for Pavement Design.

9.3 DESIGN OF FLEXIBLE PAVEMENT BY IRC METHOD

9.3.1 General

The flexible pavement is modelled as an elastic multilayer structure. Stresses and strains at critical locations are computed using linear layered elastic model. The stress - strain analysis software IITPAVE has been used for the computation of stress and strain in flexible pavements as mentioned below.

- Horizontal Tensile Strain at bottom of bituminous layer, which can cause fatigue failure of bituminous layer.
- Vertical Compressive Strain at the top of sub grade, which can cause rutting failure of pavement layers.
- Horizontal Tensile Strain at bottom of Cement treated base, which can cause fatigue failure of cement treated layer.



The flexible pavement has low flexural strength and hence layers reflect the deformation of the lower layers/sub-grade on to the surface layer after the withdrawal of wheel load. To control the deflections in the sub-grade so that no permanent deflections results the pavement thickness is so designed that the stresses on the sub-grade soil are kept within its bearing power. Loading of bituminous pavement requires the stiffest layers to be placed at the surface with successive weaker layers down to sub-grade.

For the purpose of structural design, only the number of commercial vehicles of laden weight of 3 tonnes or more and their axle loading will be considered.

9.3.2 Fatigue Model

Due to repetition of loads, tensile strain develop cracks at the bottom of bituminous layers which is a problem for long term serviceability. The phenomenon is called fatigue of the bituminous layer and the number of load repetitions in terms of standard axles that cause fatigue denotes the life of the pavement. Two fatigue equations are considered, one in which the computed strains in by termed as 80% reliability level and the other corresponding to 90% reliability level. The 80% reliability equation is used for the pavement where VG30 grade bitumen is used and 90% reliability equation is used for the pavement where VG40 grade of bitumen is used. The two equations for the conventional bituminous mixes designed by Marshall method are given below:

$$\mathbf{Nf = 2.21 \times 10\text{-}4 \times (1/E_t)^{3.89} \times (1/M_R)^{0.854}} \text{ ---------1 } \mathbf{(80\%\ Reliability)}$$

$$\mathbf{Nf = 2.021 \times 10\text{-}4 \times (1/E_t)^{3.89} \times (1/M_R)^{0.854}} \text{ ---------2 } \mathbf{(90\%\ Reliability)}$$

Nf = Fatigue life in number of standard axles

E_t = Maximum tensile strain at the bottom of Bituminous layer.

M_R = Resilient Modulus of the Bituminous layer

The equation 2 is modified by considering 90% reliability with air voids around 3% and the volume of bitumen about 13%.

9.3.3 Rutting Model

Rutting is the permanent deformation in pavement usually occurring longitudinally along the wheel path. The rutting may partly be caused by deformation in the subgrade and other non-bituminous layers which would reflect to the overlying layers to take a deformed shape. The 80% reliability equation is used for the pavement where VG30 grade bitumen is used and 90% reliability equation is used for the pavement where VG40 grade bitumen is used. The rutting model considers the vertical strain in subgrade and the two equations are given below by considering 80% & 90% reliability.

$$\mathbf{N = 4.1656 \times 10^{-8} \times (1/Ez)^{4.5337}} \text{ ---------3 } \mathbf{(80\%\ Reliability)}$$

$$\mathbf{N = 1.41 \times 10^{-8} \times (1/Ez)^{4.5337}} \text{ ---------4 } \mathbf{(90\%\ Reliability)}$$

N = Number of cumulative standard axles to produce 20 mm rutting.

Ez = Maximum Vertical subgrade strain (micro strain)

9.3.4 Pavement Layers

In accordance with IRC 37:2012 for the following base and sub-base options are available.

1. Granular base and sub-base.
2. Cementitious bases and sub-bases with a crack relief layer of aggregate interlayer below bituminous surfacing.
3. Cementitious bases and sub-bases with SAMI in between bituminous surfacing and the cementitious base layer for retarding the reflection cracks into the bituminous layer.
4. Cemented base and granular sub base with crack relief inter layer of aggregate above Cemented base.
5. Bituminous surfacing over treated RAP and cemented sub base

Stage construction is not permitted when we are using cemented base and sub-bases according to the guidelines of the code as it may lead to cracking of the stabilized layer leading to failure of the pavement. Hence, the consultants adopting Granular Base & Granular Sub-base for main carriageway pavement with stage construction.

9.3.4.1 Sub-base layer :

The sub-base layer serves three functions like to protect the sub-grade from over stressing, to provide a platform for the construction traffic and to serve as drainage and filter layer. Material passing through 0.425mm(425 micron), LL & PI shall not more than 25 and 6 %. Material shall have a minimum 10% fines value of 50 KN when tested in compliance with BS:812. The water absorption value(as per IS 2386) of the coarse aggregate shall be less than 2%, if not soundness test shall be carried out as per IS 383. 100% sample should pass through 75mm sieve and only 3-10% sample should pass through 0.075mm sieve for all the three grades. When coarse graded sub base is used as a drainage layer, Loss Angels abrasion value should be less than 40, so that there is no crushing during the rolling and the permeability is retained. The sub-base should be composed of two layers, the lower layer forms the separation/filter layer to prevent intrusion of sub grade soil into the pavement and upper layer forms the drainage layer to drain away any water that may enter through surface cracks.

Strength Parameter: Resilient Modulus (M_{Rgsb})

M_{Rgsb}= 0.2 X h^(0.45) X $M_{R\ subgrade}$, where h is thickness of sub base layer in mm.

M_R value of subbase is dependent on M_R value of subgrade since weaker subgrade does not permit higher modulus of the upper layer because of deformation under loads.

$M_{R\ subgrade}$ = 10 X CBR if Subgrade CBR is <=5

$M_{R\ subgrade}$ = 17.6 X (CBR)^0.64 if Subgrade CBR is >5

9.3.4.2 Base layer:

Base layer consists of WMM, WBM, Crusher run macadam, reclaimed concrete etc. Relevant specifications of IRC/MORTH are to be adopted for the construction.

Strength Parameter: Resilient Modulus ($M_{R\ granular}$)

When both sub-base and base layers are made up of unbound granular layers, the composite resilient modulus of the granular subbase and base are as follows:

$M_{R\ granular} = 0.2 \times h^{0.45} \times M_{R\ subgrade}$,

where h is combined thickness of subbase and base layers in mm.

9.3.4.3 Bituminous layers (Binder and Surface)

Binder layer consists of DBM and BM are to be adopted for construction. It is act like as load distribution and supporting layer.

Strength Parameter: Resilient Modulus ($MR_{BC/DBM}$)

The strength of bituminous mix based on extensive laboratory testing of Resilient Modulus Test. Based on the study data of India, IRC:37-2018 recommended resilient modulus for different mix types and temperatures are given below.

Table 9.13: Resilient modulus for Different mix types & temperatures

Mix Type	Temparature °C				
	20	25	30	35	40
BC and DBM for VG30 bitumen	3500	3000	2500	1700	1250
BC and DBM for VG40 bitumen	6000	5000	4000	3000	2000
BC and DBM for Modified bitumen	5700	3800	2400	1650	1300
BM with VG30 bitumen	-	-	-	700	-

9.3.5 Flexible Pavement design for new carriageway

New pavements shall be designed in accordance with **IRC: 37-2018** or any other international standard method/guidelines, subject to the condition that the overall pavement composition shall not be less than the minimum requirement specified in **IRC: 37-2018**. Based on the inputs explained in above paragraphs, pavement composition has been given below.

By considering the developments of Economic corridors, Inter corridors & Coastal Roads and improvements of freight movements a design traffic of 100 MSA is considered.

Table – 9.14: Inputs for the Pavement Design

Design Inputs		Design Chainage(Km)		(Total Construction) (15 Yrs.)
		From	To	
Design Life				
Wearing Course				15 Years
Sub-base and Base Course				15 Years
Design MSA				
Wearing Course & Sub-base and Base Course	Project Stretch	0.000	290.700	100
Design CBR				
CBR for entire Stretch				10%

Table – 9.15: Option-1: Conventional Pavement Composition details

Stretch	Eff. CBR (%)	Design Life in Years	MSA	Bitumen Grade	Crust Composition in mm				
					BC	DBM	WMM	GSB	Total
Surat - Nashik- Ahmednagar	10	15	100	VG-40	50	110	250	200	610

Table – 9.16: Option-2: Cemented base & Sub base with Crack Relief Inter layer of Aggregate

Stretch	Eff. CBR (%)	Design Life in Years	MSA	Bitumen Grade	Crust Composition in mm					
					BC	DBM	Agg. In. layer	CTB	CTSB	Total
Surat - Nashik- Ahmednagar	10	15	100	VG-40	50	50	100	100	250	550

Table – 9.17: Option-3: Cemented base & Sub base with SAMI Interface layer

Stretch	Eff. CBR (%)	Design Life in Years	MSA	Bitumen Grade	Crust Composition in mm					
					BC	DBM	SAMI	CTB	CTSB	Total
Surat - Nashik- Ahmednagar	10	15	100	VG-40	50	50	SAMI	150	250	500

Table – 9.18: Option-4: Cemented Base & Granular Sub base with Crack Relief Interlayer of Aggregate

Stretch	Eff. CBR (%)	Design Life in Years	MSA	Bitumen Grade	Crust Composition in mm					
					BC	DBM	Agg. In. layer	CTB	GSB	Total
Surat - Nashik- Ahmednagar	10	15	100	VG-40	50	50	100	180	250	630

9.4 Paved shoulders

9.4.1 Paved Shoulders Roads

Paved Shoulder: The shoulder would be useable during all seasons of the year and hence as per Clause 5.10 of IRC:SP:87-2019, the crust composition and specification of paved shoulder shall be same as of the main carriageway.

Earthen Shoulder: Earthen shoulder shall be covered with 150 mm thick layer of granular material confirming to the requirements given in Clause 401 of MORTH specifications.

9.5 Recommendation for Pavement Option

Flexible pavement i.e., Option-3 (BC+DBM+SAMI+CTB+CTSB) is proposed for the entire stretch.

Stretch	**Eff. CBR (%)**	**Design Life in Years**	**MSA**	**Bitumen Grade**	**Crust Composition in mm**					
					BC	DBM	SAMI	CTB	CTSB	Total
Surat - Nashik-Ahmednagar	10	15	100	VG-40	50	50	-	150	250	500

10 ENVIRONMENTAL IMPACT ASSESSMENT

10.0 Introduction

The National Highway Authority of India (herein after referred to as the "Authority" or "NHAI") is engaged in the development of the National Highways. As part of this endeavour, NHAI has decided to undertake the project namely "Consultancy services for preparation of DPR for development of stretches for improving direct connectivity in Indian cities (Lot-8/Package-1)".

In order to fulfil the above task, the National Highway Authority of India has appointed M/s Aarvee Associates Architects Engineers & Consultants Pvt. Ltd. (herein after referred to as the "Consultant") to provide services for the above-mentioned project. The Letter of Commence of Services (COS) was issued on 12th December 2018.

10.1 Project Description

The Project Stretch passes through Gujarat and Maharashtra states and the details of the stretch is given below. This corridor traverses through the districts of Navsari and Valsad in the state of Gujarat and Nashik and Ahmednagar in the state of Maharashtra. The proposed project stretch of length 290.700 km. Index map of the proposed project stretch is shown in Figure -1.

Table 1: Details of project stretch

S. No	Stretch Name	Chainage (Km)		Geographic Coordinates	
		From	To	Start	End
1	Surat-Nashik-Ahmednagar Greenfield stretch	0.000	290.700	21° 7'38.39"N 72°54'10.16"E	19° 5'41.56"N 74°49'56.40"E

10.1.1 Terrain

Terrain is classified by the general slope of the country across the highway alignment. Based on this criteria, the entire project stretch traverses through plain terrain followed by Rolling and Mountainous terrain.

Figure 1: Plain Terrain

Figure 2: Mountainous Terrain

10.2 Preliminary Screeening and Environmental Assessment Report

This report describes the proposed work plan related to environmental aspects and makes desirable modifications keeping in view the requirement of the project road. Standard methods/procedures are adopted during environmental monitoring process. The sampling locations will be finalized after conducting field studies in the presence of various environmental experts. The sampling locations for various environmental attributes are given in this report. The methodology for carrying out the study and specifications pertaining to environment to be adopted in this project are as follows:

10.2.1 Objectives

The major objective of this study is to establish present environmental condition along the project corridor through available data/information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project, to recommend adequate mitigation measures, to minimize/reduce adverse impacts, and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to ensure that the project will result in a high quality and safe road to users in a sustainable and environment friendly manner. An Environmental Impact Assessment (EIA) study basically includes:

- Establishment of the present environmental scenario;
- Study of the specific activities related to the project;
- Evaluation of the potential environmental impacts;

- Undertake analysis of alternatives by bringing in environmental considerations into the upstream stages of sub-project planning and design;
- Preparation of EMP that specifies the measures to mitigate adverse impacts and enhance positive impacts of the sub-project on the environment, along with the monitoring, capacity building and institutional arrangements;

10.2.2 Need for Environment Impact Assessment

Highway developmental activities should be planned and executed after considering the potential environmental impacts. To minimize these adverse impacts that may be created by highway development projects, the techniques of EIA become necessary. Identification and assessment of potential environmental impacts should be an integral part of the project life cycle. It should commence early in the planning process of the project to enable a full consideration of alternatives and to avoid later delays and complications.

10.2.3 Legal and Environmental Clearance Requirements

The increase of environmental concerns has necessitated appropriate tools to protect the environment. India has developed a fairly comprehensive regulatory framework to address environmental and social concerns in relation to development projects. It's wide ranging enactments cover almost all major issues that need to be addressed in the course of development of infrastructure from a social and environmental perspective. This section describes the institutional set-up and key legislation pertaining to environmental issues.

10.2.3.1 Institutional Framework

The Ministry of Environment, Forest and Climate Change (MoEF&CC) came in picture to serve as the focal point in the administrative structure for the planning, promotion and coordination of environmental and forestry programmes. The MoEF&CC has overall authority for the administration and implementation of government policies, laws and regulations related to the environment, including conservation, environmental assessment, sustainable development and pollution control. MoEF&CC identifies the need to enact new laws and amend existing environmental legislation when required, in order to continue to conserve and protect the environment. At the state level, the MoEF&CC authority is implemented by the Department of the Environment and the Department of Forest.

In 1976, the 42nd Constitutional Amendment created Article 48A and 51A, placing an obligation on every citizen of the country to attempt to conserve the environment. As a result, number of laws related to environmental conservation were passed to strengthen existing legislation. Environment (Protection) Act, 1986 is the landmark legislation as it provides for the protection of environment and aims at plugging the loopholes in the other related acts.

The Government of India (GoI) through specific legislation regulates the environmental management system in India. The Ministries/Statutory Bodies responsible for ensuring environmental compliance by project proponents include:

- The Ministry of Environment & Forests and Climate Change (MoEF&CC)
- Central Pollution Control Board (CPCB)
- State Pollution Control Board (SPCB)
- Department of Environment and Forests

10.2.3.2 Applicability of International, National and State Environmental Norms

The proposed highway development project is attracting various Ineternational, National and State laws, rules and regulations. These regulations and rules are helpful in impact mitigation and improvement of the environment. The environmental assessment study will be carried out as per the requirement of the National/State/World Bank environmental guidelines. The applicability of the regulatory norms are given in below.

Table 1: Applicability of Environmental Regulatory Norms for the Project

Project	Project Components	Applicability of Environmental Laws, Policies and Notifications	Remarks
Consultancy services for preparation of DPR for development of stretches for improving direct connectivity in Indian Cities (Lot-8/Package-1) Surat-Nashik-Ahmednagar	• Right of Way • Land Acquisition • Protected Social Forestry throughout the RoW • Quarries & Borrow Areas • Utilisation of waste materials • Establishment of Hot	The Environment (Protection) Act, 1986 and further notifications issued under this Act.	Any act during implementation causing damage to environment.
		Water (Prevention and Control of Pollution) Cess Act, 1977 including Rules.	Applicable to all activities, which discharge effluents as a result of process or operations. Section 3 (2) (a) of the Act and Cess to the Govt. of India as per Schedule-I & II for consumption of water for domestic, commercial and industrial purposes.
		Water (Prevention and Control of Pollution) Act, 1974 - as amended in 1978 & 1988.	
		Forest (Conservation) Act, 1980 and amendeds in 1988.	Applicable The project involves activities in the reserved forests, village forests, protected forests and other areas as declared by the state Government.

Project	**Project Components**	**Applicability of Environmental Laws, Policies and Notifications**	**Remarks**
Greenfield Stretch	Mix Plants and Batch mix Plants • Sensitive Locations (Schools, hospitals etc.,) • Archaeological Sites	The Ancient Monuments and Archaeological Sites and Remains Act, 1958 and amendeds in 2010. Ancient Monuments and Archaeological Sites and Remains Rules, 1959.	Not Applicable.
		Wildlife Protection Act, 1972 and amendeds thereafter. The Wildlife (Protection) Rules, 1995	Applicable. This act bans the use of injurious\ substances, chemicals, explosives that may cause injury or endanger any wildlife.
		Coastal Regulation Zone (CRZ) Notification, 1991 as amended in January, 2011	Not Applicable.
		The Hazardous Wastes (Management And Handling) Rules, 1989 and subsequent amendments thereof till date.	Materials such as heavy metals, toxic inorganic, oils, emulsions, spent chemicals and metal finishing wastes emanating during construction and operation shall be stored and disposed of as per the Rules. Rule 17, 18 & 19 of the Act.
		The Public Liability Insurance Act, 1991.	Act enables the people to access legal aid to claim compensation in the event of an accident occurred while handling any hazardous substance. So insurance needs to be taken up by the project implementing agencies or contractors. PLI Act: Act 6 of 1991 as amended by Act 11 of 1992.
		Ministry of Environment Forests & Climate Change (MoEF&CC) EIA Notification issued on 14th September, 2006 and subsequent amendments thereof till date.	Applicable.
		Provision for utilization of Fly Ash is to be made as per the IRC SP:58 – 2001 and Fly Ash Notification 2007 and the subsequent amendments in 25th January, 2016.	Applicable. Five Thermal Power stations are present within 300 Km from the project corridor .
		World Bank Operational Directive and Operational	Applicable for the preparation of Environmental assessment report.

Project	Project Components	Applicability of Environmental Laws, Policies and Notifications	Remarks
		Policies for Environmental Impact Assessment OP 4.01: Environmental Assessment, OP 4.04: Natural Habitats, OP 4.36: Forests, OP 4.11: Operational Policy on cultural property and OP 4.12: Involuntary Resettlement for roads & highways projects.	
		Noise Pollution (Regulation and Control) Rules, 2000	Applicable. Under Rule 3(1) & 4 (1)
		Land Acquisition Act 1894 Land Acquisition Act 1989 RFCTLARR Act 2013	Applicable.
		Motor Vehicles Act, 1988 Rules of Road Regulations, 1989	Applicable. To enforce urban roads/highway codes during construction and operation.

A brief description of the relevant laws is given below:

EIA Notification, 2006 and amendment made in 2013:

This is the Indian Government's Guidelines for Environmental Impact Assessment governing all of the development interventions that takes place within the boundaries of India. The Ministry of Environment, Forests and Climate Change (MoEFCC), GoI through Notification number S.O.1533 (E), dated 14th September 2006 issued the Environmental Impact Assessment (EIA) Notification, directed that on and from the date of its publication, the required construction of new project or activities or the expansion or modernization of existing projects or activities listed in the Shedule to the said Notification entailing the capacity addition with change in process or technology and/or product mix shall be undertaken in any part of India only after Prior Environmental Clearance (PEC) from the Central Government or as the case may be, by the State level Environmental Impact Assessment Authority (SEIAA), duly constituted by the Central Government. The objective of the Notification is to formulate a transparent, decentralized and efficient regulatory mechanism to:

- Incorporate necessary environmental safeguards at planning stage;
- Involve stakeholders in the public consultation process;
- Identify developmental projects based on impact potential instead of the investment criteria;

As per EIA Notification 2006 and subsequent amendment made through Notification S.O.2559

(E) dated 22nd August 2013 stated that expansion of National Highway projects up to 100 km length and involving additional RoW or land acquisition up to 40 m on existing alignments and 60 m on re-alignments or bypasses can be exempted from the purview of the Notification.

Summary of EIA Notification and amendments on Highway projects is given in Box-1.

Box-1
Categorization of projects and activities as per EIA Notification 2006

All projects and activities are broadly categorized into two categories – Category A and Category B.

a) Category A: New National Highways and Expansion of National Highways greater than 30 km, involving additional RoW greater than 20 m involving land acquisition and passing through more than one State.

b) Category B: New State High ways and Expansion of National/State Highways greater than 30 km involving additional RoW greater than 20 m involving land acquisition.

All projects or activities included as Category A shall require prior environmental clearance from the Central Government in the MoEF&CC on the recommendations of an Expert Appraisal Committee (EAC).

All projects or activities included as Category B will require prior environmental clearance from the State/Union territory Environment Impact Assessment Authority (SEIAA).

General Condition:

Any project or activity specified in Category B will be treated as Category A, if located in whole or in part within 10 km from the boundary of: (i) Protected Areas notified under the Wild Life (Protection) Act, 1972, (ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time, (iii) Notified Eco-sensitive areas, (iv) inter-State boundaries and international boundaries.

Amended Notification:

As per the amended Notification of the MoEF&CC on 22nd August 2013 on Highway projects - "Expansion of National Highways greater than 100 Km involving additional RoW or land acquisition greater than 40 m on existing alignment and 60 m on re-alignments or bypasses" may require clearance from EAC, MoEF&CC.

Forest (Conservation) Act 1980 and amendment made in 1988:

The Forest Conservation Act, 1980 is a Central Act of Parliament with a view to provide for the conservation of forest and for matters connected therewith or ancillary or incidental thereto. The act extends to the whole of India except the state of Jammu and Kashmir. Section 2 of the act makes a provision of a prior approval of the Central Government necessary before a State Government or any other authority issues direction for dereservation of reserved forests (which have been reserved under the Indian Forest Act, 1927), use of forest land for non – forest purpose, assigning forest land by way of lease or otherwise to any private person or to any authority, corporation, agency or any other organization not owned, managed or controlled by the government and clear felling of naturally grown trees. The term "forest land" mentioned in Section 2 of the Act refers to reserved forest, protected forest or any area recorded as forest in the government records. Lands which are notified under section 4 of the Indian Forest Act would also come within the purview of the Forest Conservation Act 1980.

Submission of the proposals seeking approval of the Central Government under section 2 of the Act:

(1) Every user agency, who wants to use any forest land for non-forest purposes shall make his proposal in the appropriate Form appended to these rules, i.e. Form A for proposals seeking first time approval under the Act and Form B for proposals seeking renewal of leases where approval of the Central Government under the Act had already been obtained earlier, to the concerned nodal officer authorized in this behalf by the State Government, along with requisite information and documents, complete in all respects, well in advance of taking up any non-forest activity on the forest land.

(2) Every State Government or other authority, after having received the proposal under sub-rule (1) and after being satisfied that the proposal requires prior approval under section 2 of the Act, shall send the proposal to the Central Government in the appropriate forms, within ninety days of the receipt of the proposal from the user agency for proposals seeking first time approval under the Act and within sixty days for proposals seeking renewal of leases where approval of the Central Government under the Act had already been obtained earlier: Provided that all proposals involving clearing naturally grown trees in forest land or portion thereof for the purpose of using it for re-afforestation shall be sent in the form of Working Plan or Management Plan.

(3) The proposal referred to in sub-rule (2) above, involving forest land of more than forty hectare shall be sent by the State Government to the Secretary to the Government of India, Ministry of Environment and Forests, Paryavaran Bhavan, CGO Complex, Lodhi Road, New Delhi-110 003, with a copy of the proposal (with complete enclosures) to the concerned Regional Office.

(4) The proposal referred to in sub-rule (2) above, involving forest land up to forty hectares shall be sent to the Chief Conservator of Forests or Conservator of Forests of the concerned Regional Office of the Ministry of Environment and Forests.

(5) The proposal referred to in sub-rule (2) above, involving clearing of naturally grown trees in forest land or portion thereof for the purpose of using it for reafforestation shall be sent to the Chief Conservator of Forests or Conservator of Forests of the concerned Regional Office of the Ministry of Environment and Forests.

Committee to advice on proposals received by the Central Government:

(1) The Central Government shall refer every proposal, complete in all respects, received by it under sub-rule (3) of rule 6 including site inspection report, wherever required, to the Committee for its advice thereon.

(2) The Committee shall have due regard to all or any of the following matters while tendering its advice on the proposals referred to it under sub-rule (1), namely: a) Whether the forests land proposed to be used for non-forest purpose forms part of a nature reserve, national park wildlife sanctuary, biosphere reserve or forms part of the habitat or any endangered or threatened species of flora and fauna or of an area lying in severely eroded catchment; b) Whether the use of any forest land is for agricultural purposes or for the rehabilitation of persons displaced from their residences by reason of any river valley or hydro-electric project; c) Whether the State Government or the other authority has certified that it has considered all other alternatives and that no other alternatives in the circumstances are feasible and that the required area is the minimum needed for the purpose; and d) Whether the State Government or the other authority undertakes to provide at its cost for the acquisition of land of an equivalent area and afforestation thereof.

(3) While tendering the advice, the Committee may also suggest any conditions or restrictions on the use of any forest land for any non-forest purpose, which in its opinion, would minimize adverse environmental impact.

Wild Life Protection Act 1972:

The Wildlife Act was passed in 1972 to protect the wildlife and their habitats. The habitat destruction due to agriculture, industries, urbanization and other human activities had led to the erosion of the country's wildlife.

The major activities and provisions in the act can be summed up as follows:

1. It defines the wildlife related terminology.
2. Enactment of an All India Wildlife Protection Act (1972).
3. It provides for the appointment of wildlife advisory Board, Wildlife warden, their powers, duties etc.
4. Becoming a party to the Convention of International Trade in Endangered Species of Fauna and Flora (CITES, 1976).
5. Launching National component of UNESCO's 'Man and Biosphere Programme' (1971).
6. Under the Act, comprehensive listing of endangered wildlife species was done for the first time and prohibition of hunting of the endangered species was mentioned.
7. Protection to some endangered plants.

8. The Act provides for setting up of National Parks, Wildlife Sanctuaries etc.
9. The Act provides for the constitution of Central Zoo Authority.
10. There is provision for trade and commerce in some wildlife species with license for sale, possession, transfer etc.
11. The act imposes a ban on the trade or commerce in scheduled animals.
12. It provides for legal powers to officers and punishment to offenders.
13. It provides for captive breeding programme for endangered species. Several Conservation Projects for individual endangered species like Lion (1972), Tiger (1973), Crocodile (1974) and Brown antlered Deer (1981) were stated under this Act. The Act is adopted by all states in India except J & K, which has its own Act.

The Water (Prevention and Control of Pollution) Act 1974:

The act resulted in the establishment of the Central and State level Pollution Control Boards whose responsibilities include managing water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of any facility. This will include generation of liquid effluent during construction of road from civil engineering activities or from domestic activities in workers colony. There are specific penalties for violation, which include imprisonment for responsible officials.

The Air (Prevention and Control of Pollution) Act 1981:

The act empowers Central and State Pollution Control Boards for managing air quality and emission standards, as well as monitoring air quality, prosecuting offenders and issuing licenses for construction and operation of any facility. Air quality includes noise level standards. There are specific penalties for violation, which include imprisonment for responsible officials. This act has notified National Ambient Air Quality Standard for different regions e.g. Industrial, Residential and Sensitive. Air quality during construction and operation phases will be guided by this specific act.

Environment (Protection) Act 1986:

This act was passed as an overall comprehensive act "for protection and improvement of environment". Under this act rules have been specified for discharge/emission of effluents and different standards for environmental quality. These include Ambient Noise Standard, Emission from Motor Vehicles, Mass Emission standard for Petrol Driven Vehicles, General Effluent Standards etc., especially important for road project.

Fly ash Notification:

According to the Notification No. S.O. 763 (E), dated 14.09.1999 and its amendment thereafter on 27.08.2003 and notification S.O. 2804 (E) dated 3rd November 2009 by Ministry of Environment and Forests, it is mandatory to use fly ash within a radius of 300 kilometres of Thermal Power Plant. No agency, person or organization shall within a radius of 300 kilometre of Thermal Power Plant undertake construction or approve design for construction of roads of flyover embankments in contravention of the guidelines/specification issued by the Indian Road Congress (IRC) as contained in IRC specification No. SP: 58: 2001. Any deviation from this direction can only be agreed to a technical reasons if the same is approved by Chief Engineer (Design) or Engineer-in-chief of the concerned agency or organization or on production of certificate of "Pond ash not available" from the Thermal Power Plant located within 100 kilometers of the site construction. This certificate shall be provided by TPP within two working days from the date of making request for fly ash.

