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Annexure-2C: Summary of Classified Traffic Volume Count Survey
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2.3 Transportation design

2.3.1 Past studies

Haskoning Consulting Engineers had carried out pre-feasibility study on Kalpasar Project Project in 1998. Transportation study is one of the component of the pre-feasibility study. The report was submitted in February, 1998. Major findings summarised below :

(1) It is a pre-feasibility study and scope of work is preliminary in nature without envisaging comprehensive traffic studies;
(2) Consultants had carried out traffic volume counts and Origin-Destination surveys during June, 1996. The results of the survey were used to verify and substantiate the assumptions made;
(3) Distance savings considered in report is much higher as dam alignment was different from the current alignment. Further, along with Kalpasar link, bridge over Narmada River connecting Hansot to Dahej Road is also considered. This link will further reduce the distance between Bhavnagar and Surat;
(4) Very conservative GDP estimate in the order of 3% to 5% is considered for India. Growth in GDP considered for period 1995-2000 and 2001-2010 is 5% respectively and 4.5% whereas actual growth rate achieved during the above periods is 6.5% and 7.5% respectively;
(5) The forecast can be taken as conservative as many major projects such as DMIC, Dholera SIR and SEZs etc were not envisaged during the study period and remain unaccounted and therefore generated traffic is under estimated. Since, future developments were not known generated traffic components is taken as 20% of the diverted traffic.
(6) Toll Rates considered for Car, Bus and Truck is Rs.171, Rs.188 and Rs.256 respectively (1996 financial prices) based on willingness to pay the toll which is equal to the financial out of pocket expenses; and
(7) The road configuration of road over dam is assumed to be of 4-lane only. Traffic is kept constant beyond 2026 as lane configuration is freezed at 4-lane configuration.

Traffic Forecast provided by Haskoning Consulting Engineers is presented below in **Table 2.1**.

Table 2.1: Traffic forecast by Haskoning (1998)

Year	Cars	Buses	Trucks	Total vehicles	PCUs
2000	2,639	308	2,971	5,918	12,476
2010	5,750	460	5,955	12,165	24,995
2020	11,462	657	11,018	23,137	46,487
2030	15,125	758	14,109	29,992	59,726
2040	15,125	758	14,109	29,992	59,726
2050	15,125	758	14,109	29,992	59,726

L&T Ramboll Consulting Engineers Limited had carried out a Traffic Assessment Study in 2010. Comprehensive traffic surveys were carried out and traffic forecast is made by calibrating the travel demand model. The impact of all the major developments i.e. tourism, irrigation, DFC, DMIC, other industrial nodes and SEZs as well as urbanization in project influence area have been considered. The major findings of the study are presented below:

This study carried out traffic forecast for eight scenarios, the assumptions underlying each of the scenarios is presented below:

1. **Scenario-I** : 50% of perceived benefits considered as toll and without induced traffic;
2. **Scenario-II** : 75% of perceived benefits considered as toll and without induced traffic;
3. **Scenario-III** : 50% of perceived benefits considered as toll and with induced traffic;
4. **Scenario-IV** : 75% of perceived benefits considered as toll and with induced traffic;
5. **Scenario-V** : 50% of perceived benefits considered as toll and without induced traffic + Additional East-West link across Sabarmati river;
6. **Scenario-VI** : 75% of perceived benefits considered as toll and without induced traffic + Additional East-West link across Sabarmati river;
7. **Scenario-VII** : 50% of perceived benefits considered as toll and with induced traffic + Additional East-West link across Sabarmati river;
8. **Scenario-VIII**: 75% of perceived benefits considered as toll and with induced traffic + Additional East-West link across Sabarmati River.

Table 2. 1: Traffic Forecast for various Scenarios

Scenarios	Total Traffic	2025	2030	2035	2040	2045	2050	2055
Scenario I	Vehicles	31142	43188	56569	70451	79093	87150	95207
	PCUs	66608	92490	121843	152176	170843	186258	201804
Scenario II	Vehicles	26567	37191	50024	58741	68618	74313	80008
	PCUs	56824	79647	107745	126882	148216	158852	169588
Scenario III	Vehicles	32783	44992	58563	72575	80600	89254	97908
	PCUs	70118	96353	126137	156765	174098	190744	207529
Scenario IV	Vehicles	28098	38866	51917	60638	69516	75747	81979
	PCUs	60098	83235	111824	130980	150157	161908	173765
Scenario V	Vehicles	30720	42465	50697	55446	69262	75764	82265
	PCUs	65706	90941	109196	119765	149608	161936	174373
Scenario VI	Vehicles	26191	41989	50570	55355	69289	75717	82145
	PCUs	56020	89922	108922	119569	149667	161838	174118
Scenario VII	Vehicles	32517	43435	51717	56499	70297	74306	78315
	PCUs	69549	93020	111392	122039	151843	158882	166000
Scenario VIII	Vehicles	27796	41851	51598	56317	70324	76711	83098
	PCUs	59451	89627	111137	121647	151902	163966	176137

Traffic forecast for various scenarios varies from 1.66 lakh PCUs per day to 2.07 lakh PCUs per day.

The study estimated 6-lane configuration till 2030 and beyond 2035, 8-lanes configuration was suggested based on traffic forecast for various horizon years. And the study mentioned that actual number of lanes to be provided will depend upon the economics of dam design, as traffic demand will be high as it will be going to be important transportation link connecting two regions of Gujarat.

Only road link is considered over Kalpasar dam and no railway link is considered. The estimated cost of road component was Rs. 6600 million at 2010 prices. The project was economically viable considering the cut-off rate of 12%.

2.3.2 Regional transportation network

(a) Project influence area

The project influence area for the Kalpasar project covers the Saurashtra and South Gujarat regions which get benefitted due to reduced travel distance and travel time between them. The influence area in Saurashtra region comprises of following districts (i) Devbhoomi Dwarka, (ii) Jamnagar, (iii) Porbandar, (iv) Rajkot, (v) Junagadh, (vi) Amreli, (vii) Gir Somnath, (viii) Bhavnagar, (ix) Botad, (x) Morbi, and (xi) Surendra Nagar) and the influence area in South Gujarat comprises of following districts (i) Vadodara, (ii) Chhota Udaipur, (iii) Bharuch, (iv) Narmada, (v) Surat, (vi) Tapi, (vii) Navsari, (viii) Dang, and (ix) Valsad. The map showing the project influence area is presented in **Figure 2.1**.

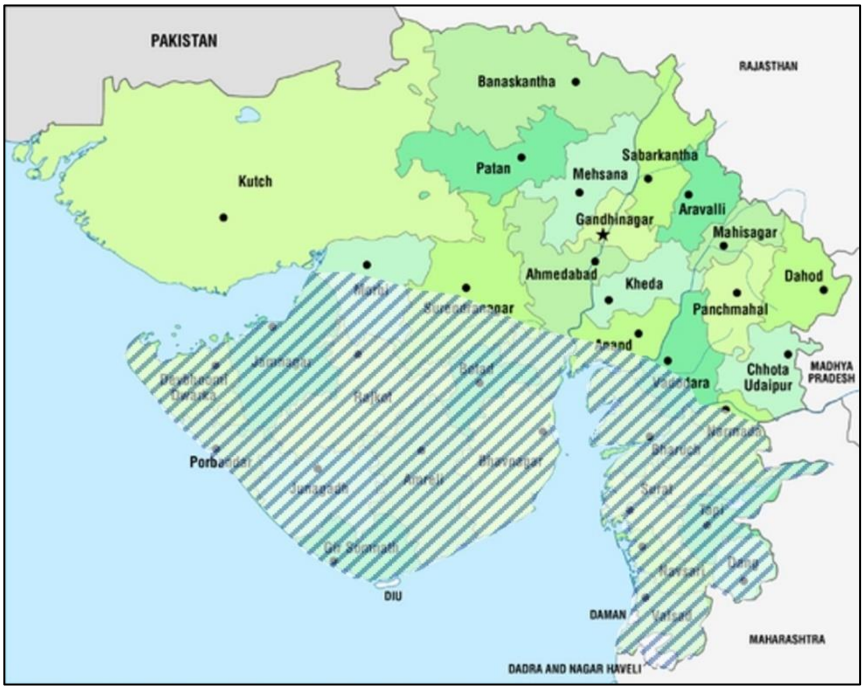


Figure 2.1: Project influence area of Kalpasar project

(b) Roadways

The existing road network in project influence area is presented below in **Figure 2.2**. Proposed Kalpasar Dyke connects Paniyadra in Bharuch district to Kalatalav in Bhavnagar District. Paniyadra village is located on near Dahej - Amod Road (SH-6) and the nearby town is Gandhar. Kalatalav is about 9 km from Dholera - Bhavnagar Road (NH-751). Kalatalav is located close to Nirma factory and Salt Pans.

Figure 2.2: Map showing existing road network surrounding the Kalpasar dam project

Table 2.2: Coordinates points of the Kalpasar project alignment

Location	Longitude	Latitude
A	72°9'2.02"E	21°48'25.22"N
B	72°15'28.91"E	21°48'25.60"N
C	72°30'58.03"E	21°48'26.00"N
D	72°38'51.17"E	21°48'25.71"N

The photographs showing Kalpasar Project start point on end point of Gulf of Khambhat is presented in **Figure 2.3.**

Project Start Point (Paniyadra in Bharuch)

Project End Point (Kalatalav in Bhavnagar)

Figure 2.3: Photographs of project start point on either end of Kalpasar

There are several toll plazas operational on the road network in Project influence area and the same are presented in **Figure 2.4**. The road users of Kalpasar project will save tolls on existing roads at Karjan, Bochasan, Vataman etc., once Kalpasar Project becomes operational.