Soil required for top or side cover of embankment of roads or flyovers shall be excavated from the embankment site and it is not possible to do so, only the minimum quantity of the soil required for the purpose shall be excavated from soil borrow area. In either case, the topsoil should be kept or stored separately. Voids created due to soil borrow area shall be filled up with ash with proper compaction and covered with top soil kept separately as mentioned above.

No agency, person or organization shall within a radius of 100 kilometers of coal or lignite based Thermal Power Plant allow reclamation and compaction of low lying areas with soil. Only pond ash shall be used for compaction. They shall also ensure that such reclamation and compaction is done in accordance with the bye-laws, regulation and specification laid down by Authorities. All agencies undertaking construction of roads or fly over bridges including Ministry of Shipping Road Transport and Highways (MoSRTH), National Highways Authority of India (NHAI), Central Public Works Department (CPWD), State Public Works Department and other State Government Agencies, shall within three months from the 1st day of September 2003 make provision in their documents, schedules of approved materials and rates as well as technical documents; including those related to soil borrow area or pits. Make necessary specifications/guidelines for road or fly over embankments that are not covered by the specification laid down by the Indian Road Congress (IRC).

Statutory Clearance for Borrow Area and Stone Quarry:

Mining of minor minerals such as sand, gravel, clay, marble and other stones will not be allowed in the country without the approval of the Central government. The Hon'ble Supreme Court, vide its order dated 27.02.2012 in I.A.No. 12-13 of 2011 in SLP (C) No. 19628-19629 of 2009 titled Deepak Kumar etc. Vs. State of Haryana & Ors. has inter alia ordered that leases of minor mineral including their renewal for an area less than 5 ha be granted by the State/Union Territory only after getting environment clearance (EC) from the MoEF&CC. In order to ensure compliance of the aforesaid order of the Hon'ble Supreme Court, MoEF&CC issued an OM No. L-11011/47/2011-IA.II (M) dated 18.05.2012 stating inter alia that all mining projects of minor minerals including their renewal, irrespective of the size of the lease would require prior EC and that the projects of minor minerals with lease area less than 5 ha would be treated as Category B as defined in EIA Notification, 2006 and will be considered by the respective State Environment Impact Assessment Authorities (SEIAAs) notified by MoEF&CC and following the procedure prescribed under the EIA Notification, 2006. The mining projects having more than 5 Ha of lease area will be categorised as Category A project and will be appraised by Central Committee of MoEF&CC.

Regarding the borrow area for ordinary soil, the Contractor has to obtain environmental clearance from State Environmental Impact Assessment Authority (SEIAA) of MoEF&CC in compliance to the Supreme Court's order and MoEF&CC conditions vide their circular no. L-11011/47/2011-IA.II (M) dated 20th June, 2013. If the area of a borrow area is less than 5 Ha then this will be treated as Category B2 Project and will be appraised and approved based of only Form 1. No EIA study will be required for such area. However if the size of the borrow area is more than 5 Ha then it will be categorized as "Category B1" and therefore will require EIA study, based on which the SEIAA will give clearance for the same.

10.2.3.3 Applicability of Clearances

Environmental Clearance:

The proposed Surat – Nashik - Ahmednagar has project stretch of total length 314.064 km. According to new EIA Notification issued on 14th September, 2006 by the MoEFCC, GoI and amended Notification on 22nd August, 2013 on Highway projects, "New, expansion or modernization of any activity falling within categories of developmental and industrial activities shall be undertaken in any part of India only after it has been accorded environmental clearance by the MoEFCC in accordance with the procedures specified in the Notification". Among categories listed in Schedule-I of Notification and amendments thereof, the proposed project stretch falls under Category -A , hence, Environmental Clearance is required. Also, the highways improvement/upgradation project of this magnitude needs to prepare the EIA/EMP report as per the standard ToR given by MoEF&CC in order to safeguard the interests of the environment and it will also acts as an environmental guide to the Project Proponent & Environment Interested Groups/NGOs.

Forest Clearances:

Forest (Conservation) Act, 1980 (amended in 1988) enacted by Government of India, restricts the diversion of forests for use of non-forest purposes. As per the Act, State Government requires prior approval of GoI for the use of forest land for non-forest purposes (means the breaking up or clearing of any forest land) or for assigning lease to any private person or agency not controlled by Government. Compensatory afforestation is one of the most important conditions stipulated for diversion of forest land. The proposed project stretch is passing through forest land for a length of 62.900 Km with the width requirement of 70m. Hence, Forest Clearance is required from MoEFCC.

Wildlife Clearance:

As per the Wildlife (Protection) Act, 1972 and the orders of Hon'ble Supreme Court makes it mandatory for following certain procedures for taking up any non-forestry activity in wildlife habitats. In this regards, MoEFCC has issued guidance document for taking up non-forestry activities in wildlife habitats, dated 15th March 2011. As per this document, the project activities falling within sanctuary or within 10 Kms from the boundary of the National Park/ Sanctuary, the project proponet should seek clearance/ NoC from the standing committee of NBWL.

Other Permissions/Clearances:

The project implementing agency will ensure the following clearances before initiating the works.

- Permission from Water Resources Department for new and widening cases and to draw water during the construction period.
- All the borrow areas, quarries, sand mines proposed to be utilized in the project shall get the permissions from respective departments/owners.
- Permission and clearance from electricity board for shifting/moving of transformers, electric poles during construction of road.

10.2.4 Methodology to be adopted for EIA study

The methodology to be adopted for the EIA study is shown in Figure 1 .

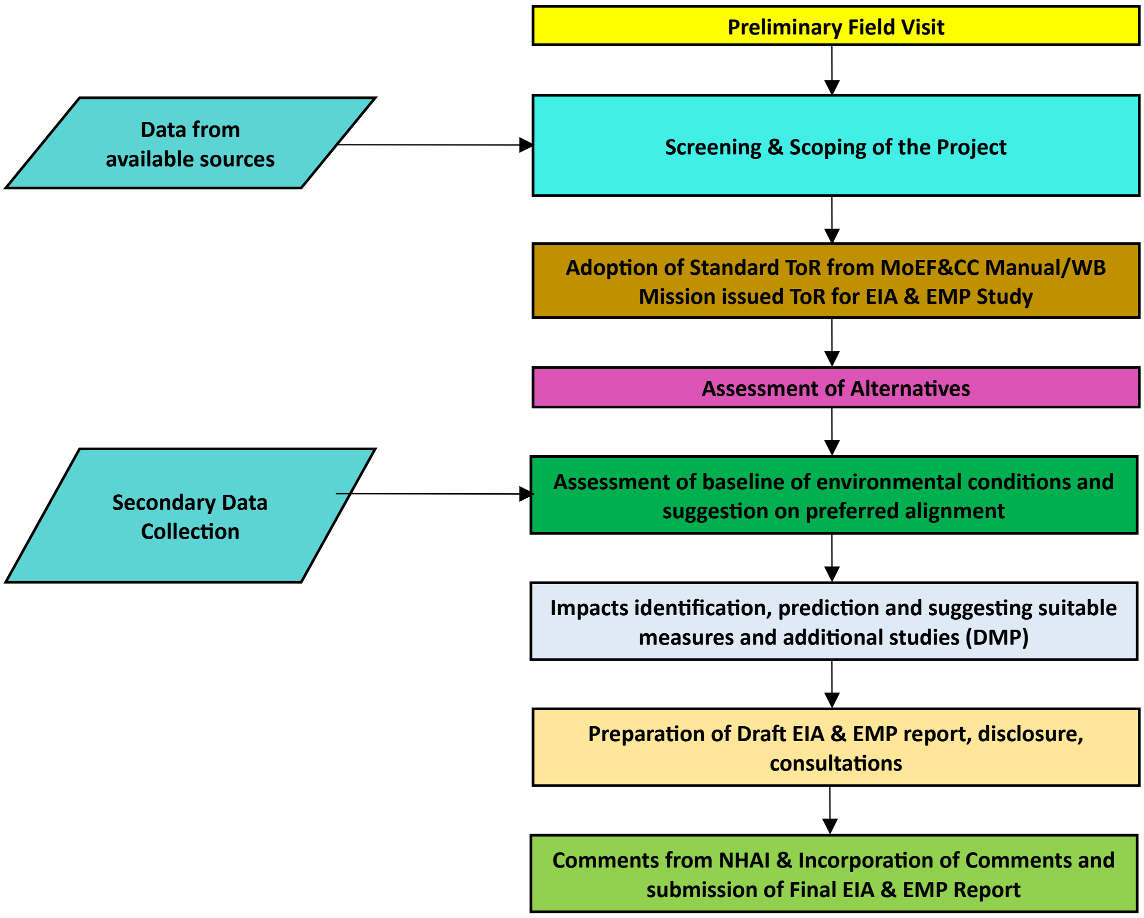


Figure 1: Flow Chart showing the EIA Methodology

10.2.5 Scope of Environmental Impact Assessment (EIA) Study

The proposed EIA/EMP report encompasses the findings of the study to identify, predict and evaluate the likely impacts due to the proposed activity and suitable measures to mitigate and minimize the adverse impacts and ameliorate environmental quality in the surrounding region. The environmental safety concerns which can be internalized in the project planning and implementation stages have been identified and suitable measures needed are elicited as Environmental Management Plan (EMP).

Detailed baseline data collection prior to project implementation are under progress for air, noise, water, land, biological, socio-economic environment etc., within the project area. The baseline data for pre-project environmental status will be presented along with identification, prediction and evaluation of impacts due to project activities. The published literature will be collected from different Govt. Organizations/Institutions, NGOs etc., to assess the baseline environment. The aim is to collect secondary information to the maximum extent possible. The information on flora like road side plantation and fauna within the study area will be collected from the Forest Dept., Botanical survey of India, Zoological survey of India and through field verification. The information on wetland, grassland and other ecologically important areas will also be collected.

The information on geology and soil within the study area will be collected from Geological Survey of India. The information on ground water i.e. depth of water table, yield etc., will be collected from the Central Ground Water Authority, Central Water Commission, Survey of India, District Planning Maps etc. The land use pattern within the study area in general and adjacent to the road in particular will be established through collection of maps/documents from Survey of India, Agriculture Department and Forest Dept., and through field verification.

The climate and meteorology data i.e. temperature, wind speed, wind direction, rainfall, relative humidity, cloud cover and cyclone will be collected from Meteorological Department. Available information on ambient air quality and water quality will be collected from Central Pollution Control Board (CPCB), Maharashtra Pollution Control Board (MPCB), Reputed Research Laboratory and Universities. The information on archaeological and historical places, if any, will be collected from Archaeological Survey of India, Dept. of Tourism etc.

10.2.6 Primary/Secondary Data Collection

Field Reconnaissance Survey

Preliminary field survey are under progress to identify the critical issues and to examine different alignment options. The following information/documents are collected during reconnaissance survey.

- Information on location, type and sensitivity of all critical natural habitats such as reserved/protected forest, wild life sanctuaries/wild life migratory route across the road, wet lands, grass land, sacred groves etc.

- Information on sensitive such as location of schools, hospitals, religious, archaeological and historical places.
- Assessment of air quality, noise level, water quality and soil quality monitoring stations as per BIS, CPCB and MoEF & CC Guidelines.
- Details of roadside plantation i.e. chainage wise and girth size wise no. of trees.
- Information on industries i.e. pollution status, discharge point/disposal site of effluent/solid waste along the corridor, if any.
- Information on flora and fauna within the study corridor will be collected and verified in the field.

Environmental Impact Assessment

EIA will include the following:

- The collected primary and secondary data will be compiled to assess the existing baseline environmental condition;
- Prediction of significant impacts;
- The assessment of impact during construction and operation phase;
- Suggestion for mitigation measures;

10.2.7 Generic Structure of EIA report

In terms of the EIA notification of the MoEF & CC dated 14th September 2006, the generic structure of the EIA document shall be as under:

1. Introduction
2. Project Description
3. Approach & Methodology
4. Environmental Regulatory Framework
5. Analysis of Alternatives (Technology and Site)
6. Description of the Environment
7. Anticipated Environmental Impact & Mitigation Measures
8. Environmental Management Plan
9. Environmental Monitoring Plan
10. Environmental Cost Estimates
11. Summary & Conclusions
12. Disclosure of Consultants engaged

10.3 Analysis of Alternatives

The proposed Surat – Nashik - Ahmednagar project stretch is a Greenfiled alignment. The purpose of this chapter is to identify an environmentally feasible alignment for NH between Surat and Ahmednagar. The assessment of alternative alignment for the proposed highway is very challenging task due to presence of towns, villages, water bodies, homestead, agriculture lands, non-agriculture areas, built-up areas, tin sheds etc.

The feasible alignment was decided on the basis of analysis of different parameters. The parameters considered for the alternative analysis are given below:

1. Geometric Standards
2. Ecology and Environment
3. Drainage
4. Land Acquisition
5. Construction cost
6. Operational Efficiency
7. Townships
8. Entry and Exit Points
9. Design requirements

Geometric Standards

Design speed for the proposed highway plays an important role in choosing super elevation rates and radii of curves, sight distances, and the lengths of crest and sag vertical curves. Roads with higher travel speeds require sweeping curves, steeper curve banking, longer sight distances, and more gentle hill crests and valleys. "IRC:SP:87-2013 – Manual for Specification and standards for design of 6 Laning of Highways" is strictly followed for the proposed road. The gradients are considered not to be steeper than 3 %. The alignment shall enable the ruling gradient to be attained in minimum of the length, minimizing steep gradient, hairpin bends and needless rise and fall. Right of Way of 70m is uniformly maintained along the project stretch except at Tunnel section which is proposed to be provided 150m.

Ecology and Environment

The proposed alignment shall not pass through unstable natural slopes and ecologically & environmentally sensitive areas such as national parks, sanctuaries, tiger reserves, reserve forests. The impact on wild life habitat, biodiversity, forest resources, displacement of human settlements, religious places etc. shall be marginally minimal. The effect of alignment on productive lands on selection of borrow areas, erosion and consequent modification of natural conditions, destabilization of slopes, diversion of natural surface water flows etc. shall be nil.

Drainage

Hill slope geomorphology and hydrologic factors shall be important considerations in fixing the alignment of a road. Adequate drainage facility shall be feasible along the alignment in such a way where the number of cross drainage structures required are minimum. This will reduce the construction cost. The alignment is planned to have efficient drainage pattern along the stretch.

Land Acquisition

The alignment is fixed keeping in view of the existing and planned land uses. It is ensured that the alignment avoids large scale land and property severance, acquisition of residential, commercial and institutional areas, industrial parks, special economic zones, etc. Acquisition of fertile agricultural land shall be minimal. The highway is aligned along non-agricultural waste lands, government lands, etc. to minimize the negative social and economic impact of highway construction.

Construction Cost

The alignment is fixed such that it should avoid excessive cutting and filling so as to minimize the construction cost. The cost for the requirements of bridging, tunneling, protection works, environmental mitigation measures etc shall be optimal while satisfying the design requirements. The alignment will be preferably pass through better soil area to minimize pavement thickness. Its location shall be near sources of embankment and pavement materials. The suitability of the alternative options when the alignment shall pass through mountains is studied depending on factors like topography, site conditions and construction and operation cost so as to minimize the total construction cost.

Operational Efficiency

The alignment is planned to have an operationally efficient highway, which permits efficient collection and distribution of the highway traffic through the already existing secondary road network, with or without improvement. The location of interchanges and facilities along the alignment are planned accordingly.

Townships

The alignment is planned so as to have proper townships along, keeping in view the availability of land, water facilities etc. The highway is aligned in such a way to provide proximity to the nearest industrial hubs, tourism attractions, terminal points and major settlements.

Entry and Exit Points

The alignment is planned to have proper entry and exit points for the highway to the existing highway stretches, ring roads etc. which offer better connectivity to the traffic of highway.

Design requirements

Design requirements for the proposed highway comprise the following main fundamental features:

- 100 kmph design speed
- Six Lanes
- Grade Separated Intersections

The Figure 4 shows the Alignment alternatives at different locations for the proposed road considering above mentioned parameters. At three alternative options have been proposed due to limitations. These are summarized in Table 1.

Alignment Options Shown below:

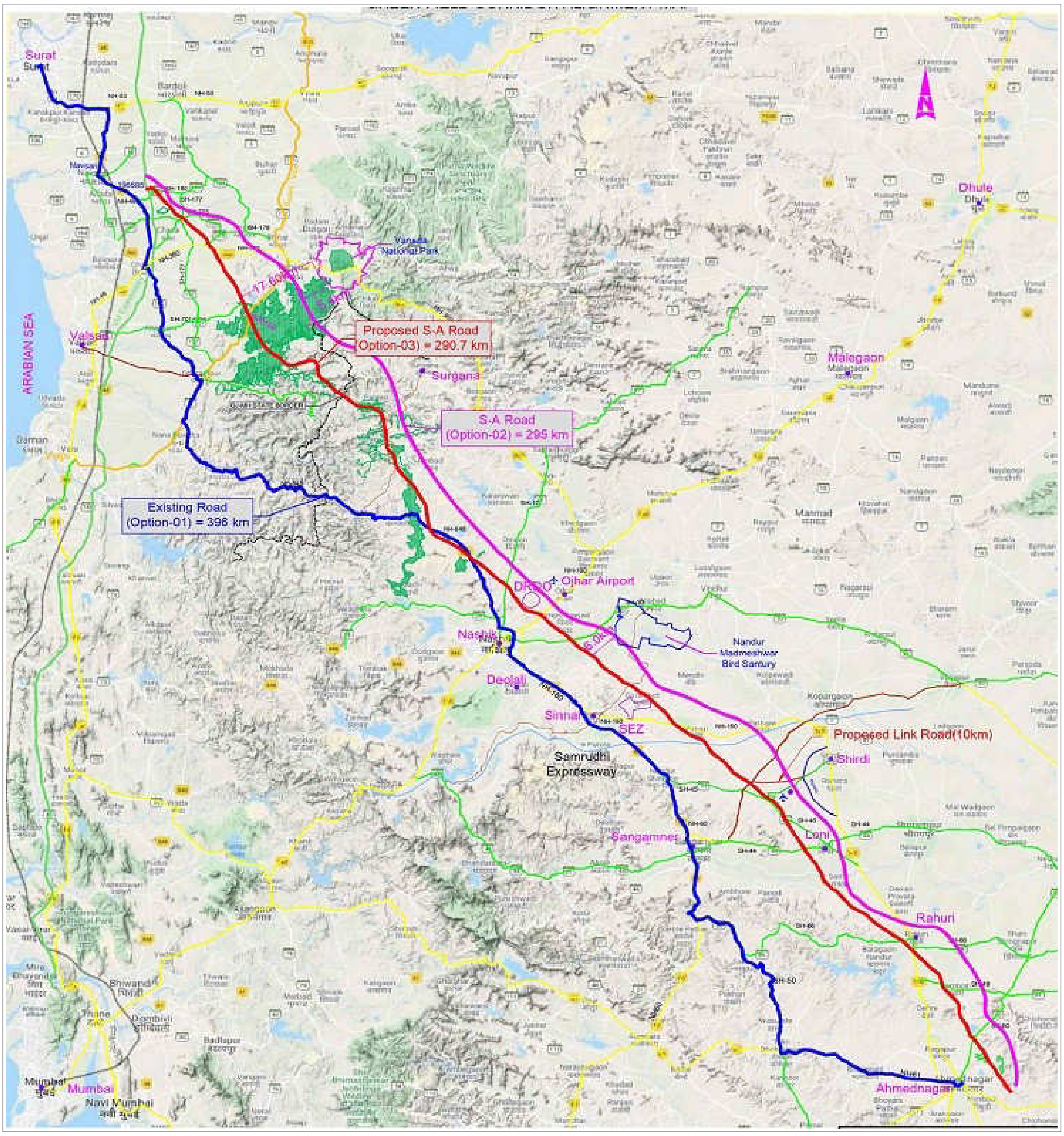


Figure 2: Alignment Alternatives for Surat – Nashik – Ahmednagar greenfield stretch

Table 1: Proposed Alignment Options

Sl. No.	Description	Existing Route (Option -I)	Greenfield Alignment (Option -2)	Greenfield Alignment (Option -3)
1	**Starting & Ending Chainages**	Starts Near Surat and traverses through Nashik district and ends near Ahemdnagar district. It follows NH-53, NH-48, SH-181 NH-848, NH-160, SH-50,NH-61.	Chainage: Starting at Design Km.0+000 & Ending at Km.295+000	Chainage: Starting at Design Km.0+000 & Ending at Km.290+700
2	**Length of Proposed alignment**	-	295 km	290.700 km
3	**Length of Existing Road**	396 km	Nil	Nil
4	**Existing ROW**	Varies (15m , 45m, 60m)	-	-
5	**Proposed ROW, in m**	70m ROW	70m ROW & at Tunnel Section- 150m ROW	70m ROW & at Tunnel Section- 150m ROW
6	**Land Acquisition Required (Ha)**	1598 Ha.	2539	2402
7	**Design Speed, in kmph**	100 kmph	100 kmph	100 kmph
8	**Proposed Lane Configuration**	6-Lane with future widening to 10-lane	6-Lane with future widening to 10-lane	6-Lane with future widening to 10-lane

Sl. No.	Description	Existing Route (Option -I)	Greenfield Alignment (Option -2)	Greenfield Alignment (Option -3)
9	**Proposed Pavement**	Flexible Pavement	Flexible Pavement	Flexible Pavement
10	**Estimated Total Traffic-AADT (PCU)**	Homogeneous Section-1 (Surat-Nashik Section):47083 PCUs/Day (Year -2022) Homogeneous Section-2 (Nashik- Ahmednagar Section) :37004(PCUs/Day) (Year -2022)	Homogeneous Section-1 (Surat-Nashik Section):47083 PCUs/Day (Year -2022) Homogeneous Section-2 (Nashik- Ahmednagar Section): 37004(PCUs/Day) (Year -2022)	Homogeneous Section-1 (Surat-Nashik Section):47083 PCUs/Day (Year -2022) Homogeneous Section-2 (Nashik- Ahmednagar Section) :37004(PCUs/Day) (Year -2022)
11	**Interchange (in Nos.)**	05	13	12
12	**ROB Numbers**	04	03	03
13	**Major Bridges (in Nos.)**	14	18	16
14	**Tunnels (in Nos) & Length in (Km)**	-	03 & 15.4 kms	02 & 2.57
15	**Viaducts (in Nos & Length**	-	13 & 14.1 lms	14 & 15.95 kms
16	**Total Civil Cost+ Centages(18%)-**	11,880+2139=14019 Cr.	17022+3064=20086 Cr.	10929+1967 = 12896 Cr.

Sl. No.	Description	Existing Route (Option -I)	Greenfield Alignment (Option -2)	Greenfield Alignment (Option -3)
	in Crore			
17	**LA Cost (Cr.)**	5593	4547	4533
18	**Preconstruction Activities (Utility Shifting , Forest (NPV) , Afforestation Compensation Cost, Componsation For Forest Dwellers (Cr.)**	650	671	521
19	**Total Cost (Cr.)**	20,262	25,305	17,950
20	**cost per km**	51.17	85.78	61.75
21	**Recommendation**	Not Recommended	Not Recommended	Recommended

From the above comparision table Option-3 has less Civil cost and LA Cost compared to Option-2 and Option-1. Option-2 has more Tunnel length and cause more damage to adjacent eco sensitive lands. Option-3 has less travel distance compared to option2 & Option-1 which intern reduces travel time. Hence, Option-3 Proposed S-A Green field alignment with 290.7km length is recommended for the project corridor. It serves as the Economic corridor and provides direct connectivity between two major Indian cities from Surat to Ahmednagar..

10.4 Baseline Environmental Conditions

This section provides an overall description of the existing environmental status of the study region. Studies are undertaken to generate baseline data within a 10 Km radius of the study region along the proposed project on topography, geography, climate, drainage pattern etc. From these inputs, possible significant impacts will be identified and quantified and an appropriate Environmental Management Plan is prepared to manage and mitigate these impacts.

10.4.1 Location, Geography and Topography

The proposed stretch passes through the distrcit Navsari and Valsad in the state of Gujarat and Nashik and Ahmednagar in the state of Maharashtra.

Navsari

Navsari district is situated in the southern part of Gujarat State. It lies between Latitude 20°32′ & 21°05′ North and Longitude 72°42′ & 73°30′ East. It is bounded by Surat district in the north, Dangs district in the east, Valsad district in the South and Arabian sea in the west. Navsari district has a geographical area of about 2210.97 sq. km.

Valsad

Valsad district is located in southern part of Gujarat State. It has total geographical area of 3055 sq km, extended by the north latitude of 20°07′ to 20°45′ and east longitude of 72°43′ to73°29′. The district is bounded in the north & northeast by Navsari district and by Nasik district of Maharsahtra in the east & south. The Union territory of Dadra-Nagar Haveli lies in south while UT of Daman lies in west. The Arabian Sea forms western boundary.

Nashik

Nasik District is situated in north western part of Maharashtra. It lies between 19°35′ and 20°50′ north latitude and between 73°16′ and 74°56′ east longitude. The district has a geographical area of 15530 sq. km. It is surrounded by Dhule district in the north, Dangs and Surat district of Gujarat State in the northwest, Jalgaon in the east and northeast, Ahmednagar in the south, Aurangabad in the southeast and Thane in the west and southwest.

Ahmednagar

Ahmadnagar is the largest district of Maharashtra State in respect of area. It is situated in the central part of the State and lies between north latitudes 18°19′ and 19°59′ and east longitudes 73°37′ and 75°32′. It is bounded by Nashik district in the north, Aurangabad and Beed districts to the east, Osmanabad and Solapur districts to the south and Pune and Thane districts to the west. The district has a geographical area of 17114 sq. km., which is 5.54% of the total State area.

10.4.2 Geomorphology and Soil types

Navsari

Navsari district is situated in the southern part of the state. Four physiographic units have been established in the area. 1) High Relief Zone, 2) Piedmont Zone, 3) Alluvial Plain, and 4) Coastal Plain.

The soils derived their characteristics from the basaltic rocks as parts of the district. The basaltic lava flows are covered by black clayey to loamy soil. It is in general ranges in thickness up to one meter. The colour of the soil turns brown due to high iron content at places. In the piedmont slope area the soil is shallow to moderately deep, moderate to severely eroded and non calcareous in nature. The texture is silt clay loam to clay loams. The clay content varies from 30 to 60%. The water holding capacity of the soil is moderate. In the midland and flood plain areas, the soil is deep to very deep, light greyish to yellowish brown in colour. The texture is fine clay loam to sandy loam. The clay content varies from 25 to 60%. In coastal region the soil is deep to very deep dark grey to black colour. The texture is clay loam to silty loam. The area is affected by tide as well as leaching of salts from up land forming saline alkali soils. The content of clay in this is high and permeability is low (mud flats).

Valsad

The district has high variation in topography ranging from near sea levels all along western part to as high as 600.m amsl, in high relief tracks in eastern boundary. Based on topography and landforms, the main physiographic units identified in the district are narrow coastal plains having inter-tidal saline wastelands and adjoining alluvial plains in the west; and intermediate rocky table lands with contiguous high relief hill ranges in east.

Based upon the works of Soil Survey Organization of State Government, the soils of the district have been classified into four major group such as i) Bilimora – Bedmal Series of hilly area ii) Baldha – Vadhawania Series of piedmont slope area, iii) Ena- Jalalpur – Sisodra Series in the midland and flood plain areas of the district and iv) Jal – AH – Dandi Series of soil along the coastal region

Nashik

The district forms part of Western Ghat and Deccan Plateau. Physiographically Nasik district comprises varied topography. The main system of hills is Sahayadri and its offshoots viz., Satmala, Selbari and Dolbari hill ranges. These hill ranges along with eastern and southern plains and Godavari valley are the distinct physiographic units. The northern part of the district falls under Tapi basin and is drained by easterly flowing Girna River along with its tributaries, whereas the southern part of the district falls under Godavari basin an is drained by Godavari River and its tributaries. Other important rivers in the district are Damanganga, Vaitarna, Darna, Kadva, Aram, Mosam, Panjan and Manegad.