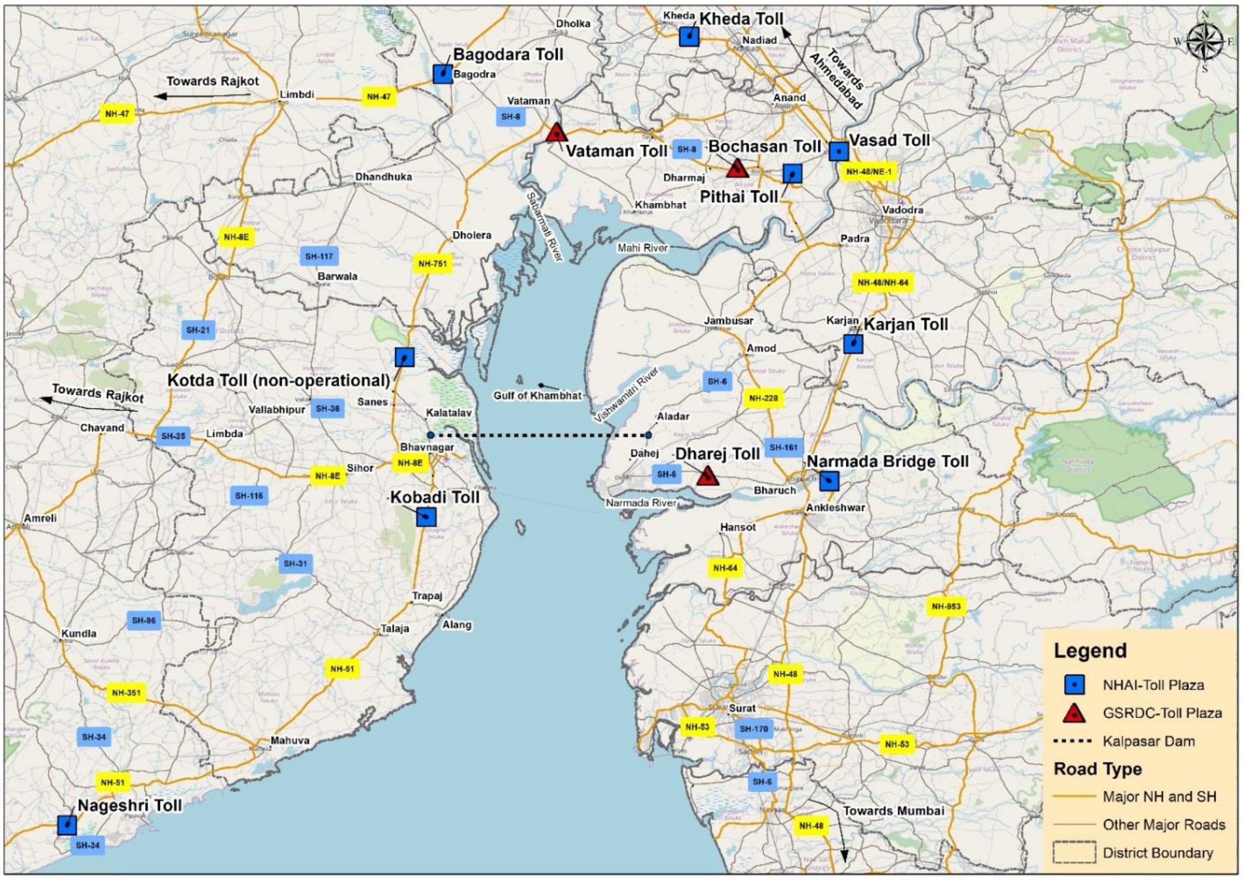


Figure 2.4: Existing toll plaza locations in the project influence area

(c) Railways

Rail network surrounding the project influence falls under Western Railway (WR) zone of Indian Railways. The map showing the existing rail network is presented in **Figure 2.5.** Currently, all the trains travelling between South Gujarat and Saurashtra passes through a detour route via Ahmedabad. Once Kalpasar Rail link is developed, significant benefits will be accrued to the users in terms of reduced travel time and travel cost. It is to be noted that the savings by Rail will be much higher as compared to the road.

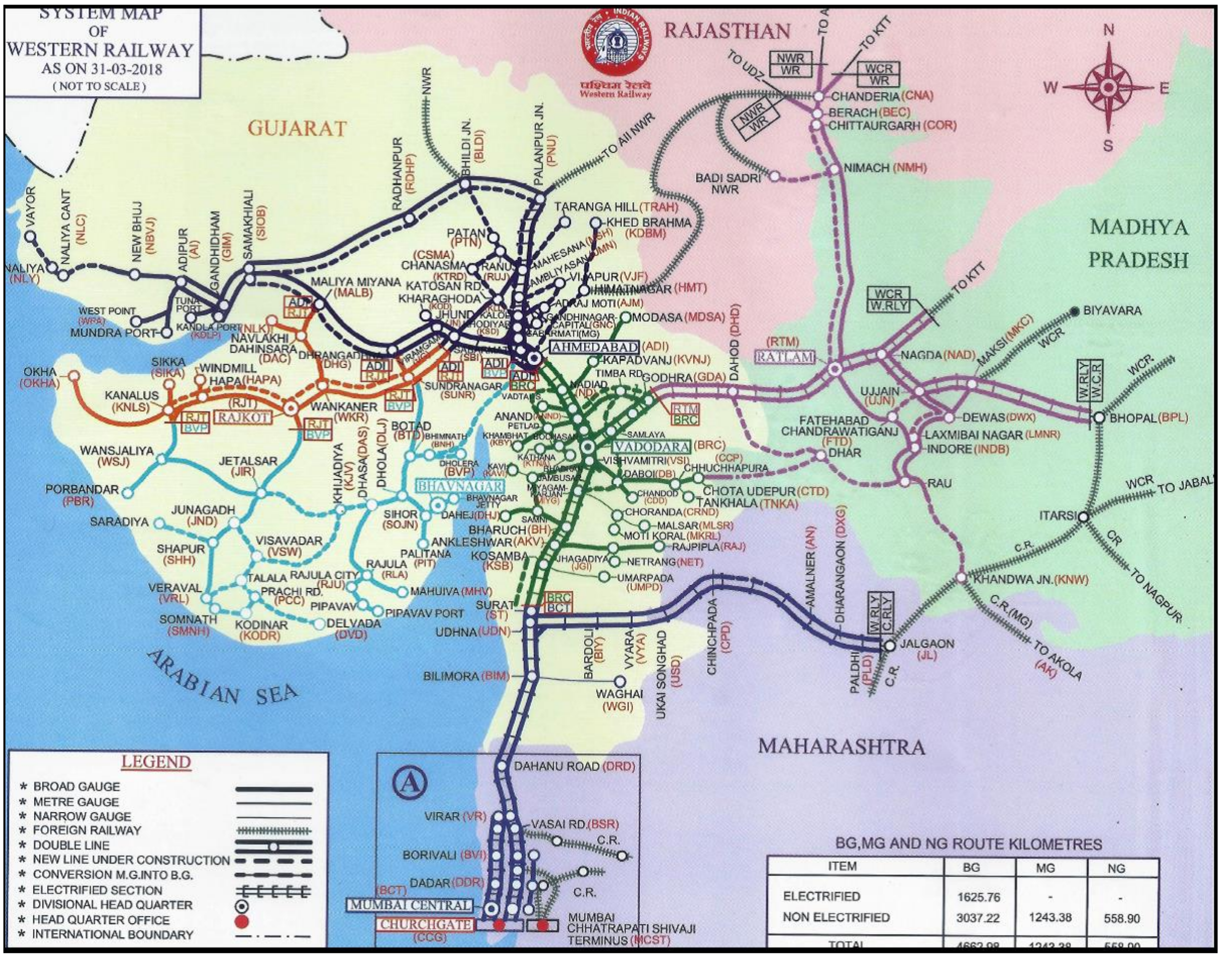


Figure 2.5: Railway network map surrounding the Kalpasar dam project

The existing Rail network comprises of broad gauge, narrow gauge and metre gauge lines. Several Narrow/metre gauge lines are being converted into broad gauge lines.

- **Impact of Transportation in the Region**

Road and Rail over dyke is one of the many components of GKDP. The total length of dam is 30 km and including access roads on either side, it is around 60 km. At present, the traffic movement from South Gujarat to Saurashtra/ Kutch are using a route via Borsad-Tarapur-Vataman which is part of SH-8/NH-751D having 6-lane toll road. Kalpasar Transportation link will have profound impact on the transport sector in the region. The transport benefits accrued from project is outlined below:

(a) Time savings for both passengers and freight shipments;

(b) Reduction in operating expenses, both for the users of the new highway on the dam, but equally for traffic which continues to use the existing routes, which may become less congested;

(c) Stimulation of regional development such as industrial development, agricultural development and tourism development;

(d) Reduce logistics costs for freight traffic and improve competitiveness of industries; and

(e) Reduction in pollution loads due to reduced vehicle kilometer and road accidents;

Secondary benefits such as savings in foreign exchange as consequence of reduction of fuel imports. **Table 2.3, Table 2.4** and **Table 2.5** provide distances to various destinations for road users' without and with Kalpasar road link and savings.

Table 2.3: Distances (KM) for road users' without Kalpasar Link

Districts	Bharuch	Dahej	Surat	Hazira	Navsari	Valsad	Mumbai	Vadodara
Bhavnagar	285	277	356	380	375	429	624	201
Amreli	377	369	449	472	467	521	716	293
Porbandar	532	524	604	620	622	676	864	448
Rajkot	367	359	444	457	457	511	706	283
Jamnagar	456	448	528	551	546	600	795	378
Junagadh	448	440	520	543	538	592	787	364
Gandhidham	477	519	549	567	567	621	811	396
Surendranagar	279	271	351	374	369	423	618	201
Veraval	541	533	612	629	631	685	873	457

*Source: Consultant Analysis

Table 2.4: Distances (KM) for road users' with Kalpasar Link

Districts	Bharuch	Dahej	Surat	Hazira	Navsari	Valsad	Mumbai	Vadodara
Bhavnagar	106	69	177	196	196	249	437	151
Amreli	221	184	293	312	312	365	553	267
Porbandar	403	366	475	494	494	547	735	449
Rajkot	277	240	349	368	368	421	609	323
Jamnagar	370	333	442	461	461	514	702	416
Junagadh	311	274	383	402	402	455	643	357
Gandhidham	451	414	523	542	542	595	783	497
Surendranagar	244	207	316	335	335	388	576	290
Veraval	382	345	454	473	473	526	714	428

*Source: Consultant Analysis

Table 2.5: Distance Savings (KM) for Road users' through Kalpasar Road Link

Districts	Bharuch	Dahej	Surat	Hazira	Navsari	Valsad	Mumbai	Vadodara*
Bhavnagar	179	208	179	184	178	180	187	50
Amreli	156	185	156	160	155	156	163	26
Porbandar	129	158	129	126	128	129	129	-
Rajkot	90	119	95	89	89	90	97	-
Jamnagar	86	115	86	90	85	86	93	-
Junagadh	137	166	137	141	136	137	144	7
Gandhidham	26	105	26	25	25	26	28	-
Surendranagar	35	64	35	39	34	35	42	-
Veraval	159	188	158	156	158	159	159	29

*Source: Consultant Analysis

Bhavnagar district, which is a part of Saurashtra region, is found to be having highest benefit from Kalpasar due to distance savings of around 170-210 km from different places of South Gujarat like Dahej, Surat, Hazira, Navsari, Valsad, Mumbai etc. On the other hand, the benefit accrued to Vadodara is around 30-50 km.

To estimate the travel time-savings for Road users due to Kalpasar project, travel time without project is deducted from travel time with project. Travel time for road users without and with Kalpasar road link are presented in Table 2.6, Table 2.7 and Table 2.8 respectively.

Table 2.6: Travel Time (Hr:Min) for road users' without Kalpasar Road Link

Districts	Bharuch	Dahej	Surat	Hazira	Navsari	Valsad	Mumbai	Vadodara
Bhavnagar	05:21	06:18	06:40	07:10	06:55	07:50	11:30	03:56
Amreli	07:09	08:07	08:37	08:56	08:53	09:48	13:35	05:53
Porbandar	09:48	10:43	11:13	11:36	11:24	12:17	15:42	08:32
Rajkot	06:36	07:35	08:05	08:25	08:21	09:31	13:06	05:20
Jamnagar	08:20	09:21	09:46	10:09	10:00	10:54	14:32	07:19
Junagadh	08:36	09:35	10:03	10:24	10:15	11:08	14:47	07:19
Gandhidham	08:22	09:25	09:47	10:05	10:01	10:54	14:27	07:07
Surendranagar	05:04	06:09	06:34	07:01	06:48	07:41	11:23	04:04
Veraval	10:40	11:50	12:18	12:28	12:25	13:18	16:54	09:21

*Source: Consultant Analysis

Table 2.7: Travel Time (Hr:Min) for road users' with Kalpasar Road Link

Districts	Bharuch	Dahej	Surat	Hazira	Navsari	Valsad	Mumbai	Vadodara
Bhavnagar	02:12	01:20	04:07	04:13	04:16	05:09	08:42	03:32
Amreli	04:40	03:48	06:35	06:41	06:44	07:37	11:10	06:00
Porbandar	07:53	07:01	09:48	09:54	09:57	10:50	14:23	09:13
Rajkot	05:57	05:05	07:52	07:58	08:01	08:54	12:27	07:17
Jamnagar	07:45	06:53	09:40	09:46	09:49	10:42	14:15	09:05
Junagadh	06:50	05:58	08:45	08:51	08:54	09:47	13:20	08:10
Gandhidham	08:59	08:07	10:54	11:00	11:03	11:56	15:29	10:19
Surendranagar	05:04	04:12	06:59	07:05	07:08	08:01	11:34	06:24

*Source: Consultant Analysis

Table 2.8: Time Savings (Hr:Min) for Road users' through Kalpasar Road Link

Districts	Bharuch	Dahej	Surat	Hazira	Navsari	Valsad	Mumbai	Vadodara
Bhavnagar	3:09	4:58	2:33	2:57	2:39	2:41	2:48	0:24
Amreli	2:29	4:19	2:02	2:15	2:09	2:11	2:25	-
Porbandar	1:55	3:42	1:25	1:42	1:27	1:27	1:19	-
Rajkot	0:39	2:30	0:13	0:27	0:20	0:37	0:39	-
Jamnagar	0:35	2:28	0:06	0:23	0:11	0:12	0:17	-
Junagadh	1:46	3:37	1:18	1:33	1:21	1:21	1:27	-
Gandhidham	-	1:18	-	-	-	-	-	-
Surendranagar	0:00	1:57	-	-	-	-	-	-
Veraval	2:27	4:29	2:10	2:14	2:08	2:08	2:11	-

*Source: Consultant Analysis

Travel time savings for road users through Kalpasar Road Link are calculated based on the following assumptions.
(a) Average speed of traffic on road link is 60 Kmph; and
(b) There will be no major changes in existing road network.

It is observed from above tables that significant travel time savings are possible because of Kalpasar project. As observed from the data set, Dahej to Bhavnagar accounts for the maximum time saving of about 4 hr 58 min. Bhavnagar has the maximum time savings from many areas of Southern Gujarat such as Bharuch, Dahej, Surat, Hazira, Navsari, Valsad ranging from 2 hr 33 min to 4 hr 58 min.

Table 2.9: Distances (KM) for Rail Users' without Kalpasar Link

Distance	Dahej	Bharuch	Surat	Mumbai	Vadodara	Ratlam	Jalgaon
Bhavnagar	519	454	513	772	384	644	816
Mahuva Junction	609	545	604	863	474	734	907
Surendranagar	349	301	360	619	231	491	663
Rajkot	503	438	497	756	367	628	800
Pipavav	606	542	600	859	471	731	903
Veraval	671	606	665	924	536	796	968
Porbandar	712	648	707	966	577	837	1010
Jamnagar	596	531	590	849	461	721	893
Bhuj	591	526	585	844	456	716	888

*Source: Consultant Analysis

Table 2.10: Distances (KM) for Rail Users' with Kalpasar Link

Distance	Dahej	Bharuch	Surat	Mumbai	Vadodara	Ratlam	Jalgaon
Bhavnagar	52	117	176	435	46	306	479
Mahuva Junction	267	332	390	649	261	521	693
Surendranagar	236	300	359	618	230	490	662
Rajkot	372	313	372	631	243	503	675
Pipavav	294	358	417	676	288	548	720
Veraval	328	393	452	711	322	583	755
Porbandar	370	435	494	753	364	624	797
Jamnagar	463	528	587	846	457	718	890
Bhuj	492	556	615	874	486	746	918

*Source: Consultant Analysis

Table 2.11: Distance Savings (KM) with Kalpasar Rail Link

Distance	Dahej	Bharuch	Surat	Mumbai	Vadodara	Ratlam	Jalgaon
Bhavnagar	467	338	338	338	338	338	338
Mahuva Junction	342	213	213	213	213	213	213
Surendranagar	113	-	-	-	-	-	-
Rajkot	130	125	125	125	125	125	125
Pipavav	312	183	183	183	183	183	183
Veraval	342	213	213	213	213	213	213
Porbandar	342	213	213	213	213	213	213
Jamnagar	133	-	-	-	-	-	-
Bhuj	99	-	-	-	-	-	-

*Source: Consultant Analysis

Similar to savings with Kalpasar road link Table 2.9, Table 2.10 and Table 2.11 provide distances to various destinations by Rail without, with Kalpasar rail link and savings in travel distance is presented above.

From the above table, it can be observed that Dahej will have maximum saving from all major Saurashtra towns (Bhavnagar, Mahuva Junction, Porbandar, Vevaral). Bhavnagar district savings due kalapasar rail link is around 338km-467km. Long distance travel from Ratlam, Jalgaon, and Mumbai will also be benefited.

Travel time for users without and with Kalpasar rail link and timing savings are presented in Table 2.12, Table 2.13 and Table 2.14 respectively.

Table 2.12: Travel time without Kalpasar Rail Link (in Hr:Min)

Districts	Dahej	Bharuch	Surat	Mumbai	Vadodara	Ratlam	Jalgaon
Bhavnagar	8:38	7:34	8:33	12:52	6:23	10:44	13:36
Mahuva Junction	10:09	9:04	10:03	14:22	7:54	12:14	15:06
Surendranagar	5:48	5:01	6:00	10:19	3:50	8:11	11:03
Rajkot	8:22	7:17	8:16	12:35	6:07	10:27	13:19
Pipavav	10:06	9:01	10:00	14:19	7:51	12:11	15:03
Veraval	11:10	10:06	11:05	15:24	8:55	13:15	16:08
Porbandar	11:52	10:47	11:46	16:05	9:37	13:57	16:49
Jamnagar	9:55	8:51	9:50	14:09	7:40	12:00	14:53
Bhuj	9:51	8:46	9:45	14:04	7:35	11:56	14:48

*Source: Consultant Analysis

Table 2.13: Travel time with Kalpasar Rail Link (in Hr:Min)

Districts	Dahej	Bharuch	Surat	Mumbai	Vadodara	Ratlam	Jalgaon
Bhavnagar	0:52	1:56	2:55	7:14	0:46	5:06	7:58
Mahuva Junction	4:26	5:31	6:30	10:49	4:20	8:41	11:33
Surendranagar	3:55	5:00	5:59	10:18	3:49	8:09	11:02
Rajkot	6:12	5:13	6:12	10:31	4:02	8:23	11:15
Pipavav	4:53	5:58	6:57	11:16	4:47	9:08	12:00
Veraval	5:28	6:33	7:31	11:50	5:22	9:42	12:34
Porbandar	6:09	7:14	8:13	12:32	6:04	10:24	13:16
Jamnagar	7:43	8:47	9:46	14:05	7:37	11:57	14:49
Bhuj	8:11	9:16	10:15	14:34	8:05	12:26	15:18

*Source: Consultant Analysis

Table 2.14: Travel time Savings with Kalpasar Rail Link (in Hr:Min)

Districts	Dahej	Bharuch	Surat	Mumbai	Vadodara	Ratlam	Jalgaon
Bhavnagar	7:46	5:37	5:37	5:37	5:37	5:37	5:37
Mahuva Junction	5:42	3:33	3:33	3:33	3:33	3:33	3:33
Surendranagar	1:53	-	-	-	-	-	-
Rajkot	2:10	2:04	2:04	2:04	2:04	2:04	2:04
Pipavav	5:12	3:03	3:03	3:03	3:03	3:03	3:03
Veraval	5:42	3:33	3:33	3:33	3:33	3:33	3:33
Porbandar	5:42	3:33	3:33	3:33	3:33	3:33	3:33
Jamnagar	2:12	-	-	-	-	-	-
Bhuj	1:39	-	-	-	-	-	-

*Source: Consultant Analysis

Travel time savings using rail over the dyke is estimated based on following assumptions,
(1) Average speeds of the trains considered are 60Km/hr;
(2) Shortest route of train considered irrespective of availability of train schedule;
(3) Waiting time and transfer time for train not considered in time saving calculation assuming direct trains will be introduced in future; and
(4) All existing narrow gauge / meter gauge are assumed to be converted to Broad gauge in future.

It can be observed from the above table, Bhavnagar- Dahej will maximum time savings viz. 7 hours and 46 minutes. All train starting form Saurashtra region to South Gujarat, Mumbai and Ratlam will have significant time savings except for Surendranagar and Jamnagar. Benefits range from 5 Hr 42 minutes to 3 Hr 33 minutes. Least travel time savings are observed for Kutch region (Bhuj) viz 1 hour 30 minutes.

2.3.3 Traffic surveys and analysis

Traffic surveys are carried out to understand current travel pattern in Kalpasar project influence area. The main objectives of traffic surveys are as follows:
(1) To identify the road links which cater to the traffic movement between Saurashtra to South Gujarat and conduct traffic surveys to assess the traffic intensity and pattern;
(2) To estimate the diverted component of traffic that will use the proposed Kalpasar road/rail linkages; and
(3) To identify the future road links that will be used for dispersal of traffic after the operation of Kalpasar project.

(a) Traffic surveys

Various traffic surveys are carried out to assess existing characteristics of the traffic. The purpose of each of the traffic surveys is presented below:
(1) **Classified Volume Counts (CVC)** is carried out to assess the traffic intensity on existing road links that would cater to road over the Kalpasar dyke;
(2) **Origin-Destination (OD) surveys** are carried out at identified locations to capture current travel pattern in general and East-West traffic (i.e., South Gujarat to Saurashtra traffic) in particular that is likely to use Kalpasar dyke;
(3) **Turning Movement Count (TMC) surveys** are carried out to understand the turning traffic and diversions at major intersections;
(4) **Speed delay surveys** are carried out to assess the travel time and delay characteristics of road network in project influence area;
(5) **Trip Generation Surveys** are conducted at selected industrial units in Kalpasar project influence area to assess the trip generation rates; and
(6) **Truck Operators willingness to pay Surveys** are conducted to assess the willingness to pay the toll on the proposed Kalpasar transportation link.