The soils of the district are the weathering products of Basalt and have various shades from gray to black, red and pink color. The soils occurring in the district are classified in the four categories namely lateritic black soil (Kali), reddish brown soil (Mal), coarse shallow reddish black soil (Koral), medium light brownish black soil (Barad). In general the soils are very fertile and suitable for growing cereal and pulses. The black soil contains high alumina and carbonates of calcium and magnesium with variable amounts of potash, low nitrogen and phosphorus. The red soil is less common and is suitable for cultivation under a heavy and consistent rainfall.

Ahmednagar

The district forms part of Deccan Plateau. Part of Sahayadri hill ranges fall in the district. Western Ghat section in Akole taluka is hilly which extends to relatively flat areas in Shevgaon and Jamkhed talukas in the east. From the main Sahayadri range three spurs namely Kalsubai, Baleshwar and Harishchandgad strech eastwards. Physiographically the district can be broadly divided in four major characteristic landforms viz., hill and ghat section (7.6% area); foothill zone (19.4% area); plateau (3.71% area) and plains (occupy 69.30% area). The district lies partly in Godavari basin and partly in Bhima basin. The northern part of the district is drained by Godavari River and its tributaries viz., Pravara, Mula, Adula and Mahalungi whereas the southern part is drained by Bhima River and its tributaries viz., Ghod and Sina. All the rivers have sub parallel to semi-dendritic drainage pattern and the drainage density is quite high. Based on geomorphological setting and drainage pattern, the district is divided into 80 watersheds.

10.4.3 Rainfall and Climate

Navsari

District receive rainfall mainly from Southwest monsoon. The rainfall is confined between June to October months. Long term normal rainfall (1951-80) for the Surat IMD station is about 1210 mm as such there is no meteorological station in the district and nearest IMD stations are located at Surat and Valsad. As such The Surat IMD station is more representative of climatological conditions for the Navsari district, therefore, the climatological data of Surat IMD station is taken into consideration for discussion.

General climate of the district is sub-tropical and is characterised by three well-defined seasons, i.e. summer - from April to June, monsoon - from July to September, and winter - from October to March. Mean maximum daily temperatures range from 30° to 37°C and mean minimum daily temperatures from 14 to 26 °C. April and May are the hottest months when the temperatures may exceed 44°C. The winters are generally pleasant with minimum temperatures around 09°C., however, at times temperatures may further drop down. In the monsoon season the humidity is high reaching up to 84%, during winters it may drop down to 47%. Mean wind speed ranges from 108 km/d during winters to more than 220 km/d during summer and monsoon.

Valsad

Valsad district is located in south of *tropic of Cancer,* comes under heavy rainfall areas of South Gujarat, having sub-tropical climate with moderately high humidity. District receives high intensity monsoon rainfall of 1800 to 3300 mm during SW monsoon. The main seasons prevailing in the district are (a) monsoon - mid of June to October, (b) winter - November to February, and (c) summer – March to June.

Nashik

The normal annual rainfall in the district varies from about 500 mm to 3400 mm. It is minimum in the north eastern part of the district and increases towards west and reaches a maximum around Igatpuri in the western ghat. The chances of receiving normal rainfall are maximum (50 to 55%) in the north eastern part around Malegaon and Nandgaon and minimum in the central part of the district. The study of negative departures of the annual rainfall over normal reveals that major part of the district (about 75%) falling east of Western Ghats comprising almost entire Sinnar, Niphad, Surgana, Kalvan, Satana, Chandwad, Yeola talukas and parts of Dindori, Peint and Malegaon talukas can be categorized as drought area.

The climate of Nashik district is characterized, by general dryness throughout the year except during the south-west monsoon season. The winter season is from December to about the middle of February followed by summer season which last up to May. June to September is the south-west monsoon season, whereas October and November constitute the post-monsoon season. The maximum temperature in summer is 42.5°C and minimum temperature in winter is less than 5.0°C. Relative humidity ranges from 43% to 62%.

Ahmednagar

The normal rainfall over the district varies from 484 mm to about 879 mm. Rainfall is minimum in the northern parts of the district around Kopargaon and Sangamner and it gradually increases towards southeast and reaches the maximum around Jamkhed. The district being situated in "Rain Shadow" zone of Western Ghats, it often suffers the drought conditions. Almost entire district covering Ahmadnagar, Rahuri , Nevasa, Shevgaon, Jamkhed, Karjat, Srigonda, Pathardi and Parner talukas comes under "Drought Area". The average rainfall for the period 1995-2004 ranges from 484 mm (Kopargaon) to 879.43 mm (Akola).

The climate of the district is characterised by a hot summer and general dryness throughout the year except during the southwest monsoon season, i.e, June to September. The mean minimum temperature is 12.3°C and mean maximum temperature is 39.1°C.

10.4.4 Demographics

Navsari

According to the 2011 census Navsari district has a population of 171,109. Navsari has a sex ratio of 930 females for every 1,000 males, and a literacy rate of 88.36%.

Valsad

According to the 2011 census Valsad district has a population of 139,764 . Valsad has a sex ratio of 955 females for every 1,000 males, and a literacy rate of 98.18%.

Nashik

The Nashik has a population of 1,486,053 as per census 2011. It is havng a sex ratio of 899 females for every 1,000 males, and a literacy rate of 89.85%.

Ahmednagar

The Ahmednagar has a population of 4,543,159 as per census 2011. It is havng a sex ratio of 939 females for every 1,000 males, and a literacy rate of 79.05 %. The district has a population density of 266 Persons per square kilometre.

10.5 Environmental Monitoring Locations

The samples (surface water, ground water, noise and soil) will be collected for establishment of baseline. Interpretation and analysis of air, water, noise and soil monitoring results will be presented in the draft EIA/EMP report. The stated parameters will be collected and analysed as per the MoEF EIA Manual for Highways, 2010. References adopted from MoEF EIA Manual for Highways are given in Table 2.

Table 2: References adopted from MoEF EIA Manual for Highways

S. No.	Characteristics	No. of samples	Selection of the parameters
1	Micro-meteorological data (The wind velocity, wind direction & wind rose, rainfall, temperature and relative humidity)	1 station x 90 days = 90 samples	MOEF&CC - Environmental Impact Assessment Guidance Manual for Highways, 2010(Page-17, Section 4.4: Air Environment) Meteorological data covering maximum and minimum wind speed, wind direction, rain fall, relative humidity and temperature for atleast 10 years period should be presented from the nearest meteorological station.
2	Ambient Air Quality Monitoring (Particulate Matter (size less than 10 µm) or PM_{10}, Particulate Matter (size less than 2.5 µm) or $PM_{2.5}$, Sulphur dioxide (SO_2), Oxides of Nitrogen (NO_x) and Carbon Monoxide)	13 stations x 2 days x 12 weeks = 312 samples	MOEF&CC - Environmental Impact Assessment Guidance Manual for Highways, 2010(Page-17, Section 4.4: Air Environment) Baseline data for the parameters - Particulate matter size less than 10 µm or PM_{10} µg/m^3, particulate matter size less than 2.5 µm or $PM_{2.5}$ µg/m^3, Sulphur dioxide (µg/m^3), Nitrogen dioxide (µg/m^3) and Carbon Monoxide (µg/m^3) in the study area should be generated for one season other than monsoon as per CPCB norms.
3	Water Quality Monitoring - Surface and Ground water (Physico-Chemical, bacteriological and heavy metals analysis)	37	MOEF&CC - Environmental Impact Assessment Guidance Manual for Highways, 2010(Page-17, Section 4.4: Air Environment) (Page - 17, Section 4.3: Water Environment) Details of surface water bodies within right of way and within 500 m from the right of way should be documented along with the present usage. The samples should be collected and analyzed as per the standard procedures.
4	Noise Quality Monitoring (L_{eq} day, L_{eq} night, L_{eq} min, and L_{eq} max)	34	MOEF&CC - Environmental Impact Assessment Guidance Manual for Highways, 2010(Page-17, Section 4.4: Air Environment) (Page - 17, Section 4.5: Noise Environment) While selecting the monitoring locations specific importance is to be given for sensitive environmental receptors like thickly populated areas, hospitals, schools, wildlife corridors etc. Hourly monitoring of noise levels (L_{eq}) should be recorded for 24 hours by using integrated noise meter. Noise standards have been designated for

S. No.	Characteristics	No. of samples	Selection of the parameters
			different types of land use, i.e. residential, commercial, industrial areas and silence zones as per the Noise Pollution (Regulation and Control) Rules 2000.
5	Soil Quality Monitoring (Physico-Chemical and heavy metals analysis)	10	MOEF&CC - Environmental Impact Assessment Guidance Manual for Highways, 2010(Page-17, Section 4.4: Air Environment) (Page - 17, Section 4.2: Land Environment) The soil profile of the highway alignment should be presented based on the soil series maps of National Bureau of Soil Survey and Land Use. The suggested parameters for soil analysis are pH, Electrical conductivity, sand (%), silt (%), clay (%), texture, moisture retention capacity (%), infiltration rate (mm/hour), bulk density (gm/ cc), porosity (%), organic matter (%), nitrogen (mg/1000g), potassium (mg/1000g), phosphorous (mg/1000g), sulphates and sodium sulphates.

10.5.1 Air Environment

Standard methods/procedures are adopted during environmental monitoring analysis. After a preliminary reconnaissance of the study region and taking into account the meteorological (predominant wind directions, wind speed), topographic conditions, major settlements & its traffic volume and details on existing industrial activities in the study region, one (01) micro-meterological station and thirteen (13) ambient air quality monitoring stations were identified in the study area spread along Surat - Ahmednagar alignment. Micro-meterological station gives climatological condition of the study area by giving temprature, relative humidity, wind direction, wind speed and rainfall data. The parameters being monitored by air quality monitoring instruments are PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO. List of the monitoring locations are given in Table 3.

Table 3: Micro-meterological and Ambient Air Quality Monitoring Locations

Location Code	Latitude	Longitude	Location
MM1	19.99967	73.79675	Nasik
AAQ1	19.13704	74.75729	Pokhardi
AAQ2	19.37837	74.64542	Rahuri

Location Code	Latitude	Longitude	Location
AAQ3	19.42271	74.55142	Kangar Kh
AAQ4	19.57668	74.45854	Loni
AAQ5	19.75508	74.20842	Nirhale
AAQ6	19.91355	74.08146	Nimgaon Deopur
AAQ7	20.03297	73.86534	Adgaon
AAQ8	20.28328	73.63547	Mahaje
AAQ9	20.536	73.41488	Jamaliya
AAQ10	20.66837	73.27439	PipalKhed
AAQ11	20.81792	73.18987	Kukeri
AAQ12	20.9913	73.03413	Supa
AAQ13	21.0861	72.91809	Bhatia

MM-Micro-meterological station

AAQ-Ambient air quality monitoring location

Methodology to be adopted

For assessing the environmental impact, collection and interpretation of baseline data is of prime importance. The primary data for the study period is collecting for 24 hourly, twice a week for all the 4 weeks as per national guidelines. The criteria followed for selecting the AAQM stations is recommended by IS: 5182 and CPCB.

Site selection criteria are:

- The sampling station should be selected so as to serve the exact purpose of investigation. For general city level it should be so located with respect to various sources, and the meteorological factors prevailing in the area.
- For local industrial pollution monitoring, sampling location may be located to give maximum pollution levels from a particular source.
- Monitoring location should be representative of whole area i.e. data generated from the site reflects the concentrations of various pollutants and their variations in that particular area.
- Public buildings like schools, laboratories, police stations, hospitals, municipal and government offices are more suitable because of the easy accessibility and security.
- Monitoring site should be sufficiently away from direct emission sources and other interferences (inlet should be atleast 15 m away from source/traffic).
- Distance of the sampler to any air flow obstacle like buildings or trees must be more than two times the height of the obstacle above the sampler.

- The instrument must be located in a place where free flow of air is available. The instrument should not be located in a confined place, corner or a balcony.
- Monitoring stations should be located in areas that are downwind from the pollution sources.
- Height of the inlet should be > 3 m (preferably 3-10 m) to protect the sampling intake from vandalism.
- Elevation angle should be less than 30 degree from inlet to top of the building.

Monitoring and Analytical Procedure

Ambient air quality was monitored for the presence of contaminants existing in the air. In order to evaluate and quantify the air pollution problem, measurements are being carried out for various air pollutants mentioned above. This data will be used not only to evaluate the air quality in the study region but also as the basis to develop programs aiming at preventing the spread of pollutants leading to a risk to human health and general environment. Fine Dust Samplers (FDS) or Respirable Dust Samplers (RDS) are using for ambient air sampling. The method for the analysis of selected parameters are based on IS: 5182.

The monitoring results and analysis of the results will be described with reference to the NAAQ Standards, 2009 and will be presented in Draft EIA & EMP report.

10.5.2 Water Environment

Selected physico-chemical parameter along with bacteriological indicators of pollution will be used for describing the baseline status of water environment. Generation of baseline data for water quality covers sources of ground and surface water. The Assessment of water quality in the study area includes:

- Surface water quality (IS 2296: 1982)
- Ground water quality (IS 10500: 2012)

10.5.2.1 Surface Water Quality

During the preliminary assessment, Seventeen (17) surface water sampling locations were identified for assessing the water quality. These monitoring locations were identified by considering proximity to the project site, their activities and depending upon its utility by the people in the region. The details of the proposed sampling locations are given in Table 4.

Table 4: Surface Water Quality Sampling Locations

Location Code	Latitude	Longitude	Location
SW1	19.1152	74.7827	Kapurwadi
SW2	19.20519	74.76217	Pimpalgaon Lake

Location Code	Latitude	Longitude	Location
SW3	19.37337	74.63507	Rahuri
SW4	19.52501	74.43307	Chanegaon
SW5	19.87525	74.09492	Gulwanch
SW6	19.97567	73.97678	Chatori
SW6	20.13162	73.7754	Ramshej
SW7	20.21697	73.71724	Waghad
SW8	20.32966	73.60177	Vadabari
SW9	20.38531	73.57189	Tetmala
SW10	20.47585	73.44926	Chavra
SW11	20.53818	73.39614	bokaddhara
SW12	20.7004	73.27954	Keliya Reservoir
SW13	20.79012	73.2023	Donja
SW14	20.83925	73.1605	Dharampur
SW15	20.97996	73.0237	Supa
SW16	21.06918	72.95166	Samrod
SW17	21.0906	72.95013	Taraj

Surface water samples will be analysed for Temperature, pH, Turbidity, EC, Colour, TSS, TDS, Odour, DO, BOD, COD, TKN, Total Hardness, Sodium, Potassium, Calcium, Magnesium, Ammonia, Chloride, Sulphate, Phosphate, Nitrate, Fluoride, Surfactants, Dissolved Iron, Copper, Zinc, Manganese, Arsenic, Lead, Mercury, Boron, Chromium, Phenols, Cadmium, Total Coliform and Faecal Coliform. Results and detailed analysis will be given in the Draft EIA/EMP report.

10.5.2.2 Ground Water Quality

Ground Water is one of the main sources of water in the project corridor for domestic, commercial and other irrigation use hence the rate of extraction of ground water is at a massive scale. For assessing the ground water quality in the study area, twenty (20) sampling locations were identified (bore wells/dug wells). Selection of samples considered as per the utilization of water by the people along the proposed stretch. The details of the proposed ground water sampling locations are given in Table 5.

Table 5: Ground Water Quality Sampling Locations

Location Code	Latitude	Longitude	Location
GW1	19.1367	74.75726	Pokhardi

Location Code	Latitude	Longitude	Location
GW2	19.28833	74.73062	Vambori
GW3	19.37813	74.64574	Rahuri
GW4	19.57479	74.45856	Loni
GW5	19.81934	74.20212	Pangri
GW6	19.91338	74.08169	Nimgaon Deopur
GW7	19.92116	74.05383	Patpimpri
GW8	19.94891	74.01406	Umrale Budruk
GW9	20.03267	73.86549	Adgaon
GW10	20.19995	73.72022	Pimpalgaon Nipani
GW11	20.28298	73.63578	Mahaje
GW12	20.39428	73.56644	Pahuchibari
GW13	20.43359	73.52302	Gurtembhi
GW14	20.53578	73.4153	Jamaliya
GW15	20.81825	73.1896	Kukeri
GW16	20.86649	73.11248	Nogama
GW17	20.92126	73.08956	Satem
GW18	20.99052	73.03411	Supa
GW19	21.03153	72.97405	Vesma
GW20	21.0873	72.92054	Bhatia

Ground water samples will be analysed for Temperature, pH, Turbidity, EC, Colour, TSS, TDS, Odour, DO, BOD, COD, TKN, Total Hardness, Sodium, Potassium, Calcium, Magnesium, Ammonia, Chloride, Sulphate, Phosphate, Nitrate, Fluoride, Surfactants, Dissolved Iron, Copper, Zinc, Manganese, Arsenic, lead, Mercury, Boron, Chromium, Phenols, Cadmium, Total Coliform, Faecal Coliform. Results and detailed analysis will be given in the Draft EIA/EMP report.

10.5.3 Noise Environment

Keeping in view of the proposed improvement and widening project, field monitoring were carried out and thirty four (34) noise monitoring locations were identified. The locations were selected based on land use pattern, traffic intersections and diversions along the existing alignment. Precision integrated sound level meter having statistical unit with digital display would be using for 24 hour noise level monitoring in the present study. The noise quality monitoring would be planned and executed as per protocol for ambient level noise monitoring.

Noise levels are recorded as L_{eq} day and L_{eq} night. The details of the proposed Noise Level Monitoring locations are given in Table 6.

Table 6: Noise Level Monitoring Locations

Location Code	Latitude	Longitude	Location
NQ1	19.0266	74.77654	Rede
NQ2	19.06319	74.80607	Nimbodi Gaon
NQ3	19.08948	74.81151	Sahapur, Ahmednagar
NQ4	19.13406	74.80389	Kapurwadi
NQ5	19.18435	74.76956	Dhangarwadi
NQ6	19.29809	74.70529	Vambori
NQ7	19.36608	74.64613	Rahuri
NQ8	19.38635	74.62469	Rahuri
NQ9	19.5754	74.42342	Chandrapur
NQ10	19.64308	74.38013	Mirpur
NQ11	19.70911	74.31175	Junegaon
NQ12	19.82898	74.15893	Bhokani
NQ13	19.91121	74.06178	Baragaon Pimpari
NQ14	20.00322	73.94166	Chehedi Khurd
NQ15	20.05302	73.8817	Jaulakedindori
NQ16	20.11349	73.80877	Dhakambe
NQ17	20.17158	73.73387	Rasegaon
NQ18	20.20905	73.69874	Dhaur
NQ19	20.35347	73.58192	Kalambari
NQ20	20.38833	73.56438	Pahuchibari
NQ21	20.66956	73.27215	Pipalkhed
NQ22	20.67969	73.26778	Mandav Khadak
NQ23	20.7488	73.22977	Vandervela
NQ24	20.80406	73.19513	Kukeri
NQ25	20.81201	73.19002	Kukeri
NQ26	20.86371	73.13624	Tankal
NQ27	20.8653	73.13259	Tankal
NQ28	20.91922	73.07878	Satem
NQ29	20.95067	73.0371	Ambada
NQ30	20.98584	73.01995	Tarsadi

Location Code	Latitude	Longitude	Location
NQ31	20.99917	73.00833	Sarona
NQ32	21.04416	72.98232	Alak
NQ33	21.05014	72.97704	Ranodra
NQ34	21.08623	72.95351	Taraj

The CPCB has specified ambient noise levels for different land use for day and night times. Importance is given to the timing of exposure and areas designated as sensitive. The National ambient noise level standards are given below in Table 7.

Table 7: National Ambient Noise Level Standards

Area Code	Category	Limits in Decibels (dB(A))	
		Day Time	Night Time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence Zones	50	40

10.5.4 Land Environment

The soil samples of different area along the project stretch would be collected from ten (10) locations near agricultural areas for assessing the physic-chemical characteristics of the soil in the project area. The quality parameters will include pH, electrical conductivity, sand, silt, clay, texture, moisture retention capacity, infiltration rate, bulk density, porosity, organic matter, Nitrogen, potassium, phosphorous, iron and organic carbon. Soil sampling locations are listed in Table 8

Table 8: Soil Sampling Locations

Location Code	Latitude	Longitude	Location
SQ1	19.137	74.76001	Pokhardi
SQ2	19.37816	74.6438	Rahuri
SQ3	19.57497	74.45773	Loni
SQ4	19.91346	74.08103	Nimgaon Deopur
SQ5	20.04251	73.87112	Adgaon
SQ6	20.28388	73.63645	Mahaje
SQ7	20.53484	73.41194	Jamaliya

Location Code	Latitude	Longitude	Location
SQ8	20.81644	73.18983	Kukeri
SQ9	20.98649	73.02019	Supa
SQ10	21.08673	72.95248	Taraj

10.6 Anticipated Environmental Impacts and Mitigation Measures

The project stretch from Surat to Ahmednagar exhibits a symbiotic relationship between the environment and development with both positive and negative and reversible and irreversible impacts. The flow chart showing the itinerary of assessment, evaluation & interpretation of impact, prediction of impacts and suggesting suitable measures are given in Figure 3. The project specific impacts assessed will be described in Draft EIA & EMP after approval of Preliminary EIA report.

10.7 Assessment of Impacts in Key Stages of the Project

The proposed project can have impacts or cause impacts in three specific situations as follows:

- Impacts due to project design stage
- Impacts during construction stage
- Impacts during operational stage

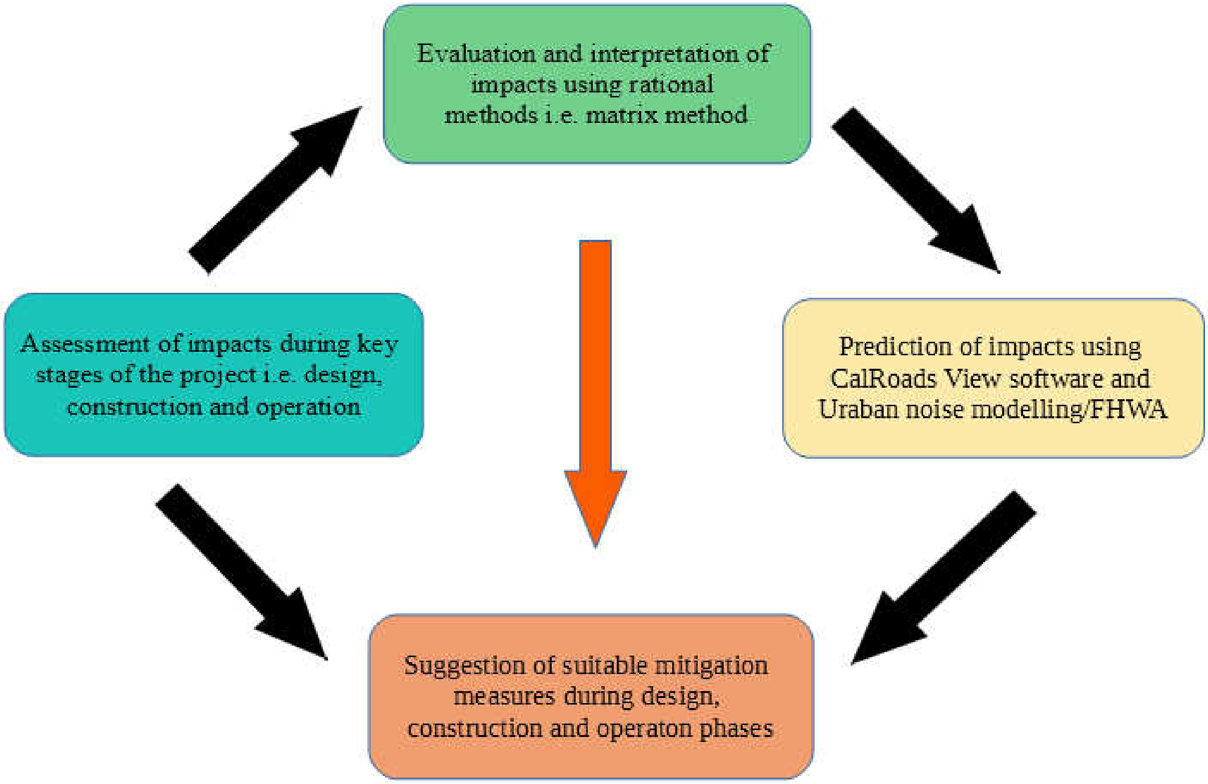


Figure 3: Itinerary of Assessment of Impacts and Mitigation Measures

10.7.1 Impacts due to Project Design Stage

The engineering design of the road are finalized by considering all environmental safeguards. The project envisages natural drainage network, roadways which will have marginal negative impacts of temporary and localized in nature. Land acquisition for road development is minimal. The Proposed project road may lead to loss of livelihood for very few project affected peoples.

10.7.2 Impacts during Construction Stage

The construction stage is one of the critical stage of the project which may pose maximum impact on the environment. The major impacts associated in this stage from site clearance to the final BT stage of the main carriageway will be identified and appropriate mitigation measures will be suggested.

10.7.3 Impacts during Operation Stage

The proposed project can harmonize with the surrounding environment and serve multiple users with the following positive impacts.

- To relieve traffic congestion in towns /cities along the proposed stretch.
- To provide effective linkage within Maharashtra State.
- To Increase access to markets, jobs, education, and health services.

However, some negative impacts are also associated in this stage. The major impact envisaged in this stage is increasing of traffic which results in increasing of air and noise pollution. To minimise these impacts, appropriate mitigative measures will be suggested.

10.8 Evaluation and Interpretation of Impacts

Matrix method will be adopted for the cumulative evaluation of impacts. Based on the scoping of the areas and the work being proposed, the following key issues will be evaluated for this project.

- Preservation of aesthetic and landscape of the area to the possible extent
- Effective restoration of borrow areas and quarries
- Evaluation of environmental quality
- Tree removal and tree plantation
- Sanitation and waste disposal
- Road safety
- Protection of flora and fauna
- Afforestation

The outcome of the results will be interpreted. The interpreted values will be helpful for the decision makers to take appropriate decision in right time.

10.9 Prediction of The Impacts

As discussed earlier, the major impacts associated with this project are air and noise. The air quality due to vehicular movement will be predicted using the CALRoads View software and to predict the cumulative noise impacts, Federal Highways Administration (FHWA) Noise Model or Uraban Noise Model will be adopted. The air and noise impacts are aimed to predict the future impacts for "without and with project scenario" by using the traffic study report. The following impact prediction models will be used are:

- Air Modelling : CALRoads View
- Noise Modelling : Federal Highway Administration Noise Model
- Dust Emission Model : US EPA AP 42 Fugitive Dust Emission Model
- Climate Change : Vehicular Emission Assessment Model (Mathematical)

Suggesting suitable Mitigation Measures

The mitigation measures are highlighted for the following key issues in the project.

- Soil quality (top soil, soil erosion etc.)
- Solid waste or muck disposal
- Air quality
- Water quality (wetlands, water bodies, groundwater etc.)
- Noise quality
- Biological Environment (Flora and Fauna)
- Socio-economic quality of life
- Safety and health aspects during construction and operation phase

10.10 Environmental Management Plan (EMP)

EMP is a procedure in which the project proponent will carry out the implementation of mitigation measures and ensure compliance with environmental regulations that are binding on the project. The EMP also specifies the organizational requirements and institutional strengthening necessary for sound environmental management of the project. The major components of the EMP are:

- EMP implementing agency
- Monitoring of the EMP implementation
- Training on environmental management
- Budget for EMP implementation

The project specific EMP with budgetary provisions will be given after approval of preliminary EIA report.

10.11 EMP Implementing Agency

The project proponent will establish an Environmental Management Cell (EMC) to supervise and implement the mitigation measures as documented in the EMP. This EMC must also be adequately empowered to discharge the responsibilities as outlined in the EMP. To ensure smooth implementation of EMP the project proponent will have to collaborate with various government agencies like Public Works Department, Revenue Department, State Pollution Control Board, State Forest Department, Police Department and other allied departments.

10.12 Monitoring of EMP Implementation

The EMP will primarily be implemented by the project proponent and civil contractor. However, for an effective implementation of EMP, the current project will be monitored by two level monitoring. The first one is internally by top management of contracting company and the second one by the National Higways under NHAI. The EMC constituted by contracting company shall be the prime agency for monitoring all the activities during construction and operation phases. GM, NHAI or supervision consultant appointed by NHAI shall supervise all activities and accordingly advise the contracting company to improve on areas where any shortcomings are observed. The EMC shall provide all the monitoring results to NHAI. GM, NHAI shall keep a record of all information and shall suggest suitable measures to be adopted by contracting company if any aspect is found to be deviating from the stipulated values/standards. Monitoring shall be carried out during construction and operation phase.