The details of survey locations and schedule of surveys are presented in **Table 2.15.**

Table 2.15: List of traffic survey locations and schedule

No.	Location Id	Location	Road name	Type of survey	Schedule
Classified Volume Count- Mid Block					
1	CVC-1	Dahej Toll Plaza	SH-6	3 days x 24 hours	8th to 10th Feb 2022

No.	Location Id	Location	Road name	Type of survey	Schedule
2	CVC-2	Bharuch-Vagra Road (Near Vagara)	SH-161		9th to 11th Feb 2022
3	CVC-3	Amod-Muler Road (Near Amod)	SH-6		9th to 11th Feb 2022
4	CVC-4	Karjan Toll plaza	NH-48	7 days x 24 hours	8th to 14th Feb 2022
5	CVC-5	Padra-Borsad Road (Near Bhadran)	NH-228	3 days x 24 hours	9th to 11th Feb 2022
6	CVC-6	Borsad Toll Plaza	SH-8	7 days x 24 hours	11th to 17th Feb 2022
7	CVC-7	Vataman Toll plaza (Non-Operational)	SH-6		15th to 21th Feb 2022
8	CVC-8	Bagodara Toll plaza	NH-47		12th to 18th Feb 2022
9	CVC-9	Kotda Toll Plaza (Non-Operational)	NH-751	3 days x 24 hours	14th to 16th Feb 2022
10	CVC-10	Bhavnagar-Talaja Road	NH-51		16th to 18th Feb 2022
11	CVC-11	Limda-Sihor (Near Sihor)	NH-8E		14th to 16th Feb 2022
Turning Movement Count Location					
12	TMC-1	Jambusar, Amod and Bharuch Junction		1 Day x 24 Hours	9th Feb 2022
13	TMC-2	Jambusar Junction (Circle)			14th Feb 2022
14	TMC-3	Mahuvad/Navpura Junction (Near Padra)			9th Feb 2022
15	TMC-4	Dharmaj Junction			14th Feb 2022
16	TMC-5	Tarapur Chowkdi			14th Feb 2022
17	TMC-6	Vataman Chowkdi			21h Feb 2022
18	TMC-7	Bagodara T-Junction			18th Feb 2022
OD Survey Location					
19	OD-1	Dahej Toll Plaza	SH-6	1 Day x 24 Hours	8th Feb 2022
20	OD-2	Karjan Toll Plaza	NH-48		8th Feb 2022
21	OD-3	Borsad Toll Plaza	SH-8		11th Feb 2022
22	OD-4	Vatman Toll Plaza (Non-Operational)	SH-6		21th Feb 2022
23	OD-5	Bagodara Toll Plaza	NH-47		18th Feb 2022
24	OD-6	Kotda Toll Plaza (Non-Operational)	NH-751		16th Feb 2022
25	OD-7	Kobadi Toll Plaza	NH-51		18th Feb 2022
Other Traffic Surveys					
Trip Generation Surveys- Major Industries nodes (50 Samples)					27th Jan 2022 to Feb
Transport Operators Survey- Project Influence Area (250 Samples)					27th Jan to 20th

No.	Location Id	Location	Road name	Type of survey	Schedule
					Feb
Speed and Delay Survey- Road network in the project influence area					18th Feb 2022 to 20th Feb

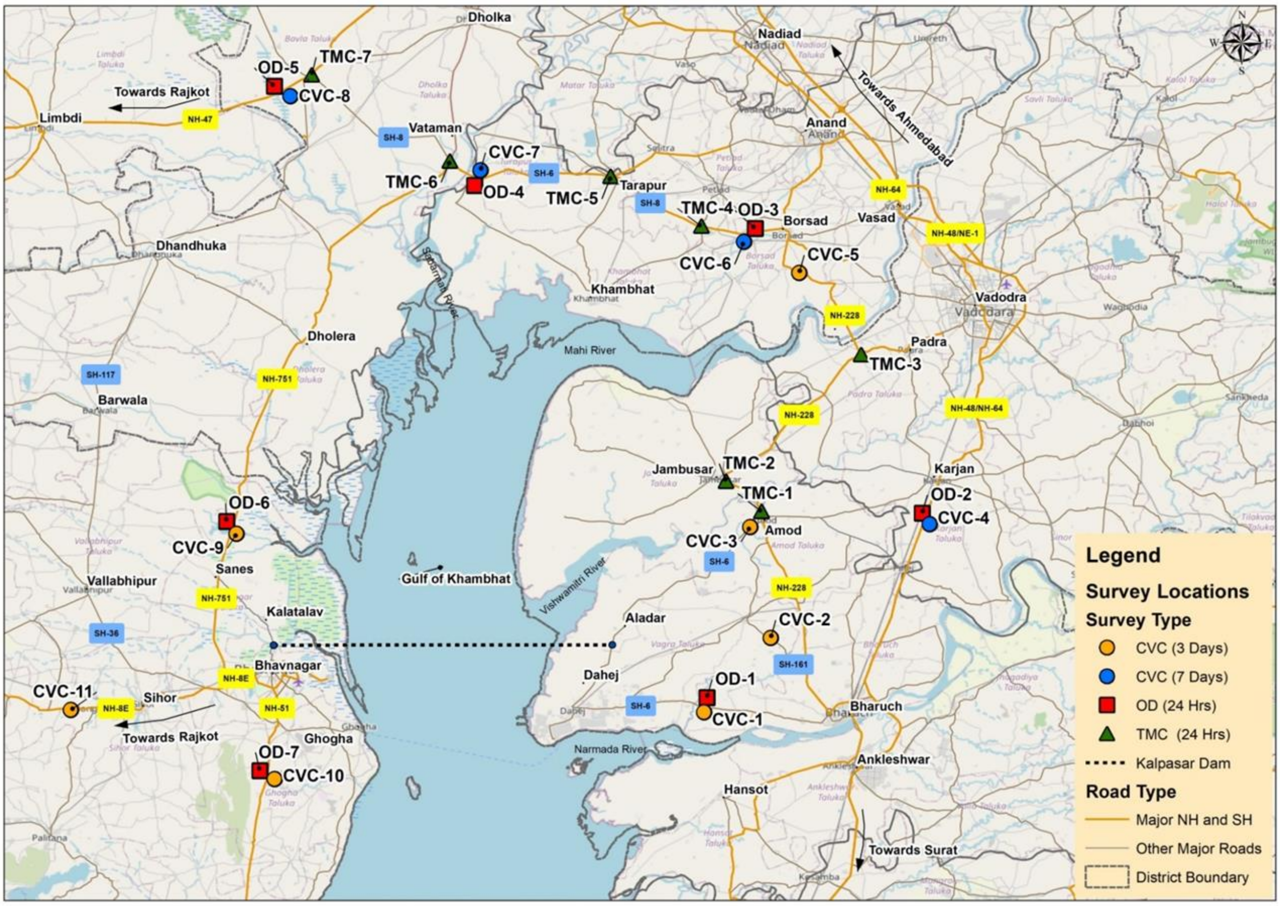


Figure 2.6: Map showing traffic survey locations

- **Classified Traffic Volume Count (CVC) survey analysis**

- **Average Daily Traffic (ADT)**

Classified traffic volume counts have been carried out for 7 days/ 3 days to understand the traffic intensity. Three day classified volume counts are conducted on road links which can serve as dispersal links. The Commercial Goods Vehicles have been classified as LCV (4 tyre), LCV (6 tyre), 2 Axle Trucks, 3 Axle Trucks and Multi Axle Trucks. Private vehicles have been classified as Two Wheelers, Private Cars (Car/ Jeep/ Van/Taxi), Bus and Minibus.

Classified vehicle counts carried out at various locations are converted into PCUs based on guidelines for capacity analysis for rural areas (IRC-64-1990 "Guidelines of Capacity Analysis for rural Areas"). The recommended PCU values as per IRC are presented in **Table 2.16.**

Table 2.16: Passenger Car Units (PCU) factors recommended by IRC (Rural areas)

Sl. No	Vehicle type	PCU value
1	Truck, Bus	3.0
2	Truck Trailer, Tractor Trailer, MAV, Agricultural tractor	4.5
3	Light Commercial Vehicle	1.5
4	Passenger Car, Jeep, Pick up Van, Auto Rickshaw	1.0
5	Motorised Two Wheeler	0.5
6	Cycle	0.5
7	Animal drawn Vehicles (Bullock Carts)	8.0

Daily traffic volume by vehicle type and direction is added separately and averaged to determine the Average Daily Traffic (ADT). In addition to determining the number of vehicles, the equivalent passenger car units (PCUs) are also calculated. The average daily traffic (ADT) on roads in the project influence area is presented in **Table 2.17.**

It can be observed that the average daily traffic (ADT) on national highways varies from **15,216 PCUs** to **1,09,812 PCUs.** The highest traffic observed on NH-48 (Karjan toll plaza) and among the State Highways, Vataman-Tarapur section of SH-6 has highest traffic of **47,097 PCUs**.

- **Traffic composition**

Location wise traffic composition is arrived, and details are presented in **Table 2.18** as well as in Figure **2.7**. Important observations are as follows:

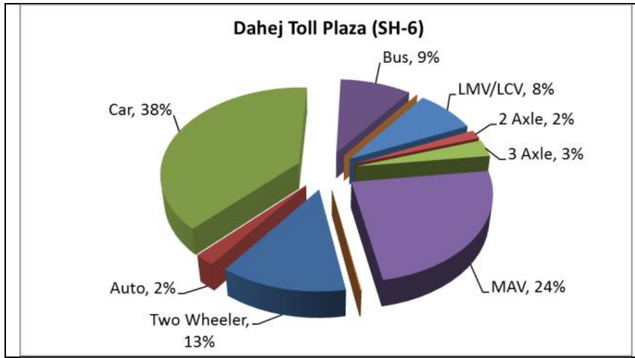
(1) It can be observed that proportion of passenger traffic varies from 58% to 88%;
(2) The proportion of passenger traffic is highest on SH-161-Bharuch-Vagra Road (88%) followed by NH-8E-Limda-Sihor Road (87%), NH-51-Bhavnagar-Talaja Road (82%), NH-228-Padra-Borsad Road (71%);
(3) Two Wheeler alone constitutes significant proportion (7% to 45%), Car constitutes around 22% to 47% of total vehicles; and
(4) Composition of Commercial traffic varies from 12% to 42%.

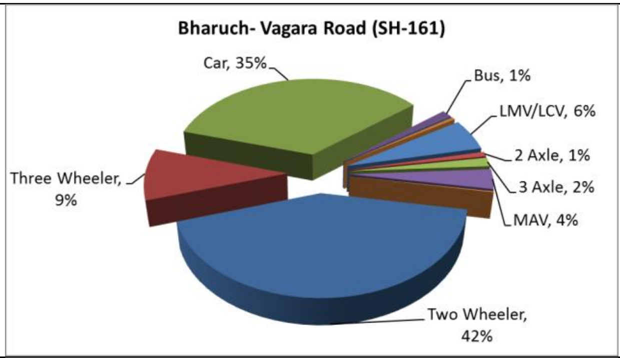
Table 2.17: Average Daily Traffic (ADT) on roads in project influence area (2022)

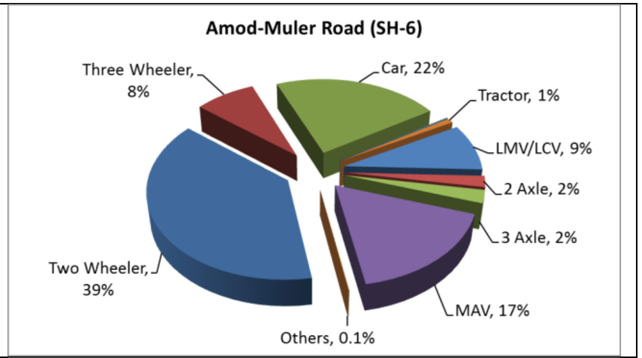
Road Name	NH-48	SH-8	SH-6	NH-47	SH-6	SH-161	SH-6	NH-228	NH-751	NH-51	NH-8E
Duration	7 days	7 days	7 days	7 days	3 days	3 days	3 days	3 days	3 days	3 days	3 days
Vehicle type\ location	Karjan toll plaza	Borsad toll plaza	Vataman toll plaza	Bagodara toll plaza	Dahej toll plaza	Bharuch-Vagra road	Amod-Muler road	Padra-Borsad road	Kotda toll plaza	Bhavnagar-Talaja road	Limda-Sihor road
Cars/Vans/ Jeeps	23,935	9,650	10,706	13,226	7,429	2,003	1,388	3,795	5,643	5,711	5,347
Auto	1,025	882	604	346	410	543	520	906	143	628	664
2 Wheelers	6,090	4,554	3,505	2,143	2,498	2,458	2,536	5,241	1,677	8,273	6,578
Bus	3,073	1,297	1,351	1,325	1,605	77	3	220	578	352	325
Mini Bus	91	52	54	78	213	5	-	19	33	36	34
2 Axle truck	2,590	826	787	1,140	309	49	130	412	456	384	258
3 Axle truck	2,625	996	1,148	1,953	603	92	157	623	535	482	267
MAV	9,971	3,616	4,386	6,277	4,660	206	1,099	1,885	1,712	1,260	339
LCV	5,762	1,570	2,111	2,742	1,234	248	351	917	1,075	813	580
Tata Ace	1,784	133	267	222	234	56	151	144	101	175	261
Goods Auto	211	138	53	61	87	24	32	166	19	61	119
Agricultural Tractors/ Tractor Trailer	52	85	147	114	17	24	57	91	24	99	53
Army/ Govt. Vehicle/ Ambulance	51	6	9	21	5	3	2	6	3	7	8
Cycle	6	6	4	11	1	3	8	121	1	5	73
Animal drawn	-	0	-	0	1	-	0	2	-	-	-
Others	13	7	38	46	12	4	6	4	9	33	61
Total Traffic (in Vehicles)	57,279	23,820	25,170	29,708	19,318	5,797	6,438	14,551	12,008	18,319	14,969
Total Traffic (in PCUs)	1,09,812	41,682	47,097	61,392	40,365	5,974	10,059	21,931	20,994	21,917	15,216