10.13 Budget for EMP Implementation

The design and construction of the project involves a number of items such as resettlement & rehabilitation, erosion prevention, rehabilitation of borrow areas, tree plantation, safety signage etc., which are included in the contract cost. Only those items that are not covered under the budget for construction will be shown in the EMP implementation budget.

The main components are as follows:

- Setting up of Environment Management Cell (EMC)
- Environmental Enhancement Measures
- Tree Plantation
- Environmental monitoring during construction and operation phases
- Conducting awareness programmes
- Capacity building and training during construction and operation phases.

11. INITIAL SOCIAL IMPACT ASSESSMENT REPORT

11.1 INTRODUCTION

National Highways Authority of India (NHAI) is engaged in the development of the National Highways. As part of this endeavour, NHAI has decided to undertake the project namely "Consultancy services for preparation of DPR for development of stretches for improving direct connectivity in Indian cities (Lot-8/Package-1) Surat-Nashik-Ahmednagar (SA) Greenfield Highway.

The main objective of development of proposed 290.700-kilometer SA road is to improve the performance of national road transport network. Apart from connectivity considerations, the corridor has been perceived to be important from the perspective of development in Navsari, Valsad, Nasik and Ahmednagar districts in general and SA regions in particular.

11.2 PROJECT ROAD DESCRIPTION

The project stretch is an interstate connectivity between Gujarat and Maharashtra states. The Project Highway starts from proposed Vadodara- Mumbai Expressway near Toli Village, Navsari taluk and district of state Gujarat (Des. Ch. Km 0.000) and ends at NH-61 at Sarola Baddi (Des. Ch 290.700) in Ahmednagar district of Maharashtra state. The detailed account of SA road is presented in Table 11.1.

Table 11.1: Proposed SA Green Field Road Details

S. No	Stretch	Chainage (Km)		Geograhic Co-ordinates (UTM)	
		From	To	Start	End
1	Surat – Nashik-Ahmed-nagar	0.000	290.700	21° 7'38.39"N 72°54'10.16"E	19° 5'41.56"N 74°49'56.40"E

With regard to district wise length of the road, Nashik district has got a substantial 122.100 kilometers constituting 42% percent of the entire corridor.

Table 11.2: District wise Length of Alignment

S. No.	State	District	Length (Km.)	Percentage (%)
1	Gujarat	Navsari	46	16%

S. No.	State	District	Length (Km.)	Percentage (%)
2		Valsad	22.36	8%
3	Maharashtra	Nasik	122.1	42%
4		Ahmednagar	100.24	34%
Total			290.700	

11.3 IMPORTANCE OF THE PROJECT ROAD

The primary objective of the proposed road is to establish the connectivity and accessibility with some Indian cities. It helps to join the missing links of some towns/cities in such a way that all the important places along the Surat-Chennai corridor are connected. The project highway aims to provide direct connectivity to Surat with Nashik and Ahmednagar. The rural and backward areas of both states may also be integrated and thereby economic multiplier effect is expected to be high. Studies universally show economic activity picking up after an upgradation in road connectivity.

11.4 ONGOING DEVELOPMENTAL ACTIVITIES ALONG THE PROJECT CORRIDOR

Following are the development Proposal along/across the project alignment which need to be considered to provide conductivities with Surat – Ahmednagar Green Alignment.

1. Proposed alignment crosses Samrudhi-Mahamarg expressway which is being taken up by Government of Maharashtra. Samrudhi – Mahamarg express-way connects Mumbai (the Financial capital of India) and Pune to Nagpur which is in Vidarbha region. Proposed alignment has a connectivity to Samrudhi – Mahamarg expressway.

2. DPR for the stretch between Nasik and Shirdi is in progress. This also need to be considered for the design of this Surat – Ahmednagar stretch.

3. Elevated Corridor (Flyover) is proposed on NH -3 near Adgaon Village at Nasik.

4. There is a Defence Firing range station near kapurwadi Village a KM 307.

5. As a part of Bharatmala Pariyojana, Pentacle consultants are preparing DPR for between Sinnar – Shirdi – Rahuri – Ahmednagar Section. This section is being crossed Surat – Ahmedangar Project Alignment.

6. Proposed alignment has a connectivity to Vadodara-Mumbai Expressway, It is part of Delhi – Mumbai expressway.

There are 25 major and a few minor roads are crossing the proposed alignment. Apart from these roads, there are few local gravel and earthen roads leading to clusters of houses and hamlets in villages and small towns. The list of major junctions is given in Table-1.3 below.

Table-11.3: Major Junctions along Project Road

S. No	Chainage (Km)	LHS	RHS	Intersecting Road
1	2.335	Satem	Ashtgam	SH-180
2	10.600	Saraiya	Tankal	SH-177
3	11.000	Saraiya	Tankal	SH-703
4	19.100	Kukeri	Surkhai	SH-178
5	20.150	Kukeri	Donja	NH-360
6	35.910	Kelia	Mandav kedak	SH-701
7	37.120	Pipal Khed	Zari	SH-5
8	86.550	Kalambari	Nanashi	SH-21
9	90.650	Kalambari	Nanashi	SH-21
10	91.020	Kalambari	Nanashi	SH-21
11	107.120	Waghar	Daur	NH-848
12	118.090	Jambutake	Nalegaon	NH-848
13	128.250	Talegaon Dindori	Pimpalnare	SH-17
14	138.650	Jaulakedinori	Adgaon	NH-60
15	147.400	Varne Darna	Chehedi Khurd	SH-30
16	163.300	Nimgaon Deopur	Baragaon pimpri	NH-160
17	177.100	Dharangaon	Bhokani	NH-160
18	198.200	Junegaon	Talegaon Dighe	SH-44

S. No	Chainage (Km)	LHS	RHS	Intersecting Road
19	208.700	Lohare	Mirpur	SH-45
20	217.400	Chandrapur	Chinchapur kh.	NH-160
21	247.900	Rahuri	Malharwadi	SH-49
22	251.159	Rahuri	Ahmednagar	NH-160
23	261.200	Vambori	Dhamori Kh.	SH-49
24	275.800	Dhangarwadi	Pokhardi	SH-60
25	288.400	Sonewadi	Shahapur	NH-61

11.5 PROJECT IMPACTS

On account of development of Surat-Chennai corridor, it is ascertained that a greenfield alignment is inevitable. The proposed Surat-Nasik-Ahmednagar alignment involves land acquisition from current owners/users. The construction of road project will have significant positive impacts, but they may simultaneously also bring negative impacts on nearby communities, if proper precaution is not taken during design and implementation stage of the project. Acquisition of land may cause social disruption and economic loss for project affected persons (PAPs) and their families. It is therefore important that disturbances and losses of PAPs due to project are minimized through proper planning. The Resettlement Action Plan needs a broad and comprehensive study and that will be incorporated in subsequent reports.

Social assessment study is generally carried out to identify critical locations and issues that need to be studied further in detailed in terms of impact assessment, mitigation measures and management plan. In socio economic point of view, the identified areas directly served by the project road delineate the broad and immediate picture of influenced area. The salient features of SA road is presented in Table 1.4.

Table 11.4: Salient Features of SA Road

S. No	Particulars	Unit	Total
1	Total Length of Proposed Road (Design Length)	Km.	290.700
2	Total Length of proposed SA alignment in Gujarat State	Km.	68.360
3	Total Length of proposed SA alignment in Maharashtra State	Km.	222.340

S. No	Particulars	Unit	Total
4	Total no. of Revenue Villages in entire project area as per 3(a) or Draft 3A	No.	171
5	Total no. of Revenue Villages in Gujarat state road as per 3(a) or Draft 3A	No.	60
6	Total no. of Revenue Villages in Maharashtra state as per 3(a) or Draft 3A	No.	111
7	Total volume of land (Tentative) to be acquired for the proposed Project road	Ha.	2363.265
8	Land required for Gujarat Section of SA road	Ha.	568.440
9	Land required for Maharashtra Section of SA road	Ha.	1794.825

11.6 OBJECTIVE OF THE STUDY

The objective of the survey is to generate an inventory of social impacts on the likely to be affected people by the project. The project impacts were identified through a series of exercises including social screening during early project preparation stage and informal discussion with villagers and road users. The screening on road sections focuses on:

- **identification of social issues such as impact on livelihood due to land acquisition;**
- **current usage of land in proposed ROW;**
- **potential impact of the proposed project on productive resources, natural resources, common property resources and social infrastructures;**
- **social, economic, cultural and demographic characteristics of the potential project affected population;**
- **identification and special need analysis of vulnerable groups, ethnic minorities and SC/STs among the population;**

11. 7 METHODOLOGY

Approach and methodology mainly consist of quantitative and qualitative tools and techniques. The following are the activities undertaken for the social screening or initial social assessment survey.

11.7.1 Collection and review of project literature

This phase intends to familiarize with the concerned and important stakeholders to identify and collect the available literature and to scope the activities. The activity is involved in two-pronged approach (a) discussions with Project Implementing authorities and other concerned, b) collection of available relevant project literature. The laws and regulations enacted by Government of India and state government of Gujarat and Maharashtra pertaining to R & R issues. Consultations were held with concerned revenue/ government officials to establish the ownership of land. Literature review and informal discussions formed the basis for identification of key stakeholders.

11.7.2 Rapid reconnaissance survey to familiarize field activities

In addition to review of literature and informal consultations, rapid preliminary field visits were conducted as part of ground truthing exercise. The reconnaissance survey helped to gather firsthand information on the likely to be affected area, revenue villages, land details e.g. private, government and forest etc.

11.7.3 Identification of Properties

For construction of new alignment, the social team conducted an identification exercises on different types of land within 70 meters of proposed ROW. Prior to initiation of physical identification of the properties, a detailed discussion was held with concerned officials to collect information on ownership of land. Since 3(A) activities are underway hence the type and classification of land and exact number of private landowners cannot be ascertained at this stage. The exact number of likely to be affected households and thereby magnitude of impact can be determined after the completion of census and socioeconomic survey. All the affected properties belonging to legitimate owners shall be incorporated in the subsequent reports.

11.7.4 Public Consultation Meetings

Meaningful, informed, and effective public consultations are inevitable for successful of any infrastructural project. Approaches to the public involvement can yield productive, long-term and trusting relationships between citizen and government. Consultative procedures are critical but very important aspects in entire social impact assessment process. Public consultations in social impact assessment facilitates to make a rapport with the villagers and simultaneously provide clear communication about the purpose of the consultation and its relationship to the larger decision-making process. In this regard, the social assessment ensures the involvement of local communities through participatory and structured consultations that would endorse and integrate important resettlement issues in the project cycle. In this regard, we planne to disseminate the inforamation to the villagers about the characteristic of the proposed alignment in terms of length, proposed right of way and upgradation features.

Navsari District - Meetings held in December -2019:

- The alignment was reviewed by Member (Projects) on 11.12.2019 and minutes were awaited from the Bharatmala Division.
- Consultants have requested Navsari District Collector to fix a date for public consultation meeting. Date 16.12.2019 was fixed by District Collector Navsari and communicated to PIU Surat on 07.12.2019.
- Consultants have coordinated with all affected village administrative officials and requested them to attend meeting.
- Public Consultation meeting was held on 16.12.2019 at Conference Hall, Navsari district Magistrate office in the presence of

Public Representatives:

- Honourable Shri. C.R Patil: Member of Parliament
- Shri. K.J Rathod: Resident Additional Collector

NHAI:

- Shri. Shashi Bhushan: Project Director & G.M (T)
- Shri. A.K Swami: Manager (T), PIU Surat.
- Shri. Bhavesh Gandhi: Land Acquisition Expert

Consultants: (AARVEE Associates)

- Mr. U. Paparaju: Manger
- Mr. M. Rakesh.: Assistant Manager
    - In the meeting consultants briefed regarding the Project alignment traversing through Navsari District and given a detailed presentation of the Project.
    - After the Meeting the Honourable Member of Parliament instructed consultants to submit detailed village wise affected areas with landowner details and approx. cost particulars.

- All affected Survey Numbers, Acquisition Areas, Costs and respective ownership details Village wise have been worked out and submitted to PIU, Surat on 26.12.2019.

Public Consultation Meeting on 16.12.2019 at Navsari District Magistrate Office:

Meetings held at Nashik & Ahmednagar Districts:

- Consultants have conducted the Public Consultation Meetings in respective districts and recorded the video under chairmanship of State Nodal Officers, Stake Holders and with public representatives of Ahmednagar district on 25.01.2021 and Nashik district on 05.02.2021.
- Minutes of meeting were received from district collector Nashik and Ahmednagar Minutes of Public consultation meetings

S. No	Suggestion from Stakeholders	Comments of PIU
1	It was suggested that just reasonable and fair compensation shall be provided to the farmers. Compensation shall be as per provisions of law and directions issued by the Government	Compensation paid by Authority is as per provision of Law. The same is worked out by CALAs.
2.	It was suggested to provide service roads/cart	May be incorporated in DPR

	track to connect field roads along the proposed greenfield highway	as per codal norms and extant NHAI policy
3.	Sufficient number of Underpasses shall be proposed for the movement/crossing of local traffic	May be incorporated in DPR as per codal norms and extant NHAI policy
4.	Small pockets of land whichever is leftover after land acquisition (Residual Lands) shall also be considered in the acquisition	Authority can't acquire more land than required for road. This demand calls for policy decision.
5.	Pattas have been issued to tribals residing in Forest area for whom compensation modalities shall be verified vis-à-vis FRA Act. In that regard National Highway shall identify the modalities of compensation to FRA affected tribals in other such projects	Compensation for tribals in Forest areas shall be as per FRA act. Moreover, compensation is worked out by CALAs
6.	Water Diversion Scheme under planning at Rakshasbhavan shall be taken into account	DPR Consultant is directed to take cognizance of Rakshasbhavan Diversion scheme which is yet to be approved
7.	Alignment passes through NMRDA (Nashik Metropolitan Region Development Authority) wherein many DP roads are proposed. Proper Underpasses of suitable widths shall be proposed therein	Underpasses for DP Roads shall be provided as per codal norms and extant NHAI Policy

11.8 INITIAL SOCIAL IMPACT ASSESSMENT

An Initial Social Impact Assessment (ISIA) is carried out to gauze the magnitude of impact and people's overall perception about the proposed project. It helps to understand if the project impacts are likely to be minor or limited, which can easily be predicted and evaluated, and for which mitigation measures can also be prescribed easily. Generally, information on ISIA is obtained during field visit from the areas that may probably be impacted by the project road. The ISIA is also done to confirm whether this indeed requires a full-scale Social Impact

Assessment (SIA) or not. A detailed SIA therefore needs to be carried out to make project design responsive to social development concerns. Usually, a comprehensive SIA is required for large projects, which entails a more detailed study, time, and resources.

Reconnaissance and initial social assessment survey were undertaken to take a detailed note of affected properties. However, full-fledged survey needs to be undertaken for preparation of the Resettlement Plan as per the policy and guidelines of Central Government and State Government. In this regard, surveys relating to social assessment of the impact will be conducted within 70 m of proposed Row.

The focus of this study is to understand the factors underlying the agricultural activity with reference to requirement of land from the villages for greenfield alignment. The input consists of a combination of secondary data and preliminary surveys and consultation with a cross-section of people.

In order to assess the potential impacts within the project corridor, critical sections from social impact point of view have been identified. Such locations have been identified with the potential issues and thereby possible options for minimizing the impact need to be suggested.

The primary information was collected through consultations with villagers to comprehend the socio-economic characteristics, physical features and cultural set-up of the project area before undertaking detailed field investigations. Relevant land data were also collected from local Revenue/Taluka offices.

While finalizing the road alignment efforts has to be made by adopting appropriate engineering designs, to minimize resettlement impacts. To minimize displacement and to reduce disruption of livelihoods, a greenfield alignment for entire SA road section has been proposed.

11.8.1 Extent of Land Acquisition

As per our initial assessment, the proposed project road would require both private and government land of approx. 2363.265 hectares. A considerable length of 222.34 km. long greenfield alignment passing through 115 revenue villages in Maharashtra state requires 1794.825 hectares of land. Similarly, about 568.440 hectares of land to be acquired from 40 villages in Gujarat state for greenfield alignment length of 68.360 km. The scope of land acquisition for the project road includes a) a minimum 70m RoW b) Greenfield alignment is proposed to avoid the impact on the properties and livelihood c) provisions on roadside amenities.

Table 11.5: Land Requirement for Proposed SA road as per 3A w.r.t 70m RoW

S. No	Project Component	Required Land (Ha.)
1	For development of greenfield alignment in Gujarat side	**568.440**
2	For development of SA road in Maharashtra side	**1794.825**
Total		**2363.265**

11.8.1.1 Revenue Villages in Project Area

The proposed Surat-Nashik-Ahmednagar road will pass through 155 villages covering 14 talukas in both Gujarat and Maharashtra state. All these talukas fall in the territory of Maharashtra state. Land is to be acquired from 115 revenue villages in Maharashtra state and about 1794.825 ha. of land is required from 40 villages in Gujarat state. The list of villages is given in Table 1.6.

Table 11.6: List of Revenue Villages

S. No	State	District	Taluk	Village
1	Gujarat	Navsari	Navsari	Toli
2				Sarpor
3				Satem
4				Dabhalal
5				Butlav
6				Bhunwadi
7				Nagdhara
8				Mahudi
9				Puni
10			Chikhli	Nagoma
11				Bodvank
12				Tankal
13				vanzna
14				Ranverikalla
15				Surkhai
16				Kukeri
17				Kakadvel
18				Mandav Khadak
19				Saravani
20			Bansda	Pratapnagar
21				Zari
22				Vandervala

S. No	State	District	Taluk	Village
23				Kelia
24				Pipakhed
25				Ravaniya
26				Bedmal
27				Anklachi
28				Chondha
29		Valsad	Dharampur	Bhavada
30				Bopi
31				Hathanbari
32				Hanmatmal
33				Ganva
34				Jamaliya
35				Manaichondi
36				Mama Bhacha
37				Kosimpada
38				Sondar
39				Murdad
40				Madhuri
41	Maharashtra	Nashik	Surgana	Rakshasbhuvan
42				Bhawada
43				Bendwal
44				Dhudhawal
45				Gahale
46				Pimpalchond
47				Kahandolsa
48				Kotamba
49				Merdand
50				Sambarkahal
51				Haste
52				Jahule
53			Peth	Pahuchibari
54				Wirmal
55				Kalambari
56				Vadabari
57				Harangaon
58			Dindori	Tetmala
59				Gandole
60				Radtodi
61				Nanashi

S. No	State	District	Taluk	Village
62				Chelharpada
63				Kawdasav
64				Mahaje
65				Golshi
66				Jaralipada
67				Ambegaon
68				Chachadgaon
69				Dhaur
70				Umrale Bk.
71				Nalegaon
72				Jambutake
73				Rashegaon
74				Indore
75				Ramshej
76				Pimpalnare
77				Dhakambe
78				Ambedindori
79				Shivnai
80				Varvandi
81			Nashik	Adgaon
82				Vinchurgavali
83				Odha
84				Lakhalgaon
85			Niphad	Chehedi Kh.
86				Varhe Davna
87				Lalpadi
88				Dharansangvi
89				Sawali
90				Chatori
91				Ramnagar
92				Pimpalgaon Nipani
93				Talwade
94			Sinnar	Deshwandi
95				Patpimpri
96				Baragaon Pimpri
97				Nimgaon Deopur
98				Gulvanch
99				Deopur
100				Khopadi Bk.

S. No	State	District	Taluk	Village
101				Fardapur
102				Dharangaon
103				Bhokani
104				Pangari Bk
105				Pangari Kh
106				Fulenagar
107				Wavi
108				Ghotewadi
109				Kahandalwadi
110		Ahmednagar	Sangamner	Chincholi Gurav
111				Ajampur
112				Arampur
113				Talegaon
114				Hasnabad
115				Junegaon
116				Wadzari Bk.
117				Wadzari Kh.
118				Kasare
119				Lohare
120				Mirpur
121				Sadatpur
122				Chinchpur Kh.
123			Rahata	Gogalgaon
124				Chandrapur
125				Hasnapur
126				Durgapur
127				Hanmantgaon
128			Rahuri	Dhanore
129				Songaon
130				Malewadi/Dukrewadi
131				Kanadgaon
132				Tandulner
133				Tambhere
134				Wadner
135				Kangar Kh.
136				Kangar Bk.
137				Chinchvihire
138				Malharwadi
139				Momin Akhada

S. No	State	District	Taluk	Village
140				Rahuri Biu
141				Rahuri Kh.
142				Digras
143				Sade
144				Khadambe Bk
145				Khadambe Kh
146				Vambori
147			Nagar	Munjar Sumbha
148				Pimpalgaon Malvi
149				Shendi
150				Pokhardi
151				Pimpalgaon Ujjaini
152				Kapurwadi
153				Bhingar
154				Shahapur
155				Sarolabaddhi

11.8.1.2 Village wise Impact and Land Requirement

The extent of land to be acquired by the project is an indicator of impact on the social environment. The type and extent of land acquisition is presented in the below table. It is analyzed that about 2363.265 ha. of land is required for the greenfield alignment for SA road with six lane configurations. The total extent of land to be acquired under the project consists of two categories. The shares in the total extent are private land (1534.90 ha.) and government (391 ha.).

Table 11.7: District wise Project Impact & Requirement of Land in Hectare

S. No	State	Districts	Total Area in (Ha)	Govt Area in (Ha)	Pvt Area in (Ha)	Forest Area in (Ha)
1	Gujarat	Navasari	568.26	107.00	247.40	214.04
		Valsad				
2	Maharash-tra	Nashik	996.00	188.00	611.80	196.20
		Ahmednagar	799.00	96.00	675.70	27.30
	Grand Total Area		2363.26	391.00	1534.90	437.54

11.8.3 Impact on Trees

Some part of proposed road section in Valsad and Nasik districts is flanked by trees. The trees not only serve as natural sheds during summer but also enhance the beauty of the area. A huge number of trees dots in and around of proposed road was observed. With regard to development of the road, thousand of trees will be felled to make space for expansion.

11.8.4 Indigenous People and Vulnerable Groups

Indigenous people are defined as those having a distinct social, cultural, economic, and political tradition and institutions compared with the mainstream or dominant society. According to Indian Constitution, indigenous people with similar cultural characteristics are recognized as Scheduled Tribes (ST). However, not a single household was found across project villages during informal consultation. The number of likely to be affected ST population will be known after the completion of census and socio-economic survey. Proper provisions and adequate measures need to be taken to protect these vulnerable community.

11.8.5 Gender Issues

The consideration of gender issues is crucial in the planning and implementation of resettlement and rehabilitation programs. Special needs and requirements of women must be considered and addressed in all program aspects—site selection, site and housing design, provision of civic infrastructure, access to service, provision of land and housing title, payment of compensation, and income restoration etc. According to LARR Act the widowed, divorced and women deserted by family is to be considered separate family. As per the primary assessment, women’s participation and attendance in meeting is moderate in project area. However, majority of them do have decision making power at household level financial matters. Social and cultural factors may exclude women from participating actively in planning, implementing, and executing resettlement activities. Special efforts need to be made to ensure their inclusion. The resettlement policy provides women to be involved in the process of sustainable development.

11.9 LAND USE PATTERN IN PROJECT AREA

A wide variation of land using pattern was observed with respect to environmental factors such as soil characteristics, climate, topography, and vegetation etc. In project area, the land use is characterized by agricultural lands, barren, water bodies, forests, hills and plantation etc. The dry/ barren land and water bodies together accounts for 30-40 per cent of the total land to be acquired for the proposed project road. With regard to land use pattern, a major tract of land is used for cultivation purposes. The project area is a mix of both fertile wet and dry land.

Fig-11.1: Land Use Pattern in Project Area

During transect visit in greenfield area, sparsely cultivated land with cotton, onion and grapevines was noticed. A large chunk of number of fallow/barren land parcel was found in Maharashtra side of SA road.

11.10 CROPPING PATTERN

Different regions of the project districts have however exhibited some differences in the proportion net area cultivated. Sugar cane and paddy are the principal crops grown in both districts. Apart from it, grapevine, mango orchid, onion, groundnut, jowar, pulses and millets are also cultivated in project villages as observed. Sugarcane is widely cultivated in Surat district as well Navsari and Valsad districts. Huge tract of mango orchids is observed in Valsad district. Surat is primarily an agricultural district with sugarcane and paddy as the predominant crops. The other major crops cultivated are jowar, wheat, groundnut, banana, vegetables etc. About 65 per cent of land holdings are with small and marginal farmers.

Paddy is cultivated mainly in the western part of the Nashik district i.e Igatpuri, Trimbakeshwar, Peth, Nashik and Surgana Talukas. Surgana and Nashik are important talukas which are part of SA alignment. Ground nuts is also grown in all parts of the Nashik district, and it is known that some of the project villages produce more of it.

Jowar, Wheat & Gram are the main rabi crops grown in Nashik district. However, cultivation of Jowar is on large scale in project talukas such as Dindori and Sinnar in Maharashtra state. Jowar occupies more area than any other crop in Maharashtra. This crop needs warm weather, black fertile soil and moderate rainfall.

Niphad and Sinnar talukas produces large quantity of Sugarcane, Jaggery, Sugar and Treacle are prepared from Sugarcane. The sugarcane crop need black fertile soil, warm climate and also plenty of water and fertilizers.

The project talukas namely Niphad and Sinnar cultivate grapes in large scale for which a wine yards/ wine parks are found in some villages. In Nashik district Mango, Pomegranate and Grapes are the main horticultural crops.

The fertile land is unevenly distributed and found in scattered region. Canal and well is the primary source of irrigation. The huge tract of project area is considered to be a dry region particularly in Maharashtra side. The cropping pattern varies from taluka to taluka.

11.11 LAND VALUE IN PROJECT VILLAGE

The land price particularly under private transaction, varies from place to place. The market price of agricultural land ranges from Rs. 2 crores to 7 crore per acre in Surat district. Land rate in Surat district is considered to be very high compared to other project districts. In Valsad and Navasari district of Gujarat state, the land value varies from 20 lakh to 50 lakh per acre close to alignment. It is understood that the private land transaction ranges Rs. 15 to 35 lakh per acre respectively proximity to proposed road in Ahmednagar and Nasik district. The land value in villages close to Surat, Navasari, Nasik, Malegaon, Ahmednagar has gone up significantly in last 2 to 3 years because of proximity to urban location and industrial zone.

11.12 FOREST

The project corridor traverses through the forest of tentative length 29.16km and 30.39km in the state of Gujarat and Maharashtra respectively.

11.13 INDUSTRIES AND RESEARCH CENTRES:

Industrial area as a part of Special Economic Zone (SEZ) in Sinnar in the state of Maharashtra and Advanced Centre for Energetic Materials (ACEM), DRDO Near Nasik are located nearby project alignment

ACEM, DRDO @ Nasik

Indiabulls company in SEZ area

Industries @ SEZ

11.14 LEGAL POLICIES AND RESETTLEMENT FRAMEWORKS

11.14.1 Principles and Policies needs to be adopted for the Project

The core involuntary resettlement and rehabilitation principles for this project are: (i) land acquisition, and other involuntary resettlement impacts will be avoided or minimized exploring all viable alternative project designs; (ii) where unavoidable, time-bound resettlement action plan (RAP) will be prepared and APs will be assisted in improving or at least regaining their pre-project standard of living;(iii) Consultation with APs on compensation, disclosure of resettlement information to APs, and participation of in planning and implementing sub-projects will be ensured; (iv) payment of compensation to APs for acquired assets at replacement rates; (v) payment of compensation and resettlement assistance prior to the construction contractor taking physical acquisition of the land and prior to the commencement of any construction activities.

11.14.2 Minimization of Social Impacts

According to the broad principle mentioned above, an appropriate decision by engineering, environmental and social impact assessment teams has to be taken to avoid land acquisition from fertile lands.

11.14.3 Rehabilitation and Relocation of PAPs

Restoring livelihood for project affected people is an important task in resettlement plan. The required support shall be extended to the affected households during relocation (if required) and a time bound, fair & just entitlements shall also be given to the people to compensate and regain their pre-project level status.