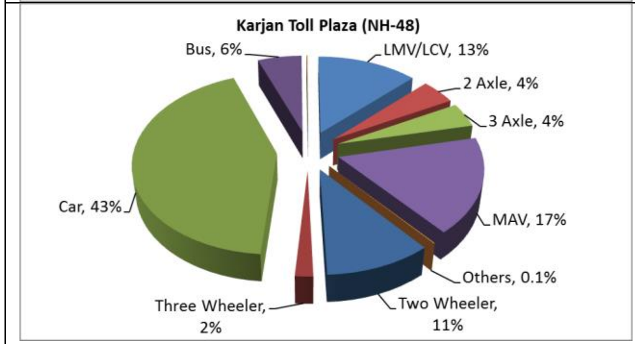
Table 2.18: Traffic composition on roads in project influence area

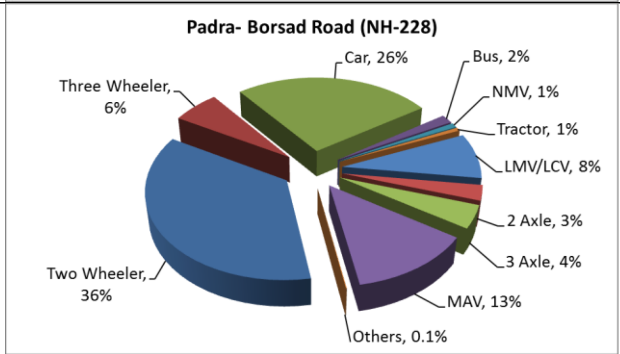
Road Name	NH-48	SH-8	SH-6	NH-47	SH-6	SH-161	SH-6	NH-228	NH-751	NH-51	NH-8E
Duration	7 days	7 days	7 days	7 days	3 days	3 days	3 days	3 days	3 days	3 days	3 days
Vehicle type\ location	Karjan toll plaza	Borsad toll plaza	Vataman toll plaza	Bagodara toll plaza	Dahej toll plaza	Bharuch-Vagra road	Amod-Muler road	Padra-Borsad road	Kotda toll plaza	Bhavnagar-Talaja road	Limda-Sihor road
Cars/Vans/ Jeeps	41.8%	40.5%	42.5%	44.5%	38.5%	34.6%	21.6%	26.1%	47.0%	31.2%	35.7%
Auto	1.8%	3.7%	2.4%	1.2%	2.1%	9.4%	8.1%	6.2%	1.2%	3.4%	4.4%
2 Wheelers	10.6%	19.1%	13.9%	7.2%	12.9%	42.4%	39.4%	36.0%	14.0%	45.2%	43.9%
Bus	5.4%	5.4%	5.4%	4.5%	8.3%	1.3%	0.0%	1.5%	4.8%	1.9%	2.2%
Mini Bus	0.2%	0.2%	0.2%	0.3%	1.1%	0.1%	0.0%	0.1%	0.3%	0.2%	0.2%
2 Axle truck	4.5%	3.5%	3.1%	3.8%	1.6%	0.8%	2.0%	2.8%	3.8%	2.1%	1.7%
3 Axle truck	4.6%	4.2%	4.6%	6.6%	3.1%	1.6%	2.4%	4.3%	4.5%	2.6%	1.8%
MAV	17.4%	15.2%	17.4%	21.1%	24.1%	3.5%	17.1%	13.0%	14.3%	6.9%	2.3%
LCV	10.1%	6.6%	8.4%	9.2%	6.4%	4.3%	5.5%	6.3%	9.0%	4.4%	3.9%
Tata Ace	3.1%	0.6%	1.1%	0.7%	1.2%	1.0%	2.3%	1.0%	0.8%	1.0%	1.7%
Goods Auto	0.4%	0.6%	0.2%	0.2%	0.4%	0.4%	0.5%	1.1%	0.2%	0.3%	0.8%
Agricultural Tractors/ Tractor Trailer	0.1%	0.4%	0.6%	0.4%	0.1%	0.4%	0.9%	0.6%	0.2%	0.5%	0.4%
Army/ Govt. Vehicle/ Ambulance	0.1%	-	-	0.1%	-	0.1%	-	-	-	-	0.1%
Cycle	-	-	-	-	-	0.1%	0.1%	0.8%	-	-	0.5%
Animal drawn	-	-	-	-	-	-	-	-	-	-	-
Others	-	-	0.2%	0.2%	0.1%	0.1%	0.1%	-	0.1%	0.2%	0.4%
Commercial Vehicles	40%	31%	35%	42%	37%	12%	31%	29%	33%	18%	13%
Passenger Vehicles	60%	69%	65%	58%	63%	88%	69%	71%	67%	82%	87%

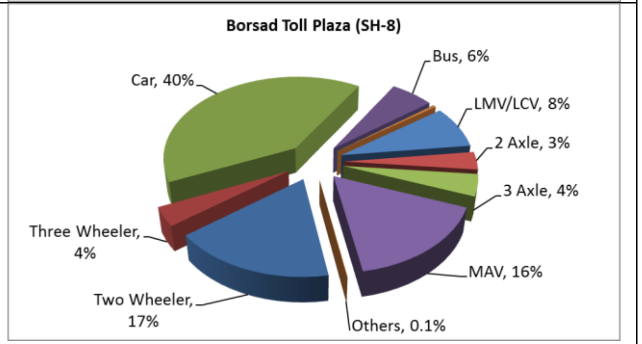

Dahej Toll Plaza (SH-6)
Bus, 9%
LMV/LCV, 8%
2 Axle, 2%
3 Axle, 3%
Car, 38%
MAV, 24%
Auto, 2%
Two Wheeler, 13%

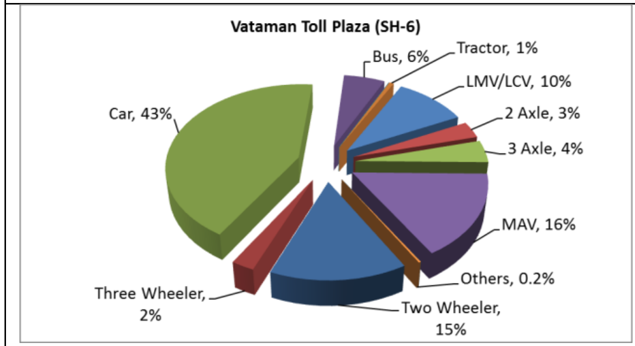

Bharuch- Vagara Road (SH-161)
Car, 35%
Bus, 1%
LMV/LCV, 6%
2 Axle, 1%
3 Axle, 2%
MAV, 4%
Three Wheeler, 9%
Two Wheeler, 42%

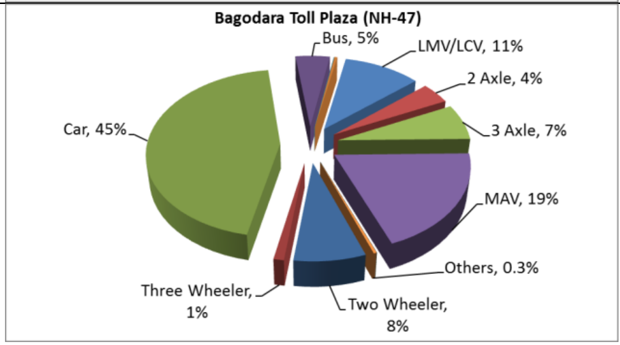

Amod-Muler Road (SH-6)
Three Wheeler, 8%
Car, 22%
Tractor, 1%
LMV/LCV, 9%
2 Axle, 2%
3 Axle, 2%
Two Wheeler, 39%
MAV, 17%
Others, 0.1%

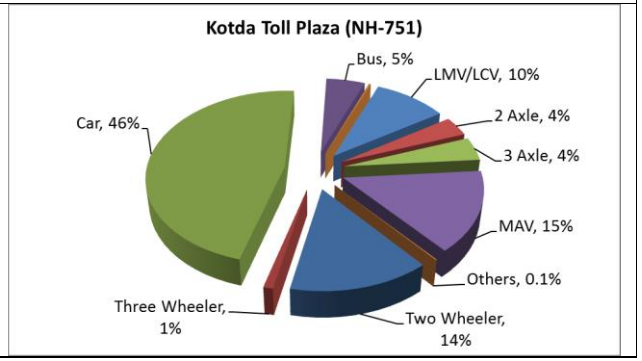

Karjan Toll Plaza (NH-48)
Bus, 6%
LMV/LCV, 13%
2 Axle, 4%
3 Axle, 4%
Car, 43%
MAV, 17%
Others, 0.1%
Three Wheeler, 2%
Two Wheeler, 11%

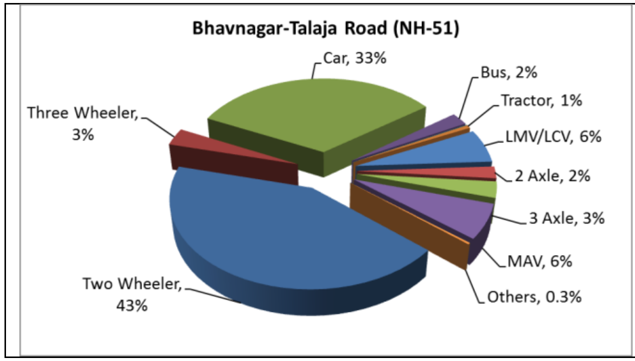

Padra- Borsad Road (NH-228)
Car, 26%
Bus, 2%
Three Wheeler, 6%
NMV, 1%
Tractor, 1%
LMV/LCV, 8%
2 Axle, 3%
3 Axle, 4%
Two Wheeler, 36%
MAV, 13%
Others, 0.1%


Borsad Toll Plaza (SH-8)
Bus, 6%
Car, 40%
LMV/LCV, 8%
2 Axle, 3%
3 Axle, 4%
Three Wheeler, 4%
MAV, 16%
Two Wheeler, 17%
Others, 0.1%


Vataman Toll Plaza (SH-6)
Tractor, 1%
Bus, 6%
LMV/LCV, 10%
Car, 43%
2 Axle, 3%
3 Axle, 4%
MAV, 16%
Others, 0.2%
Three Wheeler, 2%
Two Wheeler, 15%


Bagodara Toll Plaza (NH-47)
Bus, 5%
LMV/LCV, 11%
2 Axle, 4%
Car, 45%
3 Axle, 7%
MAV, 19%
Others, 0.3%
Three Wheeler, 1%
Two Wheeler, 8%


Kotda Toll Plaza (NH-751)
Bus, 5%
LMV/LCV, 10%
2 Axle, 4%
Car, 46%
3 Axle, 4%
MAV, 15%
Others, 0.1%
Three Wheeler, 1%
Two Wheeler, 14%



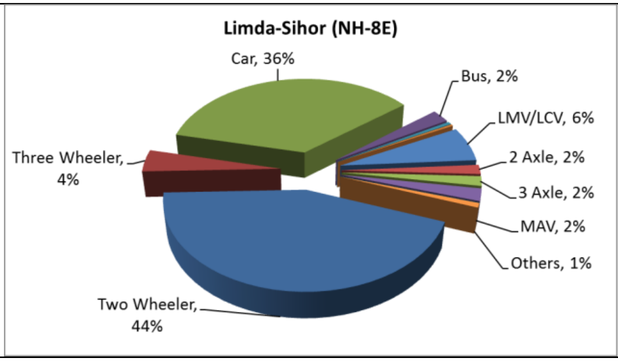


Figure 2.7: Traffic composition on roads in the project influence area

- **Peak hour traffic**

Peak hour traffic is estimated and presented in **Table 2.19**. It can be observed that peak hour traffic varies from 4.9% to 7.8% for various roads.