11.14.4 National Highways Act- 1956

Land acquisition for National Highways is done in accordance with the procedure laid in "The National Highways Act, 1956". The act is applicable to the whole of India except the state of Jammu and Kashmir. The policy provides a broad guideline of procedure for land acquisition. The National Highways Act 1956 (NH Act) is commonly used for acquisition of land for public purpose of the road. It is used at the State level made to suit local requirements.

As a general practice Revenue Divisional Officer / Joint Collector in the District level is appointed as Competent Authority for Land Acquisition (CALA). Competent authority means any person or authority authorized by the Central Government, by notification in the Official Gazette, to perform the functions of the competent authority for such area as may be specified in the notification.

11.14.4.1 Intention & Declaration

When a National Highways require a land, an application is required to be made by it to the revenue authority;

3 (a) - Intention to Acquire Land: The Central Government upon publication of the Gazette nominates "Competent Authority for Land Acquisition" and expresses its intention to acquire land in respective revenue villages;

After the government has been fully satisfied about the purpose, the least area needed, and other relevant facts as provided under land acquisition rules, it will issue a notification under Section 3A of the act that the particular land is required for public purpose;

3 (A)- Power to Acquire Land: The central Government upon publication of this Gazette expresses its intention to acquire such land for construction, maintenance and management of

National Highways. The same shall be intimated to the public through two local news papers, one of which will be in vernacular language.

The application should be accompanied with a copy of the plan showing survey nos., purpose of acquisition and the reason for the particular site to be chosen and the provision made for the cost of the acquisition;

The Competent Authority will hold an inquiry under Section 3-B of the Act;

3 (B) - Power to entry for Survey: Upon getting the 3A notification published in the official Gazette, authorized persons are empowered to carryout survey, investigations and can cut trenches.

After notification the owner is prohibited from selling his property or disposing it off and prevented from carrying out any works of improvements for which no compensation will be paid if executed without prior permission from the collector.

11.14.4.2 OBJECTION AND CONFIRMATION

Objections are invited from all persons interested in the land within 21 days from the date of notification under Section 3-A.

The objections will be valid on one or more of the following grounds:

- That the purpose for which the land is proposed for acquisition is not a public purpose.
- That the land is not or less suitable than another piece of land for the said purpose.
- That the area under acquisition is excessive.
- That the acquisition will destroy or impair historical or artistic monuments or will desecrate religious buildings, graveyards and the like.

3 (C)- Hearing of Objections: Any person interested in the land may within twenty-one days from the date of publication of the notification under sub-section (1) of section 3A, object to the use of the land for the purpose or purposes mentioned in that sub-section.

- ➢ The CALA after hearing the objections will submit his report to the Central government, who will finally declare the land for acquisition under Section 3-D of the Act.

3 (D)- Declaration for Acquisition: After hearing the objections the competent authority shall submit a report accordingly to the Central Government for declaring the extents of land proposed for acquisition. The Central Government shall declare, by notification in the Official Gazette, that the land should be acquired for the purpose or purposes mentioned in sub-section (1) of section 3A.

- Upon publication of the declaration in the official Gazette the land shall vest absolutely in the Central Government free from all encumbrances. A declaration made by the Central Government under sub-section (1) shall not be called in question in any court or by any other authority.
- After notification the collector proceeds with the claim. He is authorized to mark out the site, measure and plan of the same made vide Section 3-E.
- Power to take possession: For the lands vested in the Central Government under section 3D upon determining the compensation, the competent authority shall intimate by notice in writing direct the owner as well as any other person who may be in possession to surrender or deliver possession to the competent authority or any person duly authoritative within sixty days of the service of the notice.

11.14.4.3 Claim and Award

- The collector will issue notices under Section 3-G to all persons interested in the acquisition to file their claim reports;
- The collector is not to be a party to the proceedings, is to possess an expert knowledge on valuation, and offers a fair price to an owner and checks that the public funds are not wasted;
- The claim filed should contain the names of the claimants and co-shares, if any rents or profits for last three years and a valuation report of the land from an architect or an engineer;
- In determining the compensation, the market value of the land is determined at the date of notification. The rise and fall in the value during the period of transaction and notification is taken into consideration;

Compensation is also payable when:

- Part of the property is proposed for acquisition in such a manner that the remainder depreciates in value.
- When the land notified for acquisition has standing crops or trees.
- If the person interested has to change his place of residence or business then the excess rent payable for the new premises is also considered for compensation.

Matters which are not taken into consideration for the purpose of land acquisition are:

- The degree of urgency which has led to the acquisition.
- Any disinclination of the person interested to part with the land.
- Any increase in the land value likely to accrue from the use to which it will be put when acquired.
- After necessary inquiries the collector declares his award showing true area of the land, total amount of compensation payable and apportionment of compensation if there are more than one owners or claimants.
- **The collector has to make the award under section 11 within a period of two years from the date of notification.**

11.14.5 The Right to Fair Compensation And Transparency In Land Acquisition, Rehabilitation And Resettlement Act,2013

The 1894 Land Acquisition Act was repealed, and a new comprehensive legislation was brought in Parliament and it came to effect on 1st January 2014. This Central Act ensures, in consultation with institutions of Local Self-Government and Gram Panchayats established under the Constitution, a humane, participative, informed and transparent process of land acquisition for industrialization, development of essential infrastructural facilities and urbanization with the least disturbance to the owners of the land and other affected families and provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition and make adequate provisions for such affected persons for their rehabilitation and resettlement and ensuring that the cumulative outcome of compulsory acquisition should be that the affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto.

The provisions of this Act Under Section 2(1) relating to land acquisition, compensation, rehabilitation and resettlement, shall apply, when the appropriate government acquires land for its own use, hold and control, including for Public Sector Undertakings and for public purpose. Under LARRA- 2013 for land acquisition for various types of project, provisions of consent have been inbuilt to secure the interest of the stakeholders. As far as this project is concerned [when the appropriate government acquires land for infrastructural projects under Section-2 (1) (B) (Vii)] consent is not required.

Table 11.8: Consent Requirements for Project As per Types and Sites

Protect Type + Area	Consent	
	Landowners and Tenants	Gram Sabha/ Panchayat/ Autonomous District Council
Public + Non-Scheduled Area	Not required	Not required
Public + Scheduled Area	Not required	Required
PPP + Non-Scheduled Area	Required (70%)	Not required
PPP + Scheduled Area	Required (70%)	Required
Private + Non-Scheduled Area	Required (80%)	Not Required
Private + Scheduled Area	Required (80%)	Required

The LARRA, 2013 provides a framework for facilitating land acquisition in India. LARRA, 2013 enables the State Government to acquire private land for public purposes. With regard to land acquisition for the proposed alignment, NHAI has to adopt its own act (Schedule-IV, LARR Act). For provision of compensation and other applicable entitlements it is bound to abide by the guiding principles laid down under Schedule- I and II, LARR Act-2013. Table 1.7 presents the sections of LARRA Act-2013.

11.14.6 Scheduled Caste and Scheduled Tribes Orders (Amendment) Act, 2002

The Act provides for the inclusion in the lists of Scheduled Tribes (ST), of certain tribes or tribal communities or parts of or groups within tribes or tribal communities, equivalent names or synonyms of such tribes or communities, removal of area restrictions and bifurcation and clubbing of entries; imposition of area restriction in respect of certain castes in the lists of Scheduled Castes (SC) and the exclusion of certain castes and tribes from the lists of SCs and Sts

11.15 Various Provisions Under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013(RFCTLARR Act)

Table: 11.9 – RFCTLARR Act-2013

1. LAND ACQUISITION
In case of land acquisition, the amount of compensation to be determined is that of the value of the land +100 percent Solatium+12 percent additional market value from the date of notification to taking over the possession or award whichever is higher. Market value of land as mentioned under section 26 of LARRA Act-2013 needs to be multiplied by the radial factor (based on the distance of project from urban area as notified by the appropriate government-e.g multiplication of 2 in Rural area and Multiplication of 1 in Urban area) plus value of assets attached to land or building (mentioned in Section 29 of LARRA Act-2013) Plus Solatium (solatium includes 100% market value multiplied by 2 plus value of assets in Rural area and multiplied by 1 plus value of assets in urban area)
2. PROVISION OF HOUSING UNITS IN CASE OF DISPLACEMENT
If a house is lost in rural areas, a constructed house shall be provided as per the Indira Awas Yojana specifications. If a house is lost in urban areas, a constructed house shall be provided, which will be not less than 50 sq mts in plinth area. The benefits listed above shall also be extended to any affected family which is without homestead land and which has been residing in the area continuously for a period of not less than three years preceding the date of notification of the affected area which has been involuntarily displaced from such area: Provided that any such family in urban areas which opts not to take the house offered, shall get a one-time financial assistance for house construction, which shall not be less than one lakh fifty thousand rupees: Provided further that if any affected family in rural areas so prefers, the equivalent cost of the house may be offered in lieu of the constructed house: Provided also that no family affected by acquisition shall be given more than one house under the provisions of this Act. Explanation- The houses in urban areas may, if necessary, be provided in multi-storied building complexes

3. CHOICE OF ANNUITY OR EMPLOYMENT

The appropriate Government shall ensure that the affected families are provided with the following options:

(a) where jobs are created through the project, mandatory employment at a rate not lower than the minimum wages provided for in any other law for the time being in force, to at least one member per affected family in the project or arrange for a job in such other project as may be required; or

(b) one time payment of five lakhs rupees per affected family; or

(c) annuity policies that shall pay not less than two thousand rupees per month per family for twenty years, with appropriate indexation to the Consumer Price Index for Agriculture Labourers.

4. SUBSISTENCE GRANTS

The appropriate Government shall ensure that the affected families are provided with the following options:

Given monthly subsistence allowance equivalent to three thousand rupees per month for a period of one year from the date of award. In addition to this amount, the scheduled castes and the scheduled Tribes displaced from Scheduled Areas shall receive an amount equivalent to fifty thousand rupees.

5. TRANSPORTATION COST

The appropriate Government shall ensure that the affected families are provided with the following options:

Each affected family which is displaced shall get a one time financial assistance of fifty thousand rupees as transportation cost for shifting of the family, building materials, belongings and cattle.

6. CATTLE SHED/ PETTY SHOPS COST

Each affected family having cattle or having a petty shop shall get one-time financial assistance of such amount as the appropriate Government may, by notification, specify subject to a minimum of twenty-five thousand rupees for construction of cattle shed or petty shop as the case may be.

7. ONE TIME GRANTS TO ARTISAN, SMALL TRADERS AND OTHERS

Each affected family of an artisan, small trader or self-employed person or an affected family which owned non-agricultural land or commercial, industrial or institutional structure in the affected area, and which has been involuntarily displaced from the affected area due to land acquisition, shall get one-time financial assistance of such amount as the appropriate Government may, by notification, specify subject to a minimum of twenty-five thousand rupees.

8. ONE TIME RESETTLEMENT ALLOWANCE

Each affected family shall be given a one-time "Resettlement Allowance" of fifty thousand rupees only.

9. STAMP DUTY REGISTRATION

(1). The stamp duty and other fees payable for registration of the land or house allotted to the affected families shall be borne by the Requiring Body.

(2). The land for house allotted to the affected families shall be free from all encumbrances.

(3). The land or house allotted may be in the joint names of wife and husband of the affected family.

10. PROVISION OF INFRASTRUCTURAL AMENITIES

1. Roads within the resettled villages and an all weather road link to the nearest pucca road, passages and easement rights for all the resettled families be adequately arranged.
2. Proper drainage as well as sanitation plans executed before physical resettlement.
3. One or more assured sources of safe drinking water for each family as per the norms prescribed by the Government of India.
4. Provision of Drinking water for cattle.
5. Grazing land as per proportion acceptable in the State.
6. A reasonable number of Fair price Shops
7. Panchayat Ghars, as appropriate.
8. Village level Post Offices, as appropriate, which facilities for opening saving accounts.
9. Appropriate seed-cum-fertilizer storage facility if needed.
10. Efforts must be made to provide basic irrigation facilities to the agricultural land allocated to the resettled families if not from the irrigation project, then by developing a cooperative or under some Government scheme or special assistance.
11. All new villages established for resettlement of the displaced persons shall be provided

with suitable transport facilities which must include public transport facilities through local bus services with the nearby growth centres/ urban localities.

12.Burial or cremation ground, depending on the caste communities at the site and their practices.

13. Facilities for sanitation, including individual toilet points.

14. Individual single electric connections(or connection through non-conventional sources of energy like solar energy), for each household and for public lighting.

15.Anganwadi's providing child and mother supplemental nutritional services.

16. School as per the provisions of the right of children to Free and Compulsory Education Act, 2009 (35 of 2009);

17. Sub-health centre within two kilo metres range.

18. Primary Health Centre as prescribed by the Government of India.

19. Playground for children.

20. One community centre for every hundred families.

21. Places of worship and chowpal/tree platform for every fifty families for community assembly, of numbers and dimensions consonant with the affected area.

22. Separate land must be earmarked for traditional tribal institutions.

23. The forest dweller families must be provided, where possible, with their traditional rights on non-timber forest produce and common property resources, if available close to teh new place of settlement and, in case any such family can continue their access or entry to such forest or common property in the area close to the place of eviction, they must continue to enjoy their earlier rights to the aforesaid sources of livelihood.

24. Appropriate security arrangements must be provided for the settlement, if needed.

25. Veterinary service centre as per norms.

11.SPECIAL PROVISIONS FOR SCHEDULED CASTE AND SCHEDULED TRIBES

(1) In case of a project involving land acquisition on behalf of a Requiring Body which involves involuntary displacement of the Scheduled castes or the Scheduled Tribes families, a Development plan shall be prepared, in such form as may be prescribed, laying down the details of procedure for settling land rights due but not settled and restoring titles of tribals on alienated land by undertaking a special drive together with land acquisition.

(2) The Development Plan shall also contain a programme for development of alternate fuel, fodder and non-timber forest produce resources on non-forest lands within a period of five years sufficient to meet the requirements of tribal communities as well as the Scheduled castes.

(3) The concerned Gram Sabha or the Panchayats at the appropriate level in the Scheduled Areas under the Fifth Schedule to the Constitution or , as the case may be, Councils in the Sixth Scheduled Areas shall be consulted in all cases of land acquisition in such areas, including acquisition in case of urgency, before issue of a notification under this Act, or any other Central Act or a State Act for the time being in force as per the Provisions of the Panchayats (Extension to the Scheduled Areas) Act, 1996 (40 of 1996) and other relevant laws.

(4) In case of land being acquired from members of the Scheduled Castes or the Scheduled Tribes, at least one-third of the compensation amount due shall be paid to the affected

families at the outset as first instalment and the rest shall precede the taking over of the possession of the land. (5) The Scheduled Tribes affected families shall be resettled preferably in the same Scheduled Area in a compact block, so that they can retain their ethnic, linguistic and cultural identity. (6) The resettlement areas predominately inhabited by the Scheduled castes and the Scheduled Tribes shall get land, to such extent as may be decided by the appropriate Government, free of cost for community and social gatherings. (7) In case of a project involving land acquisition on behalf of a Requiring body, the affected families belonging to the Scheduled Castes and the Scheduled Tribes resettled out of the district of acquisition will get twenty-five percent. Higher monetary benefits under Rehabilitation and Resettlement Scheme. (8) Any alienation of tribal lands or lands belonging to members of the Scheduled Castes in disregard of the laws and regulations for the time being in force shall be treated as null and avoid; and in the case of acquisition of such lands, the rehabilitation and resettlement benefits shall be available to the original tribal land owners or land owners belonging to the Scheduled Castes. (9) The affected Scheduled Tribes, other traditional forest dwellers and the Scheduled castes families having fishing rights in a river or pond or dam in the affected area shall be given fishing rights in the reservoir area of the irrigation or hydel projects. (10) Where the affected Scheduled Castes and Scheduled Tribes are relocated outside of the district then they shall be paid an additional twenty-five percent. Rehabilitation and Resettlement benefits to which they are entitled in monetary terms along with a one-time entitlement of fifty thousand rupees.

11.16 ENTITLEMENT MATRIX

The broad entitlement matrix comprising the R & R compensation and assistance is presented in below table. The landowner (titleholder) will receive compensation for land and assets, as decided by the competent authority. The titleholders are also entitled to receive R & R assistance/ allowances and exempted from stamp duty. They should be given advanced notice to harvest non-perennial crops, or compensation for lost standing crops. They will have the right to salvage material from existing structures.

The RFCTLARR Act-2013, represents a significant milestone in the development of a systematic approach to address resettlement issues in India and closes significantly the gap between Indian national policies and operational policy of the World Bank/ADB. All the affected persons irrespective of ownership status are eligible for respective allowances. The Act gives directives for the acquisition of land in the public interest and even provides assistance to landless, agricultural labours, tenants, sharecropper, dependents and those who reside preceding three years prior to land acquisition for their loss of livelihood/income under R & R provision.

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
1.	Loss of Land	Land Owner	Compensation for land shall be considered at Market value of land. This will be determined by the District Collector as per Sections 26 to 29 of TRFC&TLARR (LARR) Act-2013). Amount equivalent to current stamp duty and registration charges on compensation amount for replacement of lost assets.	• Compensation at market value of the land • Multiplier factor up to 2 for rural area • Value of the assets attached to land • Building/Trees/Wells/Crop etc. as valued by relevant govt. authority; • Solatium: 100% of total compensation • Additional 12% per annum on market value of land from the date of publication of the notification of the SIA to till the date of the award or the date of taking possession of the land.	The method of calculation of market rate – the minimum land value, if any, specified in the Indian Stamp Act, 1899 for the registration of sale deeds in the area, where the land is situated; or – the average of the sale price for similar type of land situated in the immediate areas adjoining the land being acquired, ascertained from fifty per cent of the sale deeds registered during the preceding three years, where higher price has been paid; or – Consented amount of

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
					compensation as agreed upon under sub-section(2) of Section 2 in case of acquisition of lands for private companies or for public private partnership projects, whichever is higher – All the entitlements for loss of land will be provided for each survey number based on ownership records to the legitimate owner or their heirs as applicable.
			Land Value factor	Scale 1 to 2 based on the distance of project from urban area, as may be notified by appropriate government. Illustrative scale (0-10 km=1), (10-20=1.20), (20-30 km=1.40), (30-40 km=1.80), and (40-50 km=2).	– The proposed alignment passes through rural areas in Surat, Navsari, Valsad in Gujurat state; Nasik and Ahmednagar districts in Maharashtra state. Thus, as per First

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
					Schedule of LARRA 2013 the radial factor of 1.25 - 2 shall be applicable for calculating the market value of the land. The multiplication factor is prerogative of state government and it certainly depends on distance from the urban location.
		Affected Family/Person	Land for land	Not applicable	Not applicable
2.	Loss of other Immovable Assets	Titleholder	Value of Assets attached to land or building	To be considered: ➢ Standing crops, Trees, Livelihood loss.	➢ As per LARRA 2013 under First Schedule Sl. No.2 (ref. Section 29).
3.	Loss of Land, Structure and other immovable assets (1+2)	Titleholder	Solatium	100% on total compensation (including value of assets)	Under Section 30(1) of the LARRA Act 2013. The compensation is calculated for land and structures as applicable and the total compensation of all

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
					lost properties taken into account before considering the solatium. As per Section 30(1) of the Act Solatium of 100% on the compensation be considered.
4.	Loss of Land and other assets	Titleholder	Additional 12% on market value of land.	In addition to the market value of land, additional 12% per annum to be paid on such market value commencing on and from the date of publication of notification, till award or date of taking possession of land whichever is earlier.	➢ Provision made Under section 30 (3) of the LARR Act 2013.
5a.	Loss of Structure	Titleholder	Provision of Housing unit or value of the lost structure	➢ If a house is lost in urban areas, a constructed house shall be provided, which will be not less than 50 sq. mts. in plinth area. ➢ Provided also that no family affected by acquisition shall be given more than one house under the provisions of this Act.	➢ As per section 30 (3) of the LARR Act-2013.

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
				➢ Provided that any such family in urban areas which opts not to take the house offered, shall get a one-time financial assistance for house construction, which shall not be less than one lakh fifty thousand rupees. (Rs. 1,50,000.00) ➢ Provided further that if any affected family in rural areas so prefers, the equivalent cost of the house may be offered in lieu of the constructed house; ➢ Provided also that no family affected by acquisition shall be given more than one house under the provisions of this Act. Explanation: The houses in urban areas may, if necessary, be provided in multi-story building complexes.	

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
5b.	Loss of Structure	Non-titleholder	Provision of Housing unit or value of the lost structure	The benefits listed above shall also be extended to any affected family which is without homestead land and which has been residing in the area continuously for a period of not less than three years preceding the date of notification of the affected area and which has been involuntarily displaced from such area: ➢ Provided that any such family in urban areas which opts not to take the house offered, shall get a one-time financial assistance for house construction, which shall not be less than one lakh fifty thousand rupees. (Rs. 1,50,000.00) ➢ Provided further that if any affected family in rural areas so prefers, the equivalent cost of the house may be offered in lieu of the constructed	➢ Even Non-titleholder is eligible as mentioned in II Schedule of this LARR Act-2013 but it solely depends on the prerogative of the Executing Authority.

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
				house; ➢ Provided also that no family affected by acquisition shall be given more than one house under the provisions of this Act. Explanation: The houses in urban areas may, if necessary, be provided in multi-story building complexes.	
5c.	Loss of Livelihood	Affected Family/Person	Annuity or Employment **(a)** Job OR **(b)** 5 lakh one-time payment OR **(c)** Rs. 2000.00 per month for 20 years (with increment) (the option of availing a, b, or c shall be that of the	Where jobs are created through the project affected families will get after providing suitable training and skill development in the required field, make provision for employment at a rate not lower than the minimum wages provided for in any other law for the time being in force, to at least one member per affected family in the project or arrange for a job in such other project as may be required; or (b) onetime payment of five	➢ As per Second Schedule of LARRA Act.

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
			affected family)	lakhs rupees (Rs.5,00,000) per affected family; or (c) Annuity policies that shall pay not less than two thousand rupees per month per family for twenty years, with appropriate indexation to the Consumer Price Index for Agricultural Labourers. (Refer: http://labourbureau.nic.in).	
6b.	Loss of Livelihood	Affected Family/Person	Subsistence grant for displaced families for a period of one year (even if the families displaced due to land acquisition)	➢ Each affected family which is displaced from the land acquired shall be given a monthly subsistence allowance equivalent to three thousand rupees per month for a period of one year from the date of award. (Rs. 3000.00 per month for one year = 36,000.)	➢ As per Second Schedule of LARRA Act.
				➢ In addition to this amount, the Scheduled Castes and the	➢ Provision made in Second Schedule of LARR Act- 2013

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
				Scheduled Tribes displaced from Scheduled Areas shall receive an amount equivalent to fifty thousand rupees. (Rs. 50000.00).	
7.	Structure	Affected Family/Person	Transportation cost for displaced families.	One-time financial assistance of Rs. 50000.00 for shifting family, building material, belongings and cattle.	➢ Provision made in Second Schedule of LARR Act- 2013.
8.	Structure	Affected Family/Person	Commercial Establishments including Owners and Tenants	Each affected family having cattle or having a petty shop shall get one-time financial assistance of such amount as the appropriate government may, by notification, specify subject to a minimum of Rs. 25000.00 for construction of cattle shed or petty shop as the case may be.	➢ Provision made in Second Schedule of LARR Act- 2013.
9.	Livelihood	Affected Family/Person	One time grant to artisan, small traders and certain others	Each affected family of an artisan, small trader or self-employed person or an affected family which owned non-agricultural land or commercial, industrial or institutional structure in the affected area,	➢ Provision made in Second Schedule of LARR Act- 2013.

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
				and which has been involuntarily displaced from the affected area due to land acquisition, shall get one-time financial assistance of such amount as the appropriate Government may, by notification, specify subject to a minimum of Rs. 25000.00.	
10.	Land/Structure/ Livelihood	Affected Family/Person	One-time resettlement allowance.	Each affected family shall be given a one-time "Resettlement Allowance" of Rs. 50000.00.	• As per LARRA 2013 under Second Schedule of the Act.
11.	Land/Structure	Titleholder	Stamp duty and registration fee.	(1) The stamp duty and other fees payable for registration of the land or house allotted to the affected families shall be borne by the Requiring Body. (2) The land for house allotted to the affected families shall be free from all encumbrances. (3) The land or house allotted may be in the	➢ Provision made in Second Schedule of LARR Act- 2013

Table 11.10: Entitlement Matrix

Sl. No.	Category of Impact	Eligibility for Entitlement	TRFCTLARR Act- 2013 Provisions		Remarks
			Entitlement	Provisions	
1	2	3	4	5	6
				joint names of wife and husband of the affected family.	
12.	Land/Structure/ Livelihood	Affected Family /Person	Any other unforeseen impact	Any unforeseen impact would be addressed and mitigated as necessary by the Implementing Agency.	

12. PROJECT PROPOSALS

12.1 Proposed Greenfield Alignment

The proposed highway is a greenfield project with a total length of approx. Km 290.700. The project corridor, i.e., Surat – Nashik - Ahmednagar, is proposed as a six -lane road. The improvement proposals are arrived at keeping in view of the technical guidelines as well as governing factors as specified in TOR, and finalized after several consultations with the

Authority followed by ground-truthing of the same. A detailed illustration of the proposed alignment along with salient features and corridor improvement proposals are presented in subsequent sections. As part of development of proposed national highway, Consultant suggests improvement proposals with respect to the design of road, structures and pavement. Based on the realistic data arrived from traffic and topographic surveys, Consultant has carried out highway design as per the guidelines prescribed in IRC: SP:87-2019 (Manual of Specifications and Standards or six laning highways).

12.2 Typical Cross Sections (TCS):

Based on traffic considerations, geometric standards and existing site condition, the following parameters for cross sections have been proposed for different sections of the project road.

TCS 01: 6-lane construction without service road (Future 10 lanes)

Main Carriage way = 2x10.5 m.

Median= 5m (Edge strip=2x0.5 m).

Earthen Shoulder= 2x3 m+2x3 m

Utility Corridor=2x4m.

TCS 02: 6-lane construction without service road (future 10 lanes) (cutting)

Main Carriageway = 2x10.5 m.

Median= 5m (Edge strip=2x0.5 m).

Earthen Shoulder= 2x3 m+2x3 m

Utility Corridor/Drain=2x4m.

TCS 03: 10 lane cross section for tunnel without service road

Main Carriageway = 2x17.5 m

Spacing between Tunnel Tubes = 50.0 m

Walkway = 2x1.822 m

TCS 04: 4 lane Divided Highway with raised median in main ramp locations

Main Carriageway = 2x7.0 m.

Raised Median= 4m.

Paved Shoulder= 2x1.5m.

Earthen Shoulder= 2 x2 m

Shyness=2x0.5m

TCS 05: 2 lane cross sections for Ramps.

Main Carriageway = 7.5m.

Paved Shoulder= 2x1m.

Earthen Shoulder= 2 x1m.