Table 2.19: Location-wise peak hour traffic

S. No	Road name	Peak hour	Peak hour traffic (PCUs)	% of total traffic
1	Dahej Toll Plaza	16:30-17:30	3,140	7.8%
2	Bharuch-Vagara Road (Near Vagara)	10:45-11:45	463	7.8%
3	Amod-Muler Road (Near Amod)	17:15-18:15	711	7.1%
4	Karjan Toll plaza	19:45-20:45	6,607	6.0%
5	Padra-Borsad Road (Near Bhadran)	17:00-18:00	1,338	6.1%
6	Borsad Toll Plaza	01:30-02:30	2,127	5.1%
7	Vataman Toll plaza (Non-Operational)	00:30-01:30	2,545	5.4%
8	Bagodara Toll plaza	17:30-18:30	3,023	4.9%
9	Kotda Toll Plaza (Non-Operational)	08:45-09:45	1,136	5.4%
10	Bhavnagar-Talaja Road	10:00-11:00	1,497	6.8%
11	Limda-Sihor (Near Sihor)	09:15-10:15	1,072	7%

- **Seasonal correction factors**

Traffic varies with seasons. To account for seasonal variations, seasonal correction factors have been derived. For the estimation of seasonal correction factors, month-wise toll data for three years at Karjan Toll Plaza (2017-2019) is used. The estimated seasonal correction factors are presented in **Table 2.20.**

Table 2.20: Seasonal correction factors

Sl.No.	Month	TW	Car	Bus	LCV	Truck	MAV /EMV /HCM
1	January	0.68	0.97	1.01	0.95	1.00	0.98
2	February	0.87	1.00	1.00	1.00	1.06	1.05
3	March	1.74	1.05	1.04	0.92	0.99	0.99
4	April	1.83	0.99	1.00	0.98	1.04	1.03
5	May	1.89	0.86	0.87	0.97	1.01	1.01
6	June	1.08	1.05	0.99	1.04	1.10	1.02
7	July	0.00	1.17	1.12	1.15	1.15	1.08
8	August	0.87	1.13	1.11	1.04	0.96	0.99
9	September	1.13	1.21	1.15	1.04	0.97	0.99
10	October	2.22	0.97	1.03	1.03	0.94	1.00
11	November	2.01	0.86	0.87	1.04	0.98	1.01
12	December	2.82	0.92	0.94	0.93	0.91	0.90

- **Average Daily Traffic (AADT)**

The Annual Average Daily Traffic (AADT) obtained after applying the seasonal correction factors is presented in **Table 2.21.**

Table 2.21: Annual Average Daily Traffic (AADT) – 2022

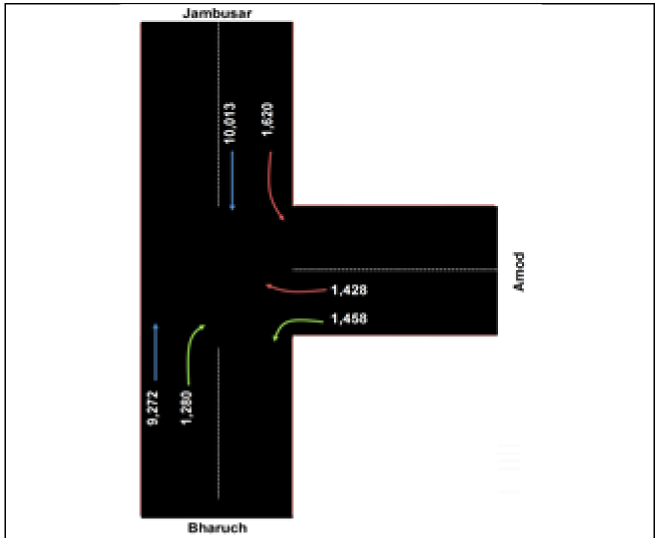
Road Name	NH-48	SH-8	SH-6	NH-47	SH-6	SH-161	SH-6	NH-228	NH-751	NH-51	NH-8E
Duration	7 days	7 days	7 days	7 days	3 days	3 days	3 days	3 days	3 days	3 days	3 days
Vehicle type\ location	Karjan toll plaza	Borsad toll plaza	Vataman toll plaza	Bagodara toll plaza	Dahej toll plaza	Bharuch -Vagra road	Amod-Muler road	Padra-Borsad road	Kotda toll plaza	Bhavnagar -Talaja road	Limda -Sihor road
Cars/Vans/ Jeeps	23,935	9,650	10,706	13,226	7,429	2,003	1,388	3,795	5,643	5,711	5,347
Auto	892	767	526	301	357	472	452	788	124	546	578
2 Wheelers	5,299	3,962	3,050	1,865	2,174	2,139	2,206	4,560	1,459	7,197	5,723
Bus	3,073	1,297	1,351	1,325	1,605	77	3	220	578	352	325
Mini Bus	91	52	54	78	213	5	-	19	33	36	34
2 Axle truck	2,746	876	834	1,209	327	52	137	436	483	407	273
3 Axle truck	2,756	1,046	1,206	2,051	633	97	165	654	562	506	280
MAV	10,470	3,797	4,605	6,591	4,893	216	1,154	1,979	1,797	1,323	356
LCV	5,762	1,570	2,111	2,742	1,234	248	351	917	1,075	813	580
Tata Ace	1,784	133	267	222	234	56	151	144	101	175	261
Goods Auto	184	120	46	53	75	21	28	144	17	53	104
Agricultural Tractors/ Tractor Trailer	52	85	147	114	17	24	57	91	24	99	53
Army/ Govt. Vehicle/ Ambulance	51	6	9	21	5	3	2	6	3	7	8
Cycle	6	6	4	11	1	3	8	121	1	5	73
Animal drawn	-	0	-	0	1	-	0	2	-	-	-
Others	13	7	38	46	12	4	6	4	9	33	61
Total Traffic (in Vehicles)	57,112	23,375	24,953	29,856	19,210	5,421	6,107	13,880	11,909	17,264	14,058
Total Traffic (in PCUs)	1,12,345	42,356	48,081	63,107	41,327	5,807	10,115	22,032	21,410	21,710	14,841

➢ **Turning Movement Count (TMC) survey analysis**

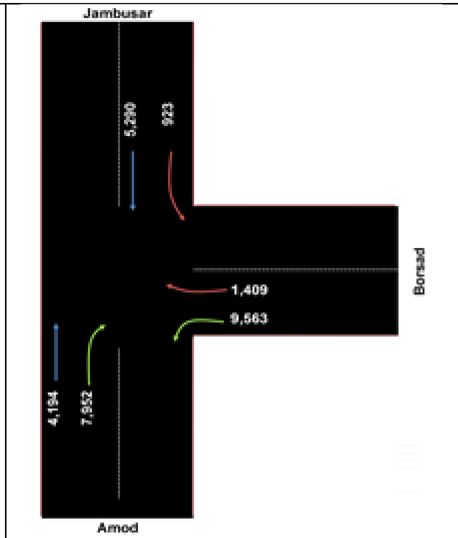
Turning movement surveys are carried out at 7 locations for 24 hrs. Turning movement data is used to understand turning traffic and the same is summarised in **Table 2.22**. Peak hour Traffic movement for the junctions are presented in **Figure 2.8.** Detailed junction volume count data is presented in **Annexure 2C.**

Table 2.22: Summary of junction counts

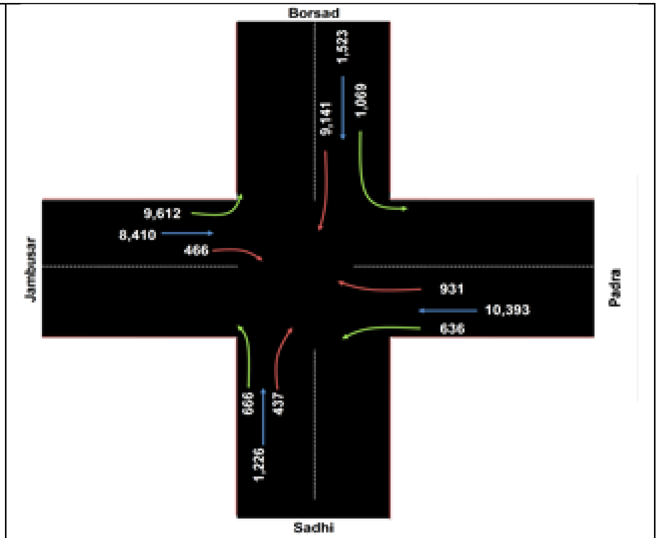
S. No.	Name of the junction	Type of junction	Daily traffic in PCUs (vehicles)	Major traffic movement in PCUs (vehicles)	Remarks
1	Jambusar, Amod and Bharuch Junction	3 arm Junction	25,070 (15,081)	Traffic movement between Jambusar – Bharuch is 19,285 (10,881) which is 77% of total junction traffic	Traffic between Amod – Bharuch is 2,737 (1,609) which is 11% of total junction traffic
2	Jambusar Junction (Circle)	3 arm junction	29,329 (22,120)	Traffic movement between Borsad - Amod is 17,514 (8,664) which is 60% of total junction traffic	Traffic between Jambusar - Amod is 9,483 (11,189) which is 32% of total junction traffic
3	Mahuvad/Navpura Junction (Near Padra)	4 arm Junction	44,508 (37,716)	Traffic movement between Borsad - Jambusar is 18,752 (9,204) which is 42% of total junction traffic	Straight traffic between Padra - Jambusar is 18,803 (20,380) which is 42% of total junction traffic
4	Dharmaj Junction	4 arm junction	18,248 (19,905)	Traffic movement between Tarapur - Borsad is 2,002 (2,307) which is11% of total junction traffic	Straight traffic between Davalpura – Virsad is 7,331 (7,629) which is 40% of total junction traffic
5	Tarapur Chowkdi	5 arm junction	59,566 (43,`)	Traffic movement between Borsad-Vataman is 37,277 (19,834) which is 63% of total junction traffic	
6	Vataman Chowkdi	4 arm junction	45,138 (24,343)	Traffic movement between Tarapur - Bhavnagar is 13,882 (7,353) which is 31% of total junction traffic	Straight traffic between Vataman – Bhavnagar is 5,231 (3,947) which is 12% of total junction traffic Cross traffic between Tarapur - Bagodara is 22,104 (9,281) which is 49% of total junction traffic
7	Bagodara T-Junction	3 arm Junction	79,889 (43,013)	Traffic movement between Tarapur – Rajkot is 23,791 (9,989) which is 30% of total junction traffic	Straight traffic between Ahmedabad - Rajkot is 54,847 (32,029) which is 69% of total junction traffic