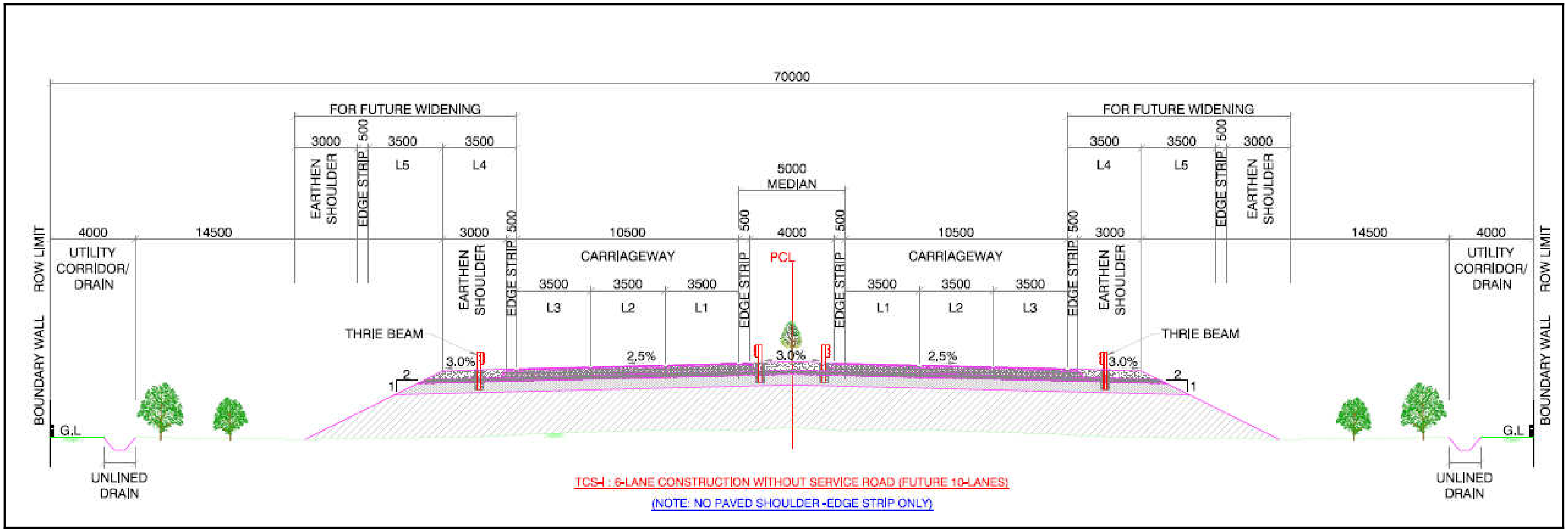


Fig:12.1 LANE CONSTRUCTION WITHOUT SERVICE ROAD (FUTURE 10 LANES)

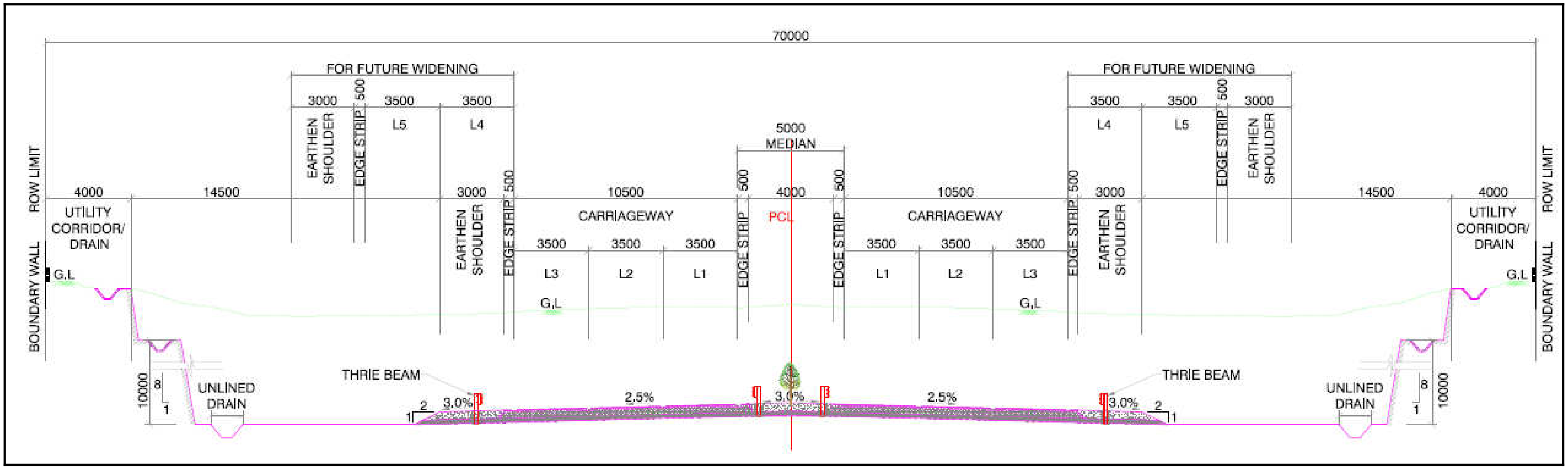


Fig:12.2 LANE CONSTRUCTION WITHOUT SERVICE ROAD (FUTURE 10 LANES) (CUTTING)

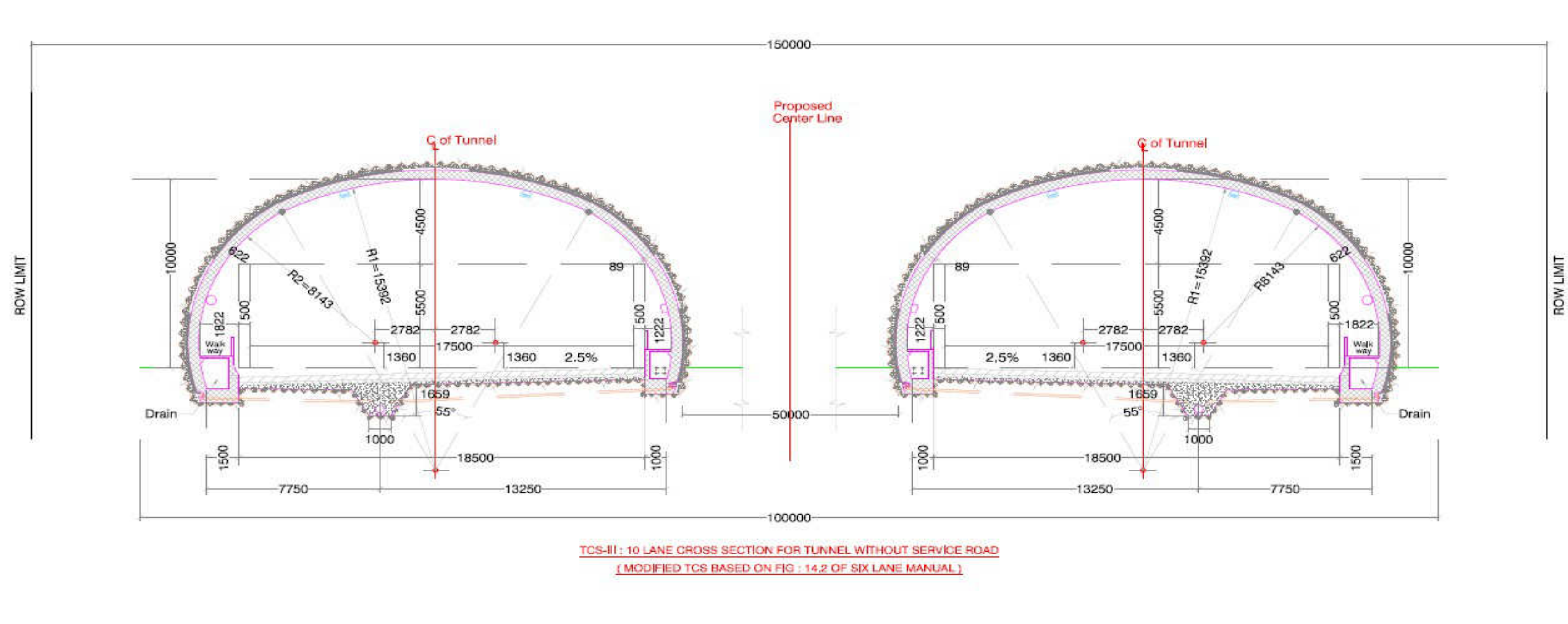


Fig:12.3 LANE CROSS SECTION FOR TUNNEL WITHOUT SERVICE ROAD (FUTURE 10 LANES)

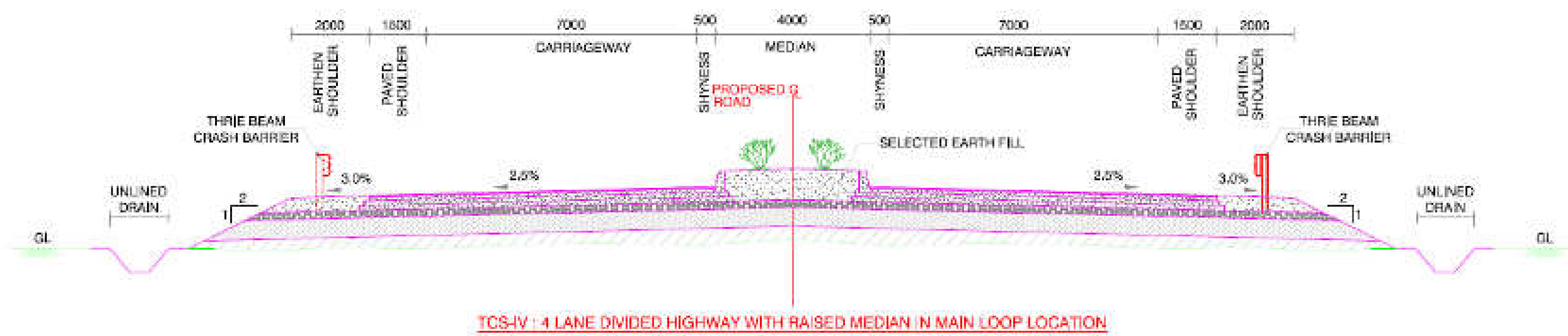


Fig:12.4 LANE DIVIDED HIGHWAY WITH RAISED MEDIAN IN MAIN RAMP LOCATIONS

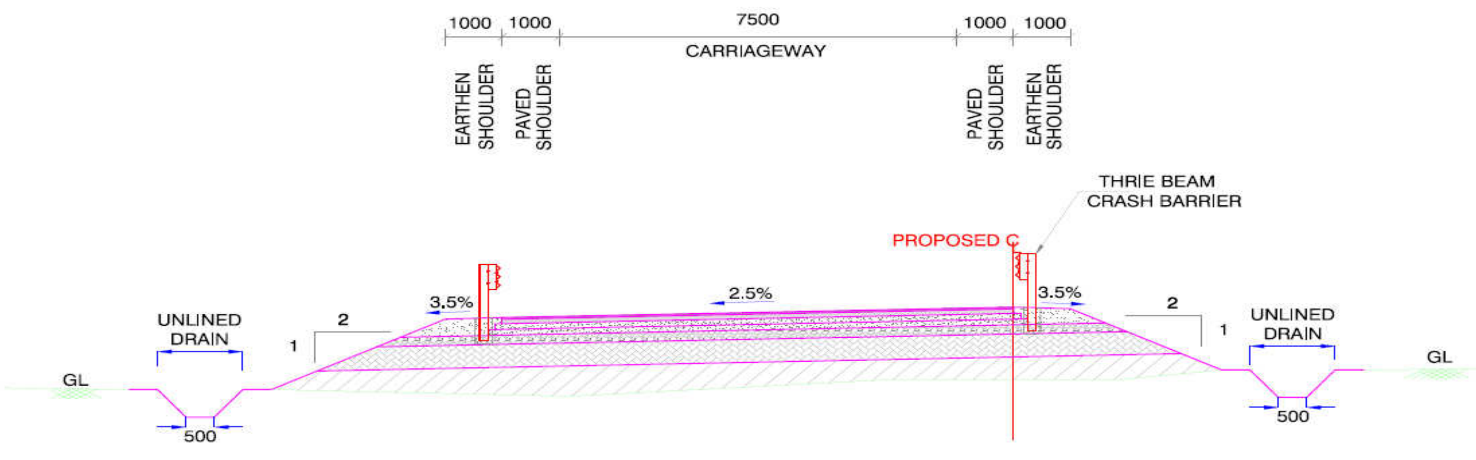


Fig:12.5. LANE CROSS SECTION FOR LOOPS

12.3 APPLICABLE CROSS SECTIONS

The project stretch under study has multi-dimensional facets in terms of geometry, pavement condition, existing utilities, religious structures, etc. and considering all these aspects the section-wise policy is adopted based on the initial investigations. The applicable typical cross-sections along the project corridor are summarized in *Tables-12.1*

Table-12.1: Applicable TCS of Main Line

S. No	Design Chainage (km)		Length (Km.)	TYPE OF TCS	Remarks
	From Ch (km.)	To Ch (km.)			
1	0.000	0.250	0.250	V	
2	0.250	37.690	37.440	I	
3	37.690	38.010	0.320	II	
4	38.010	38.400	0.390	I	
5	38.400	39.720	1.320	II	
6	39.720	39.840	0.120	I	
7	39.840	40.540	0.700	II	
8	40.540	40.700	0.160	I	
9	40.700	40.900	0.200		VIADUCT-1
10	40.900	41.180	0.280	II	
11	41.180	41.410	0.230	I	
12	41.410	41.570	0.160	II	
13	41.570	41.910	0.340	I	
14	41.910	42.290	0.380	II	
15	42.290	43.260	0.970	I	
16	43.260	43.430	0.170	II	
17	43.430	43.800	0.370	I	
18	43.800	43.920	0.120	II	
19	43.920	45.610	1.690	I	
20	45.610	46.660	1.050		VIADUCT-2
21	46.660	46.830	0.170	I	
22	46.830	46.980	0.150	II	
23	46.980	47.260	0.280	I	
24	47.260	47.510	0.250	II	
25	47.510	47.670	0.160	I	
26	47.670	47.820	0.150	II	
27	47.820	48.090	0.270	I	
28	48.090	48.140	0.050	II	
29	48.140	48.830	0.690	I	
30	48.830	50.340	1.510	II	

S. No	Design Chainage (km) From Ch (km.)	Design Chainage (km) To Ch (km.)	Length (Km.)	TYPE OF TCS	Remarks
31	50.340	50.410	0.070	I	
32	50.410	51.460	1.050		VIADUCT-3
33	51.460	51.500	0.040	I	
34	51.500	51.990	0.490	II	
35	51.990	52.280	0.290	I	
36	52.280	52.410	0.130	II	
37	52.410	52.830	0.420	I	
38	52.830	53.070	0.240	II	
39	53.070	55.190	2.120	I	
40	55.190	55.580	0.390	II	
41	55.580	55.880	0.300	I	
42	55.880	57.020	1.140	II	
43	57.020	58.760	1.740	I	
44	58.760	59.510	0.750	II	
45	59.510	62.320	2.810	I	
46	62.320	62.840	0.520	II	
47	62.840	63.480	0.640	I	
48	63.480	64.150	0.670	II	
49	64.150	65.020	0.870	I	
50	65.020	65.840	0.820	II	
51	65.840	67.080	1.240	III	TUNNEL-1
52	67.080	67.440	0.360	II	
53	67.440	68.200	0.760	I	
54	68.200	68.400	0.200		VIADUCT-4
55	68.400	69.090	0.690	II	
56	69.090	69.540	0.450	I	
57	69.540	70.060	0.520	II	
58	70.060	70.550	0.490	I	
59	70.550	70.800	0.250		VIADUCT-5
60	70.800	74.770	3.970	II	
61	74.770	74.840	0.070	I	
62	74.840	75.690	0.850		VIADUCT-6
63	75.690	75.780	0.090	I	
64	75.780	77.230	1.450		VIADUCT-7
65	77.230	77.280	0.050	I	
66	77.280	78.280	1.000	II	
67	78.280	79.630	1.350	III	TUNNEL-2

S. No	Design Chainage (km)		Length (Km.)	TYPE OF TCS	Remarks
	From Ch (km.)	To Ch (km.)			
68	79.630	79.900	0.270	II	
69	79.900	80.190	0.290	I	
70	80.190	80.390	0.200	II	
71	80.390	80.950	0.560	I	
72	80.950	81.790	0.840	II	
73	81.790	81.900	0.110	I	
74	81.900	82.850	0.950		VIADUCT-8
75	82.850	83.490	0.640	I	
76	83.490	84.310	0.820	II	
77	84.310	84.790	0.480	I	
78	84.790	87.790	3.000		VIADUCT-9
79	87.790	88.020	0.230	I	
80	88.020	89.420	1.400		VIADUCT-10
81	89.420	89.800	0.380	I	
82	89.800	92.630	2.830	II	
83	92.630	92.690	0.060	I	
84	92.690	93.290	0.600		VIADUCT-11
85	93.290	93.590	0.300	I	
86	93.590	94.890	1.300		VIADUCT-12
87	94.890	95.070	0.180	II	
88	95.070	95.100	0.030	I	
89	95.100	96.630	1.530	II	
90	96.630	96.730	0.100	I	
91	96.730	97.360	0.630	II	
92	97.360	97.860	0.500		VIADUCT-13
93	97.860	98.450	0.590	II	
94	98.450	107.820	9.370	I	
95	107.820	108.050	0.230	II	
96	108.050	110.340	2.290	I	
97	110.340	111.400	1.060	II	
98	111.400	116.050	4.650	I	
99	116.050	116.320	0.270	II	
100	116.320	234.690	118.370	I	
101	234.690	234.900	0.210	II	
102	234.900	243.460	8.560	I	
103	243.460	244.010	0.550	II	
104	244.010	264.490	20.480	I	

S. No	Design Chainage (km)		Length (Km.)	TYPE OF TCS	Remarks
	From Ch (km.)	To Ch (km.)			
105	264.490	267.640	3.150		VIADUCT-14
106	267.640	270.380	2.740	II	
107	270.380	274.470	4.090	I	
108	274.470	274.940	0.470	II	
109	274.940	280.040	5.100	I	
110	280.040	280.480	0.440	II	
111	280.480	280.840	0.360	I	
112	280.840	281.340	0.500	II	
113	281.340	285.470	4.130	I	
114	285.470	286.110	0.640	II	
115	286.110	286.870	0.760	I	
116	286.870	287.610	0.740	II	
117	287.610	290.700	3.090	I	

12.4 Proposed Structures

12.4.1 Tunnels and Viaducts

To provide uninterrupted and seamless travel to vehicle users in hilly terrain, tunnels and viaducts are proposed along the highway passing through the forest sections and few hilly terrain locations. The details are provided below.

Table-12.2(a): Proposed Viaduct locations

S. No	Design Chainage (Km)		Proposed Span Arrangement (m)	Proposed Type	Length (Km.)
	From Ch (km.)	To Ch (km.)			
1	40.700	40.900	4x50	Viaduct-1	0.200
2	45.610	46.660	21x50	Viaduct-2	1.050
3	50.410	51.460	21x50	Viaduct-3	1.050
4	68.200	68.400	4x50	Viaduct-4	0.200
5	70.550	70.880	5x50	Viaduct-5	0.250
6	74.840	75.690	17x50	Viaduct-6	0.850
7	75.780	77.230	29x50	Viaduct-7	1.450

S. No	Design Chainage (Km)		Proposed Span Arrangement (m)	Proposed Type	Length (Km.)
	From Ch (km.)	To Ch (km.)			
8	81.900	82.850	19x50	Viaduct-8	0.950
9	84.790	87.790	60x50	Viaduct-9	300
10	88.020	89.420	28x50	Viaduct-10	1.400
11	92.690	93.290	12x50	Viaduct-11	0.600
12	93.590	94.890	26x50	Viaduct-12	1.300
13	97.360	97.860	10x50	Viaduct-13	0.500
14	264.490	267.640	63x50	Viaduct-14	3.150
Total Length of Viaduct (Km.)					**15.950**

Table-12.2(b): Proposed Tunnel locations

S. No	Design Chainage (Km)		Proposed Span Arrangement (m)	Proposed Type	Length(km)
	From Ch (km.)	To Ch (km.)			
1	65.890	67.110	-	Tunnel-1	1.220
2	78.290	79.640	-	Tunnel-2	1.350
Total Length of Tunnel (Km.)					**2.570**

12.4.2 INTERCHANGES

The geometric design of intersections has been carried out taking in to account the site conditions, turning movement characteristics, level of services, overall economy and operational safety. Grade separated structures are proposed for intersections with National highways, State highways and Major District Roads with traffic exceeding the capacity of at-grade intersections as per Manual of Specifications and Standards. To make traffic flow free from conflicts and considering the future development, Trumpet/Double Trumpet interchange have been proposed. The location of the Interchanges is given in Table-12.3.

Table 12.3 Details of Interchanges

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Proposed Interchange	Remarks
1	0.549	2 x 30	Trumpet	V-M Expressway
2	20.145	2 x 35	Double Trumpet	NH-360
3	35.923	2 x 35	Double Trumpet	SH-701
4	107.051	2 x 35	Double Trumpet	MDR
5	138.794	2 x 35	Double Trumpet	NH-848
6	147.340	2 x 35	Double Trumpet	NH-60
7	185.108	2 x 35	Double Trumpet	SH-30
8	198.393	2 x 35	Double Trumpet	Marhal-Vavi Road
9	217.592	2 x 35	Double Trumpet	SH-44
10	251.275	2 x 35	Double Trumpet	NH-160
11	275.901	2 x 35	Double Trumpet	SH-60
12	288.703	2 x 35	Double Trumpet	NH-222

12.4.3 Proposed ROBs and RUBs

There are no RUBs in the project corridor. A total of three ROB's are proposed along the project Stretch.

Table 12.4 Details of ROB's

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
1	17.978	1 x 15.0 + 1 x 36.0 + 1 x 15.0	Near Rankuva Village
2	144.134	1 x 15.0 + 1 x 36.0 + 1 x 15.0	Near ODHA Railway Station
3	258.467	1 x 15.0 + 1 x 36.0 + 1 x 15.0	Near Khadambe Kurud village

12.4.4 Major Bridges

A total number of 14 major bridges are proposed in the entire stretch. Details of major bridges are mentioned below.

Table 12.5: Details of Major Bridges

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
1	7.676	1x15.0+10 x 30.00+ 1 x 15.0	Ambika River
2	21.620	4 x 30.00	Kaveri River
3	35.435	1 x 15.0+3 x 30.0+ 1 x 15.0	-
4	43.032	3 x 30.00	-
5	60.755	4 x 30	-
6	142+595	1 x 20 + 1 x 30.0 + 1 x 20.0	-
7	152.017	6 x 30.00	Godavari River
8	166.311	2 x 30	-
9	173.935	4 x 30.00	-
10	176.247	2 x 30.00	-
11	224.895	6 x 30.00	-
12	249.720	6 x 30.00	Mula River
13	256.450	4 x 30.00	-
14	273.875	6 x 30.00	Stream, weir on Left side

12.4.5 Minor Bridges

A total number of 130 minor bridges are proposed in the entire stretch. Details of Minor Bridges to be newly construction are given below:

Table 12.6: Details of Minor Bridges

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
1	4.731	1 x 30.00	Canal
2	5.161	1 x 20.00	Canal
3	6.303	1 x 10.00	Stream
4	8.836	1 x 25.00	Canal
5	10.706	1 x 20.00	Canal
6	12.224	1 x 25.00	Stream
7	13.333	1 x 10.00	Stream
8	14.745	1 x 30.00	Canal
9	15.055	1 x 10.00	Stream
10	16.290	1 x 20.00	Stream
11	17.430	1 x 10.00	Canal
12	20.249	1 x 15.00	Canal
13	22.534	1 x 15.00	Stream
14	24.536	1 x 25.00	Stream
15	26.213	1 x 25.00	Canal
16	26.720	1 x 10.00	Stream
17	28.220	1 x 10.00	Stream
18	29.920	1 x 20.00	Stream
19	31.780	1 x 15.00	Stream
20	32.722	1 x 20.00	Stream
21	33.713	2 x 20.00	Stream

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
22	34.130	1 x 20.00	Stream
23	36.543	1 x 10.00	Stream
24	36.831	1 x 30.00	Stream
25	38.182	1 x 10.00	Stream
26	38.737	1 x 15.00	Stream
27	39.063	1 x 10.00	Stream
28	39.816	1 x 30.00	Stream
29	40.030	1 x 10.00	
30	41.845	1 x 20.00	Stream
31	44.490	1 x 30.00	Stream
32	47.247	1 x 15.00	Stream
33	47.589	1 x 20.00	Stream
34	48.533	1 x 10.00	Stream
35	52.193	1 x 15.00	
36	52.593	1 x 15.00	
37	53.210	1 x 10.00	
38	53.605	1 x 30.00	
39	54.027	1 x 30.00	
40	54.467	1 x 20.00	
41	54.894	1 x 30.00	
42	55.748	1 x 20.00	
43	56.138	1 x 20.00	

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
44	57.186	1 x 20.00	
45	58.042	1 x 8.0	
46	58.414	2 x 25.00	
47	58.851	1 x 10.00	
48	61.403	1 x 10.00	
49	63.153	1 x 10.00	
50	64.321	2 x 25.00	
51	64.900	1 x 10.00	
52	67.371	1 x 15.00	
53	68.726	1 x 15.00	
54	69.227	1 x 15.00	
55	72.733	1 x 10.00	
56	80.134	2 x 25.00	
57	80.771	1 x 20.00	
58	83.370	1 x 30.00	
59	84.530	1 x 20.00	
60	90.169	1 x 10.00	
61	92.274	1 x 10.00	
62	101+423	1 x 10.00	
63	103+002	1 x 30.00	
64	106+053	1 x 25.00	
65	107+354	1 x 15.00	

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
66	108+510	1 x 20.00	
67	113+772	2 x 20.00	
68	114+483	1 x 12.00	
69	119+582	2 x 5.00	
70	121+017	1 x 30.0	
71	126+725	1 x 25.00	
72	129+255	1 x 30.0	
73	132+765	1 x 8.0	
74	136.314	1 x 10.00	
75	138+318	1 x 10.00	Canal
76	142+248	1 x 15.00	
77	152.795	1 x 8.00	
78	154.630	1 x 20.00	Canal
79	156.533	1 x 20.00	
80	157.064	1 x 25.00	
81	163.062	1 x 20.00	Stream, Weir on Right Side
82	164.330	1 x 15.00	
83	164.850	1x20.0	PPPL Bridge
84	165.236	1 x 10.00	Stream
85	168.153	2 x 20.00	Stream
86	171.000	1 x 15.00	Stream
87	181.883	2 x 25.00	

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
88	182.971	1 x 20.00	
89	183.878	1 x 30.00	Check Dam on Left Side
90	188.189	1 x 15.00	
91	193.194	2 x 5.00	Stream
92	194.792	1 x 20.00	
93	196.562	1 x 20.00	Canal
94	198.195	1 x 10.00	
95	199.435	1 x 10.00	Canal realignment to be done
96	201.468	1 x 25.00	
97	203.299	1 x 10.00	Canal
98	206.882	1 x 30.00	
99	209.831	1 x 30.00	Existing bridge at same location
100	212.616	1 x 25.00	Canal
101	220.156	1 x 30.00	Canal+mud road
102	220.453	1 x 15.00	Stream realignment to be done
103	222.077	1 x 10.00	Existing bridge at same location
104	227.906	1 x 30.00	Canal Cum Roads
105	229.031	1 x 10.00	Stream
106	233.912	1 x 20.00	Stream
107	237.144	1 x 20.00	Stream
108	238.441	1 x 10.00	Stream
109	240.072	1 x 20.00	Stream

S. No	Design Chainage (Km)	Proposed Span Arrangement (m)	Remarks
110	241.390	1 x 15.00	Stream
111	241.839	1 x 15.00	Stream
112	244.804	1 x 30.00	Canal+mud road on Both sides
113	248.229	1 x 20.00	Canal
114	253.385	1 x 10.00	Stream
115	253.858	1 x 20.00	Canal
116	254.172	1 x 30.00	Stream
117	255.831	2 x 25.00	Stream cum Mud Road
118	261.627	1 x 15.00	Stream
119	264.285	1 x 12.00	
120	268.596	1 x 15.00	Stream
121	269.006	1 x 15.00	Stream
122	271.579	1 x 10.00	Stream
123	273.155	1 x 10.00	
124	277.419	1 x 10.00	Stream
125	278.814	1 x 10.00	Stream
126	279.071	1 x 20.00	Stream
127	282.004	1 x 20.00	Stream
128	283.620	1 x 15.00	Stream
129	285.081	1 x 10.00	Stream
	287.748	1 x 15.00	

12.4.6 Culverts

Based on the information collected from reconnaissance survey and preliminary calculations, hydraulic performance of existing structures has been analyzed, and the following recommendations have been made.

Table 12.7 Culverts

S.No.	Description	No. of Culverts	Recommendation
1	Box Culvert	429	New

12.4.7 Proposed Underpasses and Overpasses

Underpasses are provided at locations where roads such as National Highways, State Highways & Major District Roads etc. are intersected with project corridor and also locations where movement of local traffic is observed. Total 128 number of underpasses including 42 VUP, 53 LVUP and 20 SVUP and 13 VOPs were proposed and same mentioned in below table.