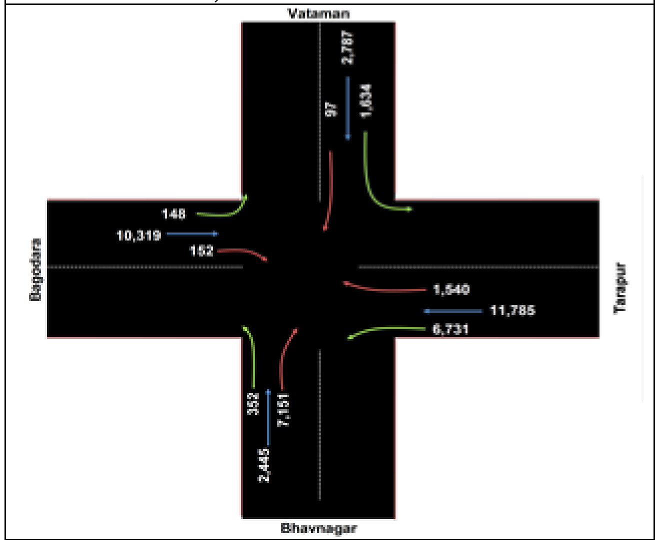
Jambusar, Amod and Bharuch Junction



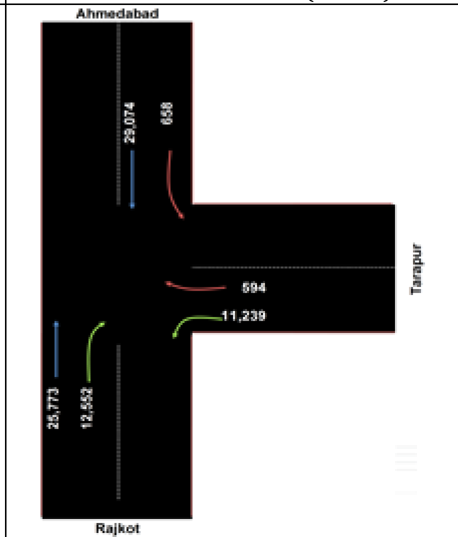
Jambusar Junction (Circle)



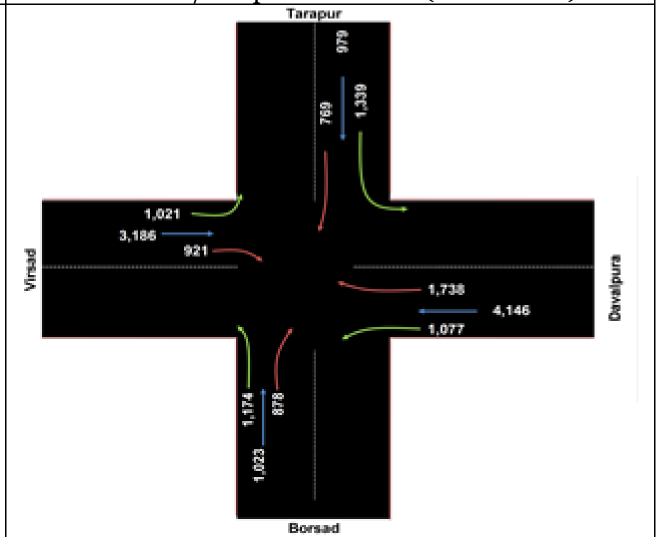
Mahuvad/Navpura Junction (Near Padra)



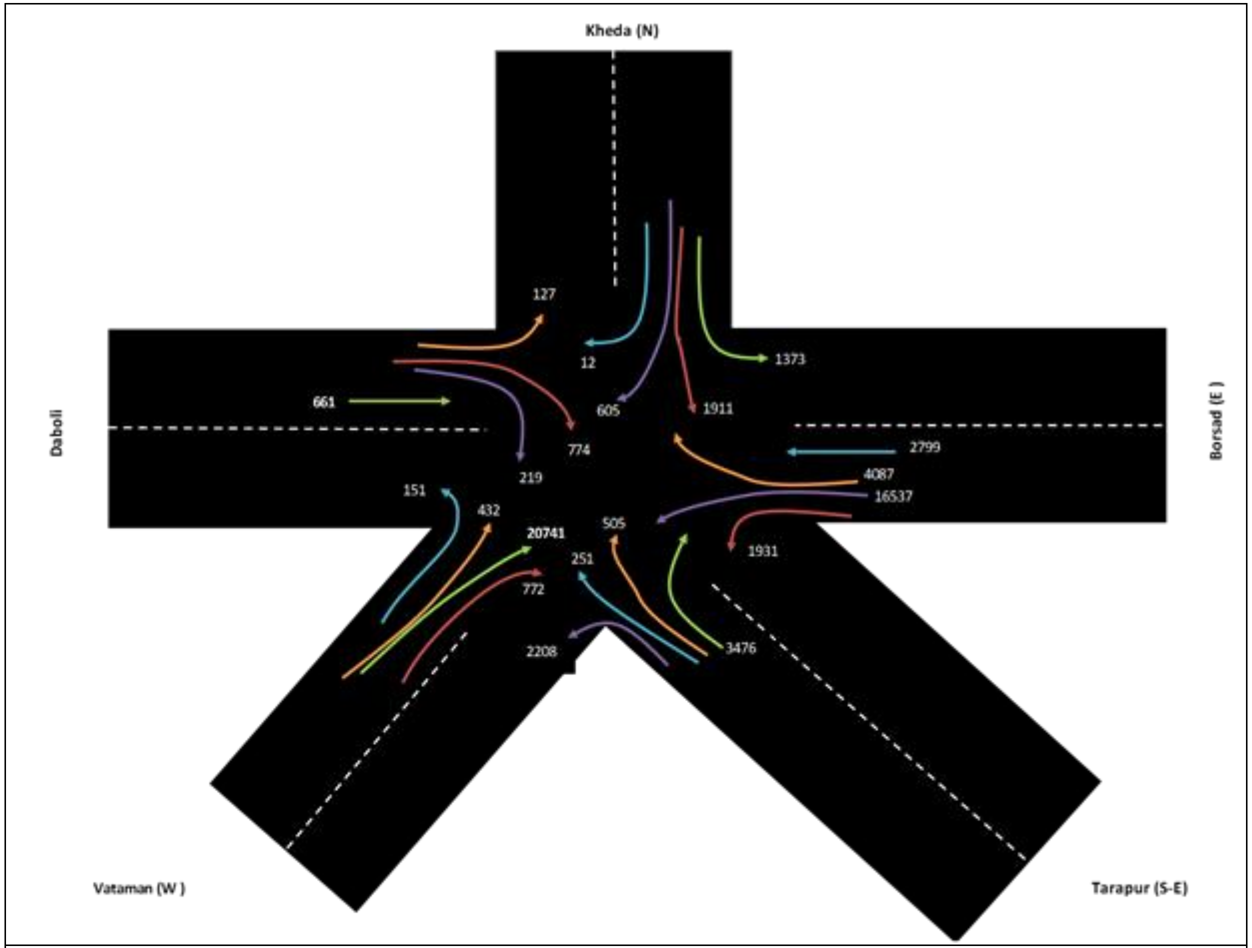
Dharmaj Junction



Bagodara T-Junction



Vataman Chowkdi



Tarapur Chowkdi

Figure 2.8: Pictorial representation of daily turning traffic (PCUs) at major intersection

➢ Origin-Destination (O-D) survey analysis

To understand the existing travel pattern, Origin-Destination (O-D) surveys are carried out for one day at 7 locations for 24 hours. Information such as origin, destination, purpose of trip (for passenger vehicles) and commodity carried, frequency of trips etc., are collected during the survey.

As part of the OD survey, willingness to pay survey for car users is carried out at Vataman Toll Plaza. Users are asked about their willingness to pay the toll rates for the new Road on Kalpasar Project. The users are informed about the savings in travel distance and travel time before asking for their willingness to pay the toll.

- **Sample size**

O-D surveys are carried out on sample basis and the percentage of samples collected for various categories of vehicles is presented in **Table 2.23**.

Table 2.23: Mode-wise sample size at origin–destination survey locations

Location	Car	LCV	2-Axle trucks	3-Axle trucks	MAV
Dahej Toll Plaza	17%	37%	49%	48%	23%
Karjan Toll Plaza	21%	43%	52%	56%	61%
Borsad Toll Plaza	29%	43%	36%	65%	61%
Vatman Toll Plaza (Non-Operational)	19%	22%	29%	33%	37%
Bagodara Toll Plaza	15%	28%	41%	65%	33%
Kotda Toll Plaza (Non-Operational)	18%	22%	24%	34%	28%
Kobadi Toll Plaza	15%	15%	23%	36%	19%

- **Zoning system**

To assess the traffic pattern on the project influence area, zoning system is developed keeping in view the major generation and attraction points. The entire project influence area is divided into 208 zones for O-D analysis and the same presented in **Figure 2.9 and in Annexure 2F.**

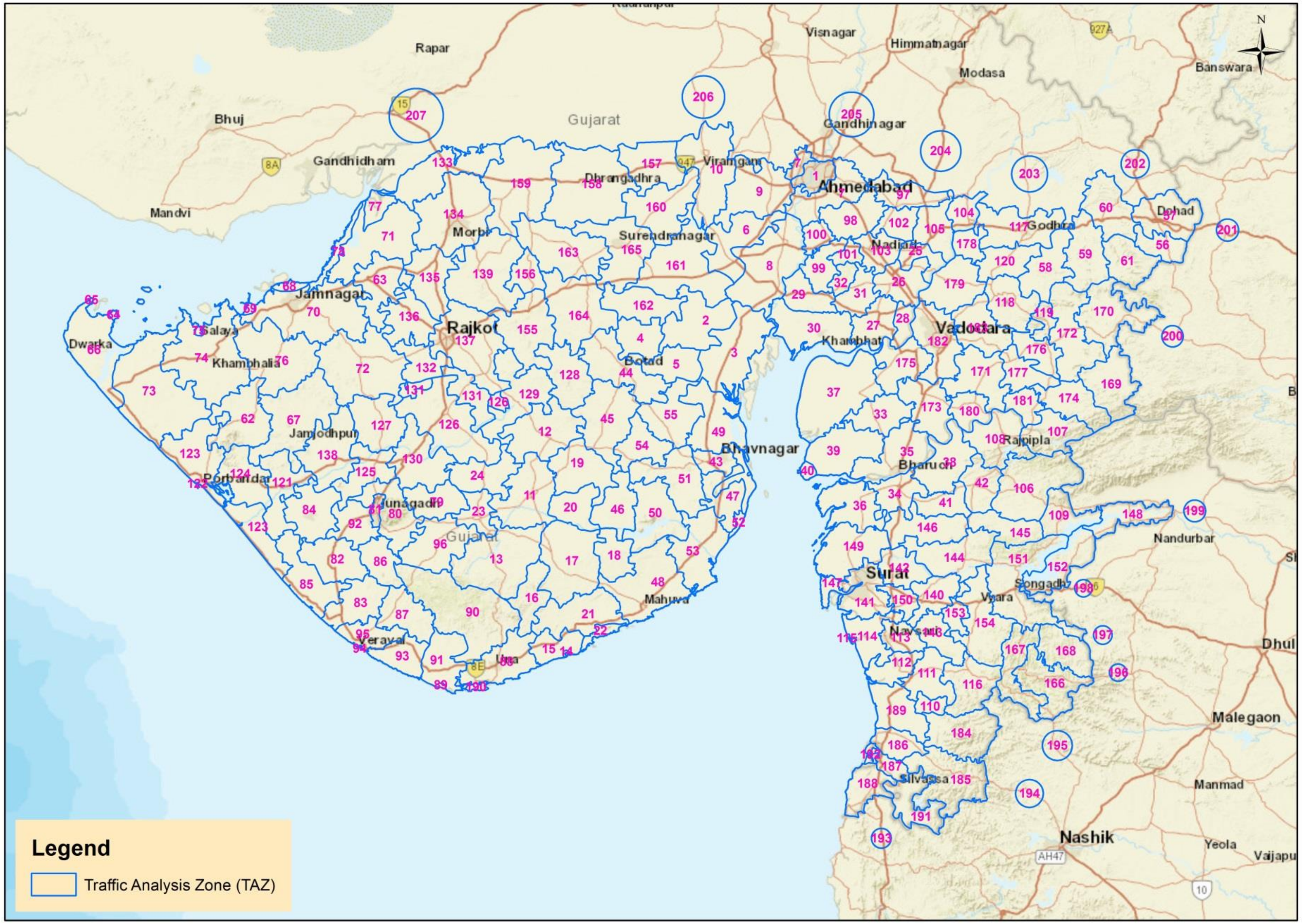


Figure 2.9: Map of Traffic Analysis Zones (TAZs)

- **Influence factor (I.F)**

O-D survey results provide a clear indication of the regions, which contribute to the traffic on existing roads in the project influence area. Number of trips originating from and destined to any zone represents the influence of that zone on the traffic. Sum of trips originating from and destined to any zone divided by twice the total number of observed trips in percentage terms gives the influence factor (I.F) of that zone. The formula for estimation of influence factor is presented below.

$$I.F = \frac{\sum O_i + \sum D_j}{\sum (O_i + D_j)}$$

The O-D matrices developed from O-D survey data is used to estimate the influence factors. Region-wise influence factors at various survey locations are presented in **Table 2.24** to **Table 2.30**.

Table 2.24: Region wise influence factors at Dahej toll plaza on SH-6

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
South Gujarat	4%	10%	-	7%	11%	11%	14%	18%	14%
Central Gujarat	95%	90%	-	93%	68%	66%	65%	59%	65%
Saurashtra	-	-	-	-	1%	1%	1%	1%	1%
Kutch	-	-	-	-	-	-	-	-	-
North Gujarat & Northern State	1%	-	-	1%	5%	4%	4%	6%	5%
Other States	-	-	-	-	14%	17%	15%	17%	16%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2.25: Region wise influence factors at Karjan toll plaza on NH-48

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
South Gujarat	24%	28%	29%	27%	18%	17%	17%	16%	17%
Central Gujarat	49%	28%	23%	34%	41%	32%	32%	30%	34%
Saurashtra	6%	32%	31%	23%	7%	8%	7%	9%	8%
Kutch	-	-	-	-	1%	1%	1%	2%	1%
North Gujarat & Northern State	7%	1%	2%	3%	9%	14%	16%	14%	13%
Other States	14%	11%	15%	13%	24%	29%	27%	28%	27%

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2.26: Region wise influence factors at Borsad toll plaza on SH-8

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
South Gujarat	17%	33%	24%	24%	9%	9%	11%	10%	10%
Central Gujarat	51%	13%	25%	30%	31%	25%	29%	27%	28%
Saurashtra	26%	44%	35%	35%	34%	43%	39%	38%	39%
Kutch	-	-	-	-	4%	4%	3%	4%	4%
North Gujarat & Northern State	2%	-	2%	2%	2%	2%	2%	1%	2%
Other States	3%	11%	14%	9%	20%	18%	16%	19%	18%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2.27: Region wise influence factors at Vataman toll plaza on SH-6

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
South Gujarat	13%	35%	25%	24%	11%	13%	11%	10%	11%
Central Gujarat	43%	8%	25%	25%	34%	26%	24%	22%	26%
Saurashtra	36%	49%	49%	45%	40%	43%	42%	42%	42%
Kutch	1%	-	-	-	1%	2%	3%	2%	2%
North Gujarat & Northern State	1%	-	-	-	1%	1%	2%	2%	2%
Other States	4%	7%	-	4%	14%	16%	18%	21%	17%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2.28: Region wise influence factors at Bagodara toll plaza on NH-47

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
South Gujarat	4%	16%	-	6%	3%	5%	3%	5%	4%
Central Gujarat	45%	28%	50%	41%	34%	32%	37%	28%	33%
Saurashtra	46%	50%	50%	49%	48%	49%	48%	46%	48%

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
Kutch	-	-	-	-	3%	1%	2%	4%	3%
North Gujarat & Northern State	4%	2%	0%	2%	2%	3%	3%	5%	3%
Other States	2%	4%	0%	2%	10%	10%	7%	12%	10%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2.29: Region wise influence factors at Kotda toll plaza on NH-751

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MAV	Average of goods vehicles
South Gujarat	7%	14%	-	7%	8%	2%	6%	5%	5%
Central Gujarat	36%	29%	49%	38%	32%	33%	32%	28%	31%
Saurashtra	51%	51%	49%	51%	51%	52%	51%	51%	51%
Kutch	-	-	-	-	1%	1%	-	1%	1%
North Gujarat & Northern State	2%	-	-	1%	4%	6%	5%	9%	6%
Other States	3%	5%	-	3%	5%	6%	5%	6%	6%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 2.30: Region wise influence factors at Kobadi toll plaza on NH-51

Zone name	Car	Bus	Mini bus	Average of passenger vehicles	LCV	2 Axle truck	3 Axle truck	MA V	Average of goods vehicles
South Gujarat	2%	24%	-	8%	2%	2%	2%	3%	2%
Central Gujarat	3%	7%	4%	5%	9%	7%	11%	15%	11%
Saurashtra	93%	66%	96%	85%	83%	87%	79%	69%	79%
Kutch	-	-	-	-	1%	0%	2%	2%	1%
North Gujarat & Northern State	1%	1%	-	1%	3%	2%	4%	6%	4%
Other States	1%	2%	-	1%	3%	2%	2%	5%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Based on the influence factors, the following inferences are drawn:
(1) The influence of Central Gujarat and South Gujarat region is high at Dahej Toll Plaza and Karjan Toll Plaza; and
(2) The Influence of Saurashtra and Central Gujarat region is high at rest of the other locations.

Based on the influence factors derived at Vataman Toll Plaza, the following inferences are drawn:
(1) Average Influence of South Gujarat, Central Gujarat and Saurashtra are 11%, 26% and 42% respectively in Commercial vehicles. The Influence of Kutch is only 2%; and
(2) Average Influence of South Gujarat, Central Gujarat and Saurashtra are 24%, 25% and 45% respectively in Passenger vehicles.

The proportion of East-West Traffic (i.e. Traffic between South Gujarat and Saurashtra and Kutch regions and vice versa) at various O-D survey locations (toll plaza locations) are derived and presented in **Table 2.31** and **Table 2.32.** East-west traffic is potential traffic for Kalpasar project.

The proportion of E-W traffic at Vataman, Karjan, Borsad and Bagodara is 57.6%, 16.9%, 41.8% and 28.6% (in total tollable traffic) respectively. At present, Vataman Toll plaza is capturing all East-West traffic, which further splits to SH-6 (toward Bhavnagar) and NH-8A (Bagodara & Rajkot etc.).

Table 2.31: East-West traffic at major Toll Plaza Locations

Vehicle type	Vataman toll plaza			Karjan toll plaza		
	total traffic	E-W traffic	% of E-W traffic	Total traffic	E-W traffic	% of E-W traffic
Car	10,706	4,865	45.40%	25,190	2,957	11.70%
Bus	1,351	1,186	87.80%	3,055	1,684	55.10%
Mini Bus	54	40	75.00%	74	40	54.50%
Tata Ace	267	155	58.20%	1,502	137	9.10%
LCV	2,111	1,513	71.70%	4,882	731	15.00%
2 Axle Truck	787	633	80.40%	2,595	425	16.40%
3 Axle Truck	1,148	592	51.60%	2,398	393	16.40%
MAV	4,386	3,007	68.60%	9,110	1,882	20.70%
Total Vehicles	20,810	11,992	57.60%	48,806	8,250	16.90%
Total PCUs	43,949	28,193	-	1,00,016	20,298	-
Vehicle type	Bagodara toll plaza			Borsad poll plaza		
	Total traffic	E-W traffic	% of E-W traffic	Total traffic	E-W traffic	% of E-W traffic
Car	13,226	1,085	8.20%	8,836	3,157	35.70%
Bus	1,326	574	43.30%	1,727	1,364	79.00%
Mini Bus	78	-	0.00%	51	27	52.90%
Tata Ace	222	45	20.10%	120	20	13.70%
LCV	2,742	927	33.80%	1,285	497	38.70%
2 Axle Truck	1,140	199	17.50%	1,060	522	49.30%
3 Axle Truck	1,953	455	23.30%	941	370	39.40%

MAV	6,277	4,435	70.70%	3,198	1239	38.70%
Total Vehicles	26,964	7,719	28.60%	17,218	7,197	41.80%
Total PCUs	59,293	26,184	-	36,595	16,319	-

Table 2.32: East-West traffic at minor Toll Plaza Locations

Vehicle type	Dahej toll plaza			Kotda toll plaza			Kobadi toll plaza		
	Total traffic	E-W traffic	% of E-W traffic	Total traffic	E-W traffic	% of E-W traffic	Total traffic	E-W traffic	% of E-W traffic
Car	7,998	38	0.50%	9,272	3,158	34.10%	9,326	603	6.50%
Bus	1,572	-	0.00%	1,369	625	45.60%	1,369	726	53.00%
Minibus	-	-	0.00%	45	49	107.70 %	45	3	7.70%
Tata Ace	205	-	0.00%	420	230	54.80%	420	70	16.60%
LCV	1,390	25	1.80%	2,001	792	39.60%	2,001	279	13.90%
2 Axle Truck	364	10	2.70%	919	202	22.00%	919	121	13.20%
3 Axle Truck	426	7	1.70%	1,198	365	30.50%	1,198	241	20.10%
MAV	5,701	70	1.20%	4,165	1,581	38.00%	4,165	1,213	29.10%
Total Vehicles	17,656	150	0.80%	19,389	7,001	36.10%	19,443	3,255	16.70%
Total PCUs	43,131	440	-	42,172	15,455	-	42,226	9,853	6.50%

Although influence factors have been worked at all the O-D survey locations, Vataman toll plaza influence is more appropriate for understanding E-W traffic which is likely to use Kalpasar and therefore Influence Factors derived at Vataman Toll Plaza is presented in **Table 2.33.** Summary of zone-wise influence factors is given in **Annexure-2E.**

- **Zone wise influence factors**

Based on O-D surveys data, mode wise zone