Table 12.8: List of Underpasses with dimensions

S. No	Design Chainage (Km)	Proposed Type	Proposed Span Arrangement (m)	Remarks
1	2.295	VUP	1 x 20.0	SH-180
2	4.836	LVUP	1 x 12.00	
3	8.146	SVUP	1 x 7.00	
4	10.604	VUP	1 x 20.00	SH-177
5	11.016	VUP	1 x 20.00	SH-703
6	14.376	SVUP	1 x 7.00	
7	19.096	VUP	1 x 20.00	SH-178
8	20.403	VUP (Loop-1)	1 x 30.0	
9	23.036	SVUP	1 x 7.00	
10	27.295	VUP	1 x 20.00	
11	32.145	VUP	1 x 20.00	
12	36.120	VUP (Loop-1)	1 x 30.0	
13	37.134	VUP	2 x 30.00	SH-5

S. No	Design Chainage (Km)	Proposed Type	Proposed Span Arrangement (m)	Remarks
14	41.814	SVUP	1 x 7.00	
15	45.374	VUP	1 x 20.00	
16	47.444	VOP	2 x 30.00	
17	49.194	VOP	2 x 30.00	
18	49.774	VOP	2 x 30.00	
19	53.541	LVUP	1 x 12.00	
20	57.252	LVUP	1 x 12.00	
21	58.082	LVUP	1 x 12.00	
22	58.592	LVUP	1 x 12.00	
23	59.232	VOP	2 x 30.00	
24	61.242	LVUP	1 x 12.00	
25	62.599	VOP	2 x 30.00	
26	64.869	SVUP	1 x 7.00	
27	71.027	LVUP	1 x 12.00	
28	71.947	LVUP	1 x 12.00	
29	81.679	VOP	2 x 30.00	
30	83.726	VOP	2 x 30.00	
31	91.136	VOP	2 x 30.00	
32	93.306	LVUP	1 x 12.00	
33	95.786	VOP	2 x 30.00	
34	98.079	VOP	2 x 30.00	
35	98.691	SVUP	1 x 7.00	
36	100.590	VOP	2 x 30.00	
37	104.262	LVUP	1 x 12.00	
38	106.294	VUP (Loop-1)	1 x 30.0	
39	110.147	LVUP	1 x 12.00	
40	111.996	SVUP	1 x 7.0	
41	115.416	LVUP	1 x 12.00	
42	117.986	VUP	1 x 20.00	
43	120.386	LVUP	1 x 12.00	
44	125.374	SVUP	1 x 7.0	
45	126.274	SVUP	1 x 7.00	

S. No	Design Chainage (Km)	Proposed Type	Proposed Span Arrangement (m)	Remarks
46	127.224	LVUP	1 x 12.00	
47	128.164	VUP	1 x 20.00	SH-17
48	129.467	SVUP	1 x 7.00	
49	132.240	LVUP	1 x 12.00	
50	139.284	VUP (Loop-1)	1 x 30.0	
51	141.067	VUP	1 x 20.00	
52	143.318	SVUP	1 x 7.0	
53	144.838	LVUP	1 x 12.00	
54	146.078	SVUP	1 x 7.0	
55	146.826	VUP (Loop-1)	1 x 30.0	
56	148.899	SVUP	1 x 7.00	
57	150.139	LVUP	1 x 12.00	
58	152.210	VOP	2 x 30.00	
59	154.200	SVUP	1 x 7.00	
60	156.798	VUP	1 x 20.00	
61	159.930	LVUP	1 x 12.00	
62	160.848	SVUP	1 x 7.0	
63	162.008	LVUP	1 x 12.00	
64	163.449	VUP	1 x 20.00	
65	166.709	VUP	1 x 20.00	
66	169.210	VUP	1 x 20.00	
67	171.880	VUP	1 x 20.00	
68	173.070	LVUP	1 x 12.00	
69	175.050	LVUP	1 x 12.00	
70	177.230	VUP	1 x 30.00	SH 39
71	179.650	VUP	1 x 20.00	
72	180.840	LVUP	1 x 12.00	
73	182.031	LVUP	1 x 12.00	Stream Cum Road
74	183.043	LVUP	1 x 12.00	
75	184.244	VUP (Loop-1)	1 x 30.0	
76	186.581	LVUP	1 x 12.00	

S. No	Design Chainage (Km)	Proposed Type	Proposed Span Arrangement (m)	Remarks
77	187.891	LVUP	1 x 12.00	
78	188.631	LVUP	1 x 12.00	
79	189.521	VUP	1 x 20.00	
80	191.441	SVUP	1 x 7.00	
81	193.051	LVUP	1 x 12.00	
82	194.056	VUP	1 x 20.00	
83	196.111	LVUP	1 x 12.00	
84	198.964	VUP (Loop-1)	1 x 30.0	
85	199.407	LVUP	1 x 12.00	
86	201.167	LVUP	1 x 12.00	
87	202.457	LVUP	1 x 12.00	
88	204.327	VUP	1 x 20.00	
89	206.517	LVUP	1 x 12.00	
90	207.337	LVUP	1 x 12.00	
91	208.887	VUP	1 x 20.00	SH45
92	210.937	VUP	1 x 20.00	
93	212.207	SVUP	1 x 7.00	
94	213.667	SVUP	1 x 7.00	
95	218.073	VUP (Loop-1)	1 x 30.0	
96	219.636	LVUP	1 x 12.00	
97	220.712	LVUP	1 x 12.00	
98	223.913	VUP	1 x 20.00	
99	225.063	LVUP	1 x 12.00	Stream Cum Road realignment to be done
100	226.767	LVUP	1 x 12.00	
101	229.086	LVUP	1 x 12.00	
102	230.736	VUP	1 x 20.00	
103	233.076	LVUP	1 x 12.00 + 1 x 5.0	
104	234.578	LVUP	1 x 12.00	
105	237.250	LVUP	1 x 12.00	
106	239.880	VUP	1 x 20.00	

S. No	Design Chainage (Km)	Proposed Type	Proposed Span Arrangement (m)	Remarks
107	240.960	SVUP	1 x 7.00	
108	242.060	LVUP	1 x 12.00	
109	245.010	VUP	1 x 20.00	
110	248.070	VUP	1 x 20.00	SH-49
111	249.274	LVUP	1 x 12.00	
112	251.497	VUP (Loop-1)	1 x 30.0	
113	252.590	LVUP	1 x 12.00	
114	253.290	SVUP	1 x 7.00	
115	254.080	LVUP	1 x 12.00	
116	258.721	LVUP	1 x 12.00	
117	261.341	VUP	1 x 20.00	SH-49
118	264.111	LVUP	1 x 12.00+ 1 x 5.0	
119	267.841	VOP	2 x 30.00	
120	272.559	VUP	1 x 20.00	
121	274.108	LVUP	1 x 12.00	
122	275.399	VUP (Loop-1)	1 x 30.0	
123	277.032	LVUP	1 x 12.00	
124	278.033	LVUP	1 x 12.00	
125	279.385	LVUP	1 x 12.00	
126	281.635	LVUP	1 x 12.00	
127	282.625	VUP	1 x 20.00	
128	289.166	VUP (Loop-1)	1 x 30.0	

12.4.8 TOLL PLAZAS

As the proposed Highway is access control, toll plazas are proposed at Interchanges in the project highway and these toll plazas will acts as closed toll system.

12.4.9 Rest Areas

Rest areas have been provided at following locations.

Table 12.9: Location of Rest Areas

S.No	Design Chainage (Km)	Side	Remarks
1	30+400	RHS	Near Saravani Village
2	108+100	LHS	Near Ambegaon Village
3	219+350	RHS	Near Chandrapur Village
4	283+100	LHS	Near Kapurwadi Village

12.4.10 Truck Lay bays

Truck Lay bays have been provided at following locations.

S.No	Design Chainage (Km)	Side	Remarks
1	158+400	Both Sides	-
2	257+400	Both Sides	-

13. COST ESTIMATES

13.1 Cost Estimates

Based on the improvement options considered, the quantities are estimated for:

- Construction of new carriageway
- Roadside furniture including safety devices

The pavement quantities are worked out for the adopted flexible pavement design made based on the traffic data and other design criteria. The analysis of rates has been carried out as per the Standard Data Book-2019 of MORT&H.

13.2 Unit Rates

The Unit rates of all items of construction work have been analyzed as per the guidelines given in Standard Data Book of MORT&H. The rates of materials are obtained from the Common schedule rates of Maharashtra SOR (2020-21). Market rates are adopted for items for which the rates are not available in SOR. The location of material quarries like gravel, sand, crushed aggregate is obtained from the material investigations. The leads of different materials are obtained by drawing the lead chart. In respect of hourly hire and operating cost of various road construction machinery and equipment, rates given in the SOR are considered. For machinery and equipment not covered by these two, the prevailing market rates are considered. The labour rates are taken from SOR. Unit rates so arrived have been compared with reference to the rates of similar items in the ongoing projects under NHAI and are found comparable.

13.3 Construction Quantities

The quantities of earthwork in cut and fill are calculated based on the highway design. Provision is made for hard rock excavation. The pavement quantities like Sub grade, GSB, WMM, DBM and BC are computed using the Pavement design and the typical cross section adopted. Adequate provision is made for roadside furniture including safety devices and miscellaneous items.

The summary of cost is as given below.

Table 13.1 Abstract of Cost

Total Project Cost	
Item Description	**Total cost in Rs.**
BILL NO: 1 - SITE CLEARANCE AND DISMANTLING	332,953,589
BILL NO: 2 - EARTHWORKS	26,144,421,460
BILL NO: 3 - BASE COURSES	12,580,166,154
BILL NO: 4 - PAVING COURSES	8,554,152,652
BILL NO: 5a - REPAIR AND REHABILATION OF STRUCTURES	-
BILL NO: 5b - BRIDGES	10,458,933,497
BILL NO: 5c - CULVERTS	4,937,480,391
BILL NO: 5d – UNDERPASSES	3,802,279,192
BILL NO: 5e –ROB	398,870,477
BILL NO: 5f – DRAINAGE, PROTECTIVE WORKS AND OTHER SERVICES	10,895,987,968
BILL NO: 5g –TOE WALLS	4,862,303,258
BILL NO: 5h – INTERCHANGES AND OVERPASSES	13,619,250,241
BILL NO: 5i – TUNNEL	8,288,000,000
BILL NO: 5j – VIADUCTS	20,114,490,522
BILL NO: 6 – JUNCTIONS	-
BILL NO: 7 – TOLL PLAZA-EXCLUDING PAVEMENT	776,033,664
BILL NO: 8 – USER AMINITIES	15,400,733
BILL NO: 9 - TRAFFIC SIGNS, MARKINGS AND APPURTE-NANCES	1,878,737,751
BILL NO: 10 - MISCELLANEOUS	2,267,663,808
Total Construction Cost including GST	**129,927,125,357**
Total Construction Cost including GST in Cr.	**12,992.71**

14.1 Economic Analysis

14.1.1 Methodology

The economic evaluation has been carried out within the broad framework of social cost benefit. The objective is to determine the appropriate improvement Scheme out of several proposals that leads to minimizing total transport costs and maximizing benefits to the road users. The indicators for economic viability analysis are Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and NPV/Cost Ratio.

The costs considered comprise of road agency costs and costs to road users as follows:

Road Agency Costs	Road User Costs
• Construction Cost • Maintenance Cost	• Vehicle Operating Cost • Travel Time Cost • Congestion Cost • Accident Cost

The benefits accruing to society from the proposed improvement are as follows

Road User Benefits	Social Benefits
• Vehicle Operating Cost Savings • Value of Travel Time Savings • Value of Savings in Accident Costs • Savings in Maintenance Costs	• Improvements in administration, Law and order • Improvements in health and education • Improvements in agriculture, Industry, trade and mining • Improvements in environmental standards • Appreciation in value of Land adjacent to roads

At the present state of knowledge in the country, it is possible to monetarily quantify only the direct road user benefits. This report, therefore, restricts itself to only the direct road user benefits.

Road users experience different costs in the "With Project" and "Without Project" scenarios. The benefits to road users are constituted by the savings in costs. Increasing traffic volumes as a result of the project implies more vehicle kilometres and hence more vehicle operating costs and, possibly showing more saving in with project conditions viz. benefits as a result of the project.

Based on traffic, Road network and Socio-economic characteristics of the project road, two different improvement options(with project) have been considered. The Economic analysis is carried out for the following improvement options

- "Without project/ Do minimum" - Routine maintenance of the existing road
- "With Project"- 6 lane road with paved shoulder as per the warrants of traffic volumes.

The total transport costs for both the options have been worked out on yearly basis for the entire analysis period of 20/30 Years. All costs and benefits considered in the study have been valued in monetary terms and expressed in economic prices for avoiding distortion in the input prices of labour, materials, equipment and foreign exchange due to market imperfections. The ratio of Economic and Financial costs is taken as 0.85.

Economic analysis is carried out with help of HDM-4 (version 1.3) developed by the World Bank. The HDM-4 Road User Effects (RUE) sub-model uses mechanistic principles for modeling of fuel and tyre consumption. The mechanistic forces comprise of the aerodynamic, gradient, rolling and inverted resistance. It calculates vehicle speeds and operating costs taking into account road roughness, geometry, together with the characteristics of representative vehicles and the traffic flow.

The new HDM-4 also makes use of the CRRI deterioration models for Indian asphalt mixes such as semi dense carpet and premix carpet and gives accurate predictions of roughness for various road maintenance related components.

This model provides for calibration of crucial input parameters to suit the local conditions and analysis of a number of alternatives and sections at relatively greater speed than is possible with HDM III. The Road user cost streams generated by HDM-4 are extracted and Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and sensitivity analysis have been carried out.

14.1.2 Measures of project Analysis

In order to quantify the economic viability of a project or projects three measures can be used. All of these use a discounting approach. These are:

* Net Present Value (NPV)

* Benefit Cost Ratio (BCR)

* Internal Rate of Return (IRR)

(1) Net Present Value (NPV)

$$\sum_{i=1}^{n} \frac{B_i}{(1+r)^i} - \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$$

NPV = Discounted Benefit – Discounted Cost

Where B_I = Benefit in the i^{th} year

C_I = Cost of the i^{th} year

(2) Benefit Cost Ratio (BCR)

$$\sum_{i=1}^{n} \frac{B_i}{(1+r)^i} \div \sum_{i=1}^{n} \frac{C_i}{(1+r)^i} \quad BCR=\frac{\text{PresentValueofbenefts}}{\text{Presentvalueofcosts}}$$

(3) Internal Rate of Return (IRR)

$$\text{or,} \sum_{i=1}^{n} \frac{B_i - C_i}{(1+r)^i} = 0$$

The IRR is that discount rate r which makes NPV = 0

IRR represents average earning power of the money used in the project over the project life.

14.1.3 Decision Criteria

The formal decision criterion is to accept all projects with a BCR of one or greater than one, NPV greater than Zero or IRR greater than opportunity cost of capital, since primary tangible returns are greater than primary tangible costs. If funds are limited, the magnitude of IRR or BCR can be used in ranking the order of priority of undertaking projects whose ratios are more than one. This assumes, of course, that the indirect tangible and intangible benefits and costs are of minor importance or are approximately the same for the various projects under consideration. Sometimes, however, the indirect tangible and intangible benefits may dictate over direct tangible benefits and so the projects with even less than one BCR may be selected for the overall intangible benefits of the society. In practice, there is really no single yardstick to measure the economic and financial viability of the project.

14.1.4 Price Elasticity of Demand and Traffic Forecasting

An important benefit of a capacity expansion project is the reduction in travel times for highway users. Travel time is a major component in overall price or cost to the user, which includes time as well as out-of-pocket costs. As with most goods and services, a lower price can be expected to lead to more quantity demanded – in this case, some additional travel.

Price elasticity of demand is an economic concept used to summarise how much more or less of something people will consume if its price changes. From the standpoint of estimating future traffic levels, elasticity represents how a change in the cost of driving, due to a reduction in travel time or implementation of a toll, may affect the volume of travel that will take place. These changes in volume result from some drivers' decisions to make more or fewer trips than they otherwise would have made.

Elasticity is stated in percentage change terms, e.g., an "*X*" percent reduction in travel time leads to a "*Y*" percent increase in travel Km or trips. An elasticity of zero implies that travel is unresponsive to a time change, no matter how large, while an infinite elasticity implies that even a one-second decrease in travel time will cause all capacity to be completely absorbed.

While price elasticity is a generally accepted tool in economics, there are differing opinions about how to apply it in a transportation context. The transportation economics literature reveals a wide range of measured elasticity values, reflecting different study methods, data, time periods, and locations. No studies, however, suggest that travel demand elasticity is either zero or infinite. When measured on a given facility, observed elasticity includes the effects of both diverted trips, which represent existing traffic that has simply shifted from other routes or time periods, and new travel taken as a consequence of the lower user cost. Additional research is needed to narrow the range of elasticity values that are applicable to a given set of circumstances – whether facility, corridor, or region – and to develop methods for better incorporating demand elasticity into traffic forecasting.

14.1.5 Road User Costs (RUC) Components

RUC consists of following three components:

- Vehicle operating costs (VOC), that is, the physical costs of operating a vehicle such as fuel, spare parts, depreciation, crew costs, etc;
- Travel time costs (TTC), that is, the value of time spent in travelling that could be used in other activities;
- Accident costs (ACC), that is, the physical costs of an accident and the value of injuries and fatalities.

The financial price is the retail market price to the consumer of the product. The economic price reflects the true value (that is, the real worth) as well as the scarcity premium of the resource to the economy. In the economic jargon, this is termed as a "shadow" or "accounting" price of the resource in the economy. The shadow price of unskilled labour, for instance, may well be lower than the wage to reflect its abundant supply, while that of a skilled professional may be higher than the salary given to him, if his opportunity cost is considered.

The economic price of a factor or a product also excludes all tax elements as they reflect mostly a transfer of resources from one sector of the economy to another. On the other hand, subsidy elements, if any, are included with the economic price.

Further more, market distortion or imperfection and government regulations or interventions are also taken into consideration while shadow-pricing a factor or a product. In case of imported inputs, economic costs were based on the border prices plus port handling, transportation, assembling and retail cost (profit margin) duly shadow priced. Local inputs of labour and materials were shadow priced using the Standard Conversion Factor of 0.85.

14.1.6 Inputs to the HDM-4 Model

14.1.6.1 Project Road Inputs

Project corridor length details mentioned in below table

Table-14.1.1: Project Length Details

NH	Design Chainage (Km)		Total Proposed length (Km)-
	From	To	
-	0.000	290.700	290.700

14.1.6.2 General Inputs

Analysis period - 20 & 30 years

Discount rate - 12 %

Construction Period - 3.0 Years

Construction Beginning Year -2023

Opening year to Traffic- 2026

Standard Conversion factor - 0.85

Salvage value - 15 %

14.1.6.3 Pavement Characteristics

Road and pavement characteristics obtained from the Road Inventory Survey have been used as Model input. These include road length, carriageway width, width of paved shoulders, roughness of the existing road (IRI), structural number and cracking area.

The details of model inputs for road and pavement characteristics are presented below.

Table-14.1.2: Details of existing Pavement Conditions

Type of distress		Percentage of Severity (%)
Raveling(%)		3.75
Pot holes (%)		2.75
Edge Fretting(m)		30 per every 100m
Rut Depth(mm)		0.75 mm per every 100m
Block cracking (%)	Wide > 3 mm	-
	Narrow < 3 mm	-
Alligator cracking (%)	Wide > 3 mm	0.07
	Narrow < 3 mm	0.14
Transverse cracking (%)	Wide > 3 mm	-
	Narrow < 3 mm	-
Longitudinal cracking(%)	Wide > 3 mm	0.00
	Narrow < 3 mm	0.00

S. No.	Item	Surat-Nashik- Ahmednagar
01	Visual Riding Quality	Not Fair
02	Surface Type	Bitumen
03	Cracking	4.75
04	Average Pot holes	2.75
05	Average Ravelled Area	3.75
06	Average Rut depth	0
07	Average Roughness	2
08	Shoulder Condition	Poor

S. No.	Item	Surat-Nashik- Ahmednagar
09	Road Length	396 Km
10	Carriageway Width	14 m
11	Shoulder Width	1 to 1.5 m

14.1.6.4 Traffic Composition and Growth Rates

The Automatic Classified Traffic Volume Count Surveys were conducted at various locations and the projected traffic on the proposed greenfield corridor has been assessed. The estimated ADT has been converted in to AADT, by applying the seasonal factor as applicable to the area. The summary of AADT is below and the details are presented in Traffic Report.

The traffic growth rates have been worked out on the basis of present GDP and NSDP for the state of Maharashtra & Gujarat State. The growth rates for the 30 horizon years are tabulated below for the motorized traffic and for the non-motorized traffic a growth rate of 1% has been considered. Based on the NHAI guidelines, the growth rates adopted to 5% along the project corridor for all modes of traffic.

Table-14.1.3: Homogeneous section wise traffic in terms of vehicles

Type of Vehicle	HS-1	HS-2
Car	8201	6849
Bus	469	315
LCV	1568	1263
2A	1922	2532
3A	2128	1437
MAV	3250	1966
TOTAL	17538	14362

Table-14.1.3(a): Estimated Traffic Growth rates of Gujarat State(%)

Year	2w	3w	Car	Car(Y)	Goods	Bus	Tractor	Tractor with Trailor	Mini Bus
2018	13%	5%	13%	13%	9%	6%	5%	5%	10%
2022	13%	5%	13%	13%	9%	6%	5%	5%	10%
2027	13%	5%	14%	13%	9%	7%	5%	5%	11%
2032	13%	5%	13%	13%	9%	6%	5%	5%	10%
2037	12%	5%	13%	12%	8%	6%	5%	5%	10%
2042	12%	5%	12%	12%	8%	5%	5%	5%	9%

2047	11%	5%	12%	11%	7%	5%	5%	5%	9%
2052	11%	5%	11%	11%	7%	4%	5%	5%	8%

Table–14.1.3 (b): Estimated Traffic Growth rates of Maharashtra State(%)

Year	2w	3w	Car	Car(Y)	Goods	Bus	Tractor	Tractor with Trailor	Mini Bus
2018	10%	5%	15%	9%	8%	12%	9%	5%	3%
2022	10%	5%	15%	9%	8%	12%	9%	5%	3%
2027	11%	5%	15%	9%	9%	12%	10%	6%	3%
2032	10%	5%	15%	9%	8%	12%	9%	5%	3%
2037	10%	4%	14%	8%	8%	11%	9%	5%	2%
2042	9%	4%	14%	8%	7%	11%	8%	4%	2%
2047	9%	3%	13%	7%	7%	10%	8%	4%	1%
2052	8%	3%	13%	7%	6%	10%	7%	3%	1%

Table-14.1.4: Adopted Traffic Growth Rates

Year	2w	3w	Car (W)	Bus	Goods	Tractor
2018- 2023	5%	5%	5%	5%	5%	3.0%
2023-2028	4.5%	4.5%	4.5%	4.5%	4.5%	3.0%
2028-2033	4.0%	4.0%	4.0%	4.0%	4.0%	3.0%
2034-2039	3.5%	3.5%	3.5%	3.5%	3.5%	3.0%
2040-2045	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
2046-2045	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Beyond 2045	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%

14.1.6.5 Road Side Friction

Roadside friction has to be computed for each project road package considering the following:

- The road width
- Total traffic Volume and its Composition (Slow, Two & Three wheelers Traffic)
- Settlement pattern along the road side
- Percentage of Built-up Area
- Number and location of Dabhas and Fuel Stations

The number of settlements along the roadside and especially the extensive ribbon development that takes place is a major factor influencing road performance. The maximum friction factor for the existing condition is taken as 0.7 and the minimum 0.6 amongst different sub projects.

Roadside friction factors have been incorporated into VOC as well as vehicle speeds for the given volumes and composition of traffic. Survey speed observations by the traffic planner have validated the speed assumption for the HDM-4 inputs. It is considered that the creation of free flow conditions will be a more important yardstick with which to measure the success of any project improvement rather than increase in vehicle speeds.

14.1.6.6 Base vehicle characteristics and Utilization data

The data as given in the table below have been obtained from manufacturer's literature and RUCS report and details are furnished in **Appendix-14.1.1.**

14.1.7 Capital cost of the Project

The capital costs (financial) of the project road have been converted into economic cost by using a standard conversion factor of 0.85, as suggested by the World Bank for highway projects in India. The conversion factor of 0.85 has been applied to all cost items except land acquisition cost and R&R cost. The economic cost excludes the cost of toll plazas and the proportionate design & supervision cost for the same. A salvage value of 15% of capital cost has been considered in the terminal year for flexible pavements. The project costs in financial and economic terms for different schemes are presented below:

Table-14.1.5: Civil Construction Cost of the Project Road

Package	Financial Cost	Economic Cost
Surat-Nashik-Ahmednagar	12992.72	11043.812

14.1.8 Routine and Periodic Maintenance

Routine maintenance, Periodic maintenance costs have been considered as per the MORT&H guidelines 1997 prices. Routine maintenance, Periodic maintenance costs of 1997 prices have been escalated to 2022 prices with an inflation rate of 5%. The details of the maintenance costs and administration charges are given below:

Table-14.1.6: Routine and Periodic Maintenance

S.No	Description	Amount (Rs. Lakhs/Km)
1	Routine maintenance in every year cost per km for the Six lane	7.76
2	Periodic maintenance in every 7th year cost per km for the Six lane	77.6

14.1.9 Project Benefits

The direct benefits of road improvement considered in the study include vehicle operating cost (VOC) savings for vehicular traffic using the project road and time savings for passengers and goods (carried) in transit. The benefit streams have been computed annually over the 20 year benefit period for all homogeneous sections.

14.1.9.1 VOC Savings:

The unit Vehicle Operating Cost (VOC) by vehicle type and VOC savings section-wise has been computed by the HDM model. The VOC computation takes into account capacity augmentation, pavement characteristics, roughness progression vis-à-vis intervening surface treatment and strengthening policies, traffic characteristics, geometric conditions and vehicle characteristics.

14.1.9.2 Time Savings:

The HDM Model has generated average speeds in km/hr by vehicle type, in the existing (without project) and the improved (with project) road conditions. The time savings for passengers and goods (in transit) vehicles have been derived separately. For computing time saving for passengers of cars and buses, a weighted average occupancy was used viz. Car – 4 persons and Bus – 40 persons. The average payloads considered for goods vehicles are: LCV – 6 tonnes, 2 Axle Truck-16.2 tonnes, 3 Axle Truck – 30 tonnes and MAV – 35 tonnes.

The value of time (VOT) for passengers and goods considered in this analysis has been based on earlier studies carried out in recent years. For the average car passenger, VOT has been taken as Rs. 68 per hour, and for the average bus passenger it was Rs. 47 per hour. The value placed on time is rather on the conservative side. For goods in transit, time value has been worked out using the inventory cost method, with a 15% interest rate considered as the opportunity cost of capital. The VOT for goods (Cargo) vehicle worked out to Rs. 3.43 per hour for LCV, Rs. 10.54 per hour for 2-axle trucks and Rs. 19.73 per hour for multi-axle vehicles.

14.1.9.3 Accident Cost Savings:

A distinction made between main cause of accident and the contributory factors of accident. It is usually difficult to identify the main cause of accidents, where as several factors which could have contributed to accidents can be identified.

14.1.9.4 Contributory factors of Accidents:

Human Factors:	Manner of executions(Deficiency in actions & behavior)
	Perceptual errors
	Impairment
	Lack of Skill
Road Factors:	Adverse Road Design
	Adverse Environment
	Inadequate Furniture or Markings
	Obstacles
Vehicle Factors:	Tyres
	Brakes
	Other defects due to poor maintenance
	Unsuitable Designs

It is possible to predict the reduction in accidents on account of road improvements. The accidents costs collected from IRC-SP-30 (the values are in the year 1990 and escalated with 3% to get the values in the year 2022 are given below.

Accident Costs (Rs.)	1990	2022
Fatal	210000	1000638
Serious injury	32000	152478
Minor injury	1100	5241
Damages to car	4700	22395
Damages to 2-wheeler	1100	5241
Damages to bus	15800	75286
Damages to truck	18100	86245

**Source IRC:SP-30:2009*

14.1.10 Economic Analysis

The annual cost and benefit streams are used to derive the net cash flow for the project. The EIRR and NPV @ 12% discount rate are determined using the discounted cash flow technique for all the Sections. The results for the improvement scheme are presented below and details are provided in **Appendix-14.1.2**

Table-14.1.7: EIRR & NPV

Total Stretch	EIRR (%)		NPV (Cr.)	
	20 Year	30 Years	20 Year	30 Years
Surat-Nashik-Ahmednagar	12.4%	14.9 %	3,476.55	41,601.59

14.1.11 Conclusion

From the results of the Economic Analysis, it can be seen that the improvement scheme, the EIRR is getting higher than minimum threshold value of 12%.

So it can be concluded that the project of six lane option is economically viable and recommended for implementation.

14.2 Financial Analysis

14.2.1 Background

The main objective of financial analysis is to assess the likely returns to the investors under realistic conditions. For this purpose, the prevailing market rates and return on debt and equity issues in local capital markets are the important factors. In the present studies, the financial viability of the project is assessed on the basis of project's financial internal rate of return on investments and Rate of Return on Equity, which is estimated on the basis of cash flow analysis.

14.2.2 Approach to Financial Evaluation

The main objective of financial analysis is to examine the viability of implementing the project on BOT basis. The analysis attempts to ascertain the extent to which the investment can be recovered through toll revenue and the gap, if any, be funded through Grant / Subsidy. This covers aspects like financing through debt and equity, loan repayment, debt servicing, taxation, depreciation, etc. The viability of the project is evaluated on the basis of Project FIRR (Financial Internal Rate of Return) on total investment). The FIRR is estimated on the basis of cash flow analysis, where both costs and revenue have been indexed to take account of inflation. Financial analysis has been carried out for the entire project road with debt equity ratio of 70:30. The basic indicators for assessing the Financial Viability of the project are as follows.

NPV (Net Present Value): The NPV for the project should be positive when a discount rate representing the opportunity cost along with a risk premium is applied in the financial analysis.

FIRR (Financial Internal Rate of Return): The FIRR should have a value above the discount rate (opportunity cost).

14.2.3 Model Concession Agreement

Financial analysis was carried out based on following Assumptions:

Time Assumptions:

1. Concession Period has been fixed to the year in which the projected traffic would cross the design capacity of the Project Road.
2. Concession Period included the time required for construction also.

Economic Assumptions:

Annual Inflation rate of 5% has been considered for determining the Project Cost, Routine Maintenance and Periodic Maintenance.

Project Cost Assumptions:

1. Contingency cost has been taken as 1% of the civil construction cost.
2. IC&Pre-Operative Expenses cost has been taken as 1% of Estimated Project Cost.
3. Financing Cost has been taken as:

Civil Cost	% on Debt amount
Up to 500 crores	2%
Between 500 crores to 1000 crores	1.5%
More than 1000 crores	1%

4. Interest rate for calculation of Interest during Construction has been taken as 12.5% (Base rate 10%+2.5% as per MoRTH Circular dated 16/06/14)
5. The Construction cost for the up gradation of the Project road does not include the Environmental, Social, Land Acquisition, Utility relocation and Tree cutting cost for the purpose of Financial Analysis.

Reference*: Guidelines/circular – NHAI Policy matter: Technical (70/2010) circulated vide NHAI, HQ letter No. 11041/218/2007-Admin, dated 08/12/2010.

Financing Assumptions:

a) The Debt has been considered as 70% of the Net Project Cost.
b) The Equity has been considered as 30% of the Net Project Cost.
c) Maximum Government/Client Contribution (Grant) is 40% of TPC.
d) Toll rates have been rounded to nearest 5 rupees.

Expenditure Assumptions:

a) Cost of Routine Maintenance and Periodic Maintenance has been taken from NHAI circular (NHAI/11033/CGM(Fin.)/2011 dated 29/04/11)
b) Interest rate on Debt has been considered as 12.50% per annum.

Other Assumptions:

a) Loan Repayment Period- 10 Years.
b) Tax Exemption/Tax Holiday- 10 Years of Concession Period to get maximum advantage of tax exemption. The MAT rate has been made applicable in those years.
c) Income Tax rate- 33.063% & MAT- 20.389%

14.2.4 Toll Policy

The new toll policy – 2008 has been used for calculation of toll revenues. The Ministry of Road Transport and Highways (MORTH) has come up with couple of amendments to National Highway Fee Rules, 2008.

a) Traffic Considerations

The share of through traffic, traffic using daily/monthly passes and local passes have been assessed by roadside interview and number plate surveys.

Three categories of traffic can avail discounted rates at the toll plaza.

- Owners residing within 20 kms distance from the plaza, using the vehicle for non-commercial purposes can take a monthly pass.
- Vehicles making return trip on the same day within 24 hours can take a daily pass.
- Vehicles making a maximum of 50 or more one-way trips/month can take a monthly pass.
- Local commercial vehicles with the same district registration number and without National permit can avail 50% discount for regular tickets and passes.

b) Amendments to National Highways Fee Rules, 2008

Following are the changes in subsequent amendments:

Particulars	As per Original Notification	Amendment
December 2010 Amendment		
Additional Toll Rates for Bypasses	Bypasses with cost more than 50 crores were eligible for cost-based toll rates	Bypasses with cost more than10 crores are eligible for additional toll rates. However, the additional toll rates are not based on the cost of bypass but are 50% more than per kilometer toll rates given in 2008 notification.
WPI to be considered for toll escalation	Week ending January1st of current year (Calendar)	For the month of December of previous year (Calendar)
Eligibility of Two Lane Roads for Tolling	The rate of fee for use of a section of National highway, having two lanes and on which the average investment for up gradation has exceeded. one crore per Km., shall be sixty per cent of the rate of fee.	The rate of fee for use of a section of National highway, having two lanes and on which the average investment for up gradation has exceeded two crore and fifty lakhs per Km., shall be sixty per cent of the rate of fee.
January 2011 Amendment		
Toll Rates for	3-axle Trucks were to be	A separate toll category has been created for

Particulars	As per Original Notification	Amendment
3-axle Trucks	charged under MAVs. MAV was defined as heavy construction machinery or earth moving equipment or mechanical vehicle including a multi axle vehicle with three to six axles or vehicle with a gross vehicle weight exceeding twenty thousand kilograms but less than sixty thousand kilogram.	3-axle trucks with substantially less toll rates. The per kilometer toll rate for 3-axle Truck is 2.4 whereas for 2-axle Truck it is 2.2. (The toll rate for 3-axle Truck was 3.45 per kilometer) Similarly, **New** toll rates are given for 3-axle Trucks for Bridges/Tunnels. 3-axle Truck is defined as a mechanical vehicle having 3-axles (including the axle of the trailer, if any) and with gross vehicle weight, of less than 25,000 kilograms. MAV is now defined as heavy construction machinery or earth moving equipment or mechanical vehicle including a multi axle vehicle with four to six axles or vehicle with a gross vehicle weight exceeding twenty five thousand kilograms but less than sixty thousand kilogram.
Local Concessions for Commercial Vehicles	Were not available.	Are now provided, as given below: A person, who owns a commercial vehicle (excluding vehicle plying under National Permit), registered with address on the Registration Certificate of a Particular district uses such vehicle for commuting on a section of the National Highway, permanent bridge, tunnel or bypass, as the rule may be, which is located within that district, shall be levied user fee on all toll plazas which are located within that district, <u>at the rate of fifty percent of prescribed rate of fee.</u> Provided that no such concession will be given, if the service road or alternative road is available for use by such commercial vehicles.
October 2011 Amendment		
Toll rates for the existing toll road users	-	The section of the national highway or the bridge has been taken for further lane up-gradation, the increase in the toll rate should not be more than 25% of the existing toll rates.
December 2013 Amendment		
Annual Revision during Construction from Four lane to Six lane		For the section of highways which has been taken up for up gradation of Four lane to Six lane, <u>increasing in rate shall be limited to Seventy Five Percent of the Toll rates</u>, from the date of commencement of work to toll the completion of the project according to the

Particulars	As per Original Notification	Amendment
		agreement entered into with the concessionaire without any annual revision. Provided also that no user fee shall be levied for the delayed period between the date of completion as per the agreement and the date of actual completion.
Structure cost	AS per Rule 4 of sub rule (4)	The rate of fee of stand-alone structure shall be calculated by converting the cost of structure into equivalent length of highway/Express way by dividing by an equalization factor equal to average cost per Km of highway/Expressway on 1st April of that year.
Stand-alone structure		The rate of fee of stand-alone structure forming part of a linear highway/expressway, shall be calculated by converting the length of the structure into an equivalent length of highway/expressways by **multiplying by a factor of ten.** The structure of Length 60me or less, on a linear highway/Expressway will be considered as part of the normal length of highways for calculation of Fee.

The Toll Rates for the project have been determined on the basis of user fees as prescribed by NHAI for collection of fees by any person for the use of National highways (effective 1st April 2007).

The rates shall be increased annually by 3 percent without compounding thereof with effect from April 1, 2008 and such incremented rates shall be deemed to be the base rate for the purpose of these rules. The applicable base rates shall be revised annually with effect from April 1 each year to reflect the increase in WPI for the month of December of the immediately preceding year and the month of December of the year subsequent to January 1st of the year in which such revision is undertaken; but restricted to 40% of such increase in WPI.

The fee and amounts shall be rounded off to a multiple of 'five rupee' in accordance with the Indian Standards IS: 2-1960 “Rules for rounding of numerical values” issued by Bureau of Indian Standards as amended from time to time. Accordingly rates applicable for 4 or more lanes of National Highway and for the permanent structures like bridge or flyover at the toll plaza for the base year 2007-08 have been calculated and presented below.

Table-14.2: Toll Capping Rates for National Highway

S.No	Type of Vehicle	Base rate of fee per Km
1	Car, Jeep, Van or Light Motor Vehicle or tractor with trolley carrying nonagricultural produce	0.65
2	Light Commercial Vehicle, Light Goods Vehicle or minibus	1.05
3	Bus or 2 Axle Truck	2.2
4	3 Axle Truck	2.4
5	Heavy Construction Machinery or Earth Moving Equipment or M axle vehicle with four to six axles	3.45
6	Oversized Vehicles	4.2

c) Discounts to users

i) Discount to frequent user:

Any user may opt for the payment of fee for multiple journeys within the specified period in accordance with the rates mentioned below, as per the toll notification.

Table – 14.2: Discounts to frequent users

Type of Pass	Amount Payable	Maximum number of one way journeys allowed	Validity period for crossing the fee plaza
Round (or) Return Pass	One and half times of fee for one-way journey.	Two	Twenty-four hours from the time of the payment
Monthly Pass	Two-third of amount of the fee payable for fifty or more-one-way trips.	Fifty	One month from the date of payment

ii) Discount to local user:

Local traffic* shall be entitled to ply on the project highway, as the case may be, and cross the toll plaza on production of a monthly pass to be issued by the concessionaire on payment of a monthly fee of 150/- per month.

*Local user means A person who owns a mechanical vehicle registered for non-commercial purposes and uses it as such for commuting on a section of national highway, permanent bridge, bypass or tunnel, may obtain a pass, on payment of fee at the base rate for the year 2007-08 of `. 150/-per calendar month. Provided that such pass shall be issued only if such driver, owner or person in charge of such mechanical vehicle resides with in a distance of 20 km from the toll plaza specified by such person and the use of such section of national highway, bypass or tunnel, as case may be, does not extend beyond the toll plaza next to the specified toll plaza.

A person, who owns a commercial vehicle (excluding vehicle plying under National Permit), registered with address on the Registration Certificate of a Particular district uses such vehicle for commuting on a section of the National Highway, permanent bridge, tunnel or bypass, as the rule may be, which is located within that district, shall be levied user fee on all toll plazas which are located within that district, at the rate of fifty percent of prescribed rate of fee.

14.2.5 Location of Toll Plaza

The fee levied and collected for use of a National highway shall be due and payable at the toll plazas. The toll revenue has been calculated considering the proposed toll plazas at the following locations as shown below.

Table-14.3: Location of Toll Plazas and their tolling lengths

Toll Plaza Location	Existing Chainages (km)		
	From	To	Length
Kukeri	0.000	20.145	20.145
Pipalkhed	20.145	35.923	15.778
Ambegaon	35.923	107.051	71.128
Adagaon	107.051	139.000	31.949
Varhe Davna	139.000	147.340	8.340
Fulenagar	147.340	185.108	37.768
Hasnabad	185.108	198.393	13.285
Chinchpur Kh.	198.393	217.592	19.199
Rahuri Kh	217.592	251.275	33.683
Shendi	251.275	275.901	24.626
Sarolabaddi	275.901	290.700	14.799

14.2.6 Traffic Data and Growth rates

The classified traffic volume count data collected has been analysed to assess the traffic intensity at the proposed toll plaza location. The summary of Annual Average Daily Traffic (AADT in number of vehicles) at the proposed toll plaza location is given below.

Table-14.4: Tollable Traffic at Toll plaza location

At Toll Plaza Location		Cars	Bus	LCV	2 AT	3 AT	M AT
0.000	20.145	8201	469	1568	1922	2128	3250
20.145	35.923	4923	309	1086	1316	1566	1782
35.923	107.051	6140	387	1435	2329	2070	1684
107.051	139.000	6640	437	1277	3205	1645	1766

At Toll Plaza Location		Cars	Bus	LCV	2 AT	3 AT	M AT
139.000	147.340	6849	315	1263	2532	1437	1966
147.340	185.108	4652	328	1141	1566	1788	1598
185.108	198.393	2358	318	1026	1178	1906	1552
198.393	217.592	3396	316	1152	1433	1823	2188
217.592	251.275	3503	284	871	1398	2169	2049
251.275	275.901	3272	358	765	1251	1842	2469
275.901	290.700	3530	351	966	1165	1748	2465

Traffic Growth Rates:

The past motor vehicle registration data at the state level provides a valuable indication regarding the trends in the traffic growth and presents a dependable tool for estimating future growth rates in different categories of vehicles. A more rational method will be to establish a relationship between the socio-economic variables such as Population, Net State Domestic Product (NSDP) and Per-Capita Income (PCI) on the one hand and the past registration data of different categories of vehicles on the other to determine the elasticity of transport demand with respect to different categories of vehicles. The computed traffic growth rates are shown below.

Table-14.5:Adopted Traffic Growth rates

Year	2 W	3 W	Cars/ Jeeps	Buses	Trucks (LCV, 2 AT, 3 AT & M AT)
2018- 2023	5%	5%	5%	5%	5%
2023-2028	4.5%	4.5%	4.5%	4.5%	4.5%
2028-2033	4.0%	4.0%	4.0%	4.0%	4.0%
2034-2039	3.5%	3.5%	3.5%	3.5%	3.5%
2040-2045	3.0%	3.0%	3.0%	3.0%	3.0%
2046-2045	3.0%	3.0%	3.0%	3.0%	3.0%
Beyond 2045	3.0%	3.0%	3.0%	3.0%	3.0%

14.2.7 Toll Revenue

Toll revenue is the product of the forecast traffic expected to use the road and the appropriate toll fee for the vehicle category. Toll indexing has been carried out as per the new toll policy and rounded off to nearest five-rupee multiples. As per the new toll policy the toll revenue calculations for through traffic, local traffic and vehicles making frequent trips are given below:

Non local category:	
Revenue from single trips (Through traffic)	No. of vehicles making single trips X Toll Rate X 365 days
Revenue from daily pass traffic (Return trips)	No. of vehicles taking Daily passes X Toll rate X 150% X 365 days
Revenue from monthly traffic (Monthly pass trips)	No. of vehicles taking monthly passes X 2/3 X 50 X Toll rate X 12 months
Local category:	
Revenue from local noncommercial traffic	No. of vehicles taking local pass X 150 X 12 months
Revenue from commercial through traffic	No. of vehicles making single trips X Toll Rate X 365 days X 0.5
Revenue from commercial daily pass traffic (Return trips)	No. of vehicles taking Daily passes X Toll rate X 150% X 365 days X 0.5
Revenue from commercial monthly traffic (Monthly pass trips)	No. of vehicles taking monthly passes X 2/3 X 50 X Toll rate X 12 months X 0.5

The summary of computed Toll Rates is presented below for quick reference and details are provided in **Appendix-14.1.1.**

Table:14.6: Toll Revenue in Crores per Year

YEAR		HS-1	HS-2	Total Revenue (Rs Crores per Year)
From	To	Total Revenue (Rs Crores per Year)	Total Revenue (Rs Crores per Year)	
2024	2025	611.978	308.267	920.245
2025	2026	672.868	338.768	1011.636
2026	2027	739.274	372.328	1111.602
2027	2028	812.775	409.652	1222.427
2028	2029	894.342	450.616	1344.958
2029	2030	978.683	493.092	1471.774
2030	2031	1071.479	540.004	1611.483
2031	2032	1173.428	590.789	1764.217
2032	2033	1285.485	647.221	1932.706
2033	2034	1408.548	709.016	2117.564
2034	2035	1535.912	772.942	2308.855
2035	2036	1675.387	842.515	2517.902
2036	2037	1827.229	919.584	2746.812
2037	2038	1993.305	1002.541	2995.846
2038	2039	2175.546	1094.600	3270.146
2039	2040	2363.070	1188.840	3551.910
2040	2041	2568.446	1292.257	3860.703
2041	2042	2789.549	1403.499	4193.048
2042	2043	3032.453	1525.831	4558.284
2043	2044	3296.492	1658.220	4954.711
2044	2045	3583.232	1802.609	5385.841
2045	2046	3896.690	1960.145	5856.835
2046	2047	4237.712	2131.922	6369.633
2047	2048	4608.280	2317.993	6926.273
2048	2049	5012.604	2521.348	7533.952
2049	2050	5454.065	2743.592	8197.657

14.2.8 Tax Calculation Model

According to the scheme under section 80-IA, 100% of the profit is deductible for the continuous period of ten years out of the concession period. However, the benefit deduction is available only for ten consecutive assessment years falling within the concession period. The tax rate adopted for this study is **33.063%** (30% tax + 7% surcharge + 3% education cess) following the deduction of depreciation and amortization. Minimum Alternate Tax (MAT) of **20.389%** (18.5% tax + 7% surcharge + 3% education cess) has been taken into account for the total concession period.

14.2.9 Proposed Source of Finance

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

Equity: To be provided by the Developer

Subsidy / Grant for viability of funding, to be provided by the client.

Debt: To be arranged by the Developer / Concessionaire.

14.2.10 Methodology

The procedure and steps undertaken to assess the financial viability of the captioned Project are outlined in this section. The first stage in evaluation of the financial viability is the identification of the revenue and expenditure streams. The revenue for the captioned Project will be generated primarily from toll income. Revenues from hoardings are not considered in the income stream.

14.2.11 Expenses

Expenses can broadly be classified based on the phases in which they are incurred, viz. construction period expenses and operation & maintenance period expenses.

Construction Period Expenses

- Preliminary and pre-operative expenses
- Contingency allowance
- Interest during construction period

Operation and Maintenance Period Expenses

- Toll collection expenses
- Maintenance expenses, which include routine and periodic maintenance.
- Interest expenses incurred for servicing term loans.

Client would extend toll collection rights to the developer. The developer then would have the option of either collecting the toll himself or further subcontracting the same to a toll collection agency. In the present study, it is assumed that the developer would undertake operation and maintenance himself. The details of the toll collection expenses are given below for the year 2018 for 4 lane road:

Table: 14.7 Operation and Maintenance Period Expenses

Toll Collection Expenses	2.36 Crores/Year/Toll Plaza
Office Expenditure	3.69 Crores/Year
Elec. & Patrolling Expenses	1.85 Lakhs/Year/Km

14.2.12 Civil Cost of the Project and Interest during construction (IDC)

The cost of Civil works of the project including the improvement of existing carriageway and cost of toll plaza and details are given below:

Table:14.8. Cost Summary

Project corridor	Length in km	Cost/ Km in Cr.	Civil Cost (Crores)
Surat – Nasahik-Ahmednagar Section	290.700	45.13	12992.72

The interest during construction, which is on the cost of funding incurred on the project, has been calculated on the basis of an interest rate of 12.50% per annum as per the present trends.

The total landed cost for the project at the end of the construction period has been estimated by adding the (capitalizing) interest during construction (IDC). The total landed cost at the time of commissioning is thus estimated and is given below

Table-14.9: Summary of Concessionaire cost in Crores

Concessionaire Cost	**Crores**
Total Civil Construction cost in 2022 year	12992.72
Contingencies/QC @ 1.0% of TPC	129.93
Total EPC Cost	13122.65
IC & Pre-operative expenses @1.5% of EPC	196.84
Financing Cost @ 1 % on Debt.	117.84
Escalation @ 5% Per Anum	1481.82

Concessionaire Cost	Crores
Interest During Construction	1914.87
TOTAL PROJECT COST in crores	16834.02

14.2.13 Operation and Maintenance Cost

Routine maintenance costs comprise of maintenance of the pavement, collection of litter, traffic management, repairs due to accident and all ancillary works including beautification.

The periodic maintenance costs include cost of overlay, repair/renovation of road furniture, drains, buildings etc. The periodic maintenance includes periodic renewals at every 7 years.

Routine maintenance/ Periodic maintenance costs have been taken from NHAI circular (NHAI/11033/CGM(Fin.)/2011 dated 29/04/11). The details of the maintenance costs and administration charges are given below.

Routine maintenance in every year for 4 lanes with paved shoulder (Flexible Pavement) is 4.92 Lakhs/km. Periodic Maintenance at every 7th year is taken as 49.25 Lakhs/Km.

14.2.14 Resource Mobilization Scheme

In general, the duration of construction for 4 lanes with paved shoulder projects ranges between 2.5-3.0 years. Since the proposed Project is planning to be implemented on a DBOT format, the developer has an incentive in early completion of the project in order to expedite toll collection. Based on the implementation period, the project cost has been phased as under:

First Year (6 months)	-	20%
Second year (12 months)	-	40%
Third year (12 months)	-	40%

14.2.15 Minimum Return Criteria

The minimum return criteria for the B.O.T project is considered as follows: -

Return on Equity (EFIRR): Considering a safe investment in bank in the form of a term deposit, an interest rate of 10% is generally a return with safety. However, when investing in the road sector, a perspective investor would normally need to cover the business risks(e.g. the decreasing revenue, increasing cost, construction time overrun, etc.) and therefore would require a return higher than a return on the safe investment as mentioned above. Based on usual trends, it is estimated that an additional return of 5% would be adequate to cover these risks. Hence, a minimum return on equity of 15% could be considered satisfying the requirement of prospective concessionaire.

The return on project investment (PFIRR): In the light of the facts as stated above Project FIRR of 12% is considered to be a satisfactory criterion.

The minimum average DSCR is taken as 1.5 to 2.5.

Considerations for Calculating the Project FIRR

* Investment = Net Project Cost

= Total Project Cost– Equity Support (Grant During Construction)

* Operating Income= Toll Revenue

O&M Support

* Operating Expenses =Toll Plaza Maintenance

(O&M Expenses) Annual Maintenance of Road

Periodic Maintenance of Road

Concession Fee

Tax on Net Profit as per Income Tax Act

Considerations for Calculating the Equity FIRR

* Investment = Equity Contribution on Net Project Cost (30% of the Net Project Cost by the Concessionaire)

(I) Operating Income = Toll Revenue
(ii) O&M Support (Grant During Operation)
(iii) Operating Expenses =Toll Plaza Maintenance

* Annual Maintenance of Road

* Periodic Maintenance of Road

* Concession Fee

* Tax on Net Profit as per Income Tax Act

* Interest on Debt/Loan (Diminishing Interest)

* Debt/Loan Repayment

Debt Service Coverage Ratio (DSCR)

DSCR = Net Operating Income after Tax / (Interest on Loan + Repayment of Loan)

Net Operating Income = Total Revenue – O&M Expenses - Tax.

Net Operating Income Period equal to Loan Repayment Period.

14.2.16 Financial Analysis Considerations

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

Following assumptions are taken into consideration for the financial analysis: -

- Debt – Equity ratio: - 70:30
- Subsidy/Grant – 40% (maximum)
- Concession period (Including construction period) – 20 years.
- Escalation – 5%
- Interest on Debt – 12.5%
- Project Phasing: First year–20%, Second year–40% and Third year -40%
- Loan Repayment period – 10 years
- Tax rebate–10 years (100% exemption for 10 years out of block of 20 years).
- Depreciation by Straight line method - 100% for Concession Period
- Depreciation by Written down value method – 10%
- Financing cost- 1.0% of TPC.

14.2.17 Financial Viability based on BOT-Toll Basis

Based on the project structure traffic study and toll rate analysis, financial feasibility analysis has been carried out as per the methodology outlined in earlier sections. The objective of the financial analysis is to ascertain the existence of sustainable project returns, which shall successfully meet the expectations of its financial investors. The analysis reveals various FIRR values corresponding to each year of toll operation. FIRR for the Returns on Investment and Returns on Equity for the concession period of 20 years has been examined and tabulated below and details are provided in Appendix.

Table-14.10: Financial Analysis Results (BOT-Toll)

Tolling Lengths (km)			Grant (%)	Concession Period	Civil Cost in Cr.	Equity FIRR (%)
From	To	Length				
0.000	290.700	290.700	20	20 years	12992.71	-4.66 %
			40	20 years	12992.71	8.04 %

Table-14.11: Financial Analysis Results (HAM)

Tolling Lengths (km)			Grant (%)	Concession Period	Civil Cost in Cr.	Bid Parameters	
From	To	Length				TPC	O&M
0.000	290.700	290.700	20	20 years	12992.71	18604.00	75.13

14.2.18 Conclusions

A minimum return on equity of around 15% could be considered satisfying the requirement of prospective concessionaire. The project is not yielding any return on equity even with 40% grant and 20 years concession period. In view of this, it can be concluded that the option with BOT (Toll) is not viable for taking up the project on BOT -Toll basis.

In view of the above it is recommended to taken up the project on HAM Mode.

15. CONCLUSIONS AND RECOMMENDATIONS

15.1 Conclusions and Recommendations

Some of the important aspects which require the attention of the authority have been presented below for consideration, along with the recommendations of the consultants.

1. Right of Way

The Right of Way required is 60m for normal section for the design TCS proposed as per IRC SP: 87-2019. However, the consultants proposed minimum Right of Way 70m throughout the project corridor and at Tunnel location Proposed Right of Way is 150m.

2. Traffic

Based on the traffic survey carried out, the traffic on Project Highway as shown in below table.

Existing Chainage	Survey location	AADT	
		Vehicles	PCUs
Km 359.600 on NH-48	Vapi	78641	111441
Km 75.800 on NH-53	Bajipur	16955	26362
Km 6.400 on SH-177	Tankal	9381	8527
Km 178.400 on NH-60	Sinnar	20977	26422
Km 106.800 on NH-160 (old SH-10)	Pimpri Nirmal	24576	29186

Assigned Traffic

Vehicle Mode	Leg 1	Leg 2	Leg-3	Leg 4	Leg 5	Leg 6	Leg 7	Leg 8	Leg 9	Leg 10	Leg 11
Car	8201	4923	6140	6640	6849	4652	2358	3396	3503	3272	3530
Bus	469	309	387	437	315	328	318	316	284	358	351
LCV	1568	1086	1435	1277	1263	1141	1026	1152	871	765	966
2 Axle	1922	1316	2329	3205	2532	1566	1178	1433	1398	1251	1165
3 Axle	2128	1566	2070	1645	1437	1788	1906	1823	2169	1842	1748
Multi Axle	3250	1782	1684	1766	1966	1598	1552	2188	2049	2469	2465
Total (Vehicles)	17538	10982	14045	14970	14362	11073	8338	10308	10274	9957	10225
Total (PCU)	38735	24144	30229	32364	30443	24601	21087	25686	25584	25884	25864

3. Pavement Type

Flexible pavement is recommended for main carriageway for the entire Project Highway.

4. Up-gradation of the structures

All major, Minor Bridges, Vehicular under pass/Overpasses and VUP(Grade-II) is 6 lane configuration were proposed in the Project Highway.

5. Land Acquisition

2364 hectares of land is required to be acquired for development of the Project Highway.

7. Project Facilities

Road side furniture like Traffic signs/over head signs, pavement markings, crash barriers, road studs is proposed as per six laning manual.

8. Mode of Execution

The mode of execution is recommended to taken up on need to be decision taken by authority.

16. TECHNICAL SPECIFICATIONS

16.1 Specifications and Standards

All Materials, works and construction operations shall conform to the MORTH/NHAI Specifications for Road and Bridge Works. Where the specification for a work is not given, Good Industry Practice shall be adopted to the satisfaction of the Authority's Engineer.

16.2 Deviations from The Specifications And Standards

Notwithstanding anything to the contrary contained in Paragraph 1 above, the following Specifications and Standards shall apply to the Project Highway, and for purposes of this Agreement, the aforesaid Specifications and Standards shall be deemed to be amended to the extent set forth below:

Additional Technical Specification from MORTH:

S.NO.	Item	Description	Clause reference
1	6 Lane Highway traffic requirement	Minimum a 6-Lane highway is to be provided if the traffic volume along a highway is more than 25,000 PCUs/day.	Policy matters – Quality Assurance (Decision taken on File No NHAI/CGM/QA/DPRs/2017, in January 2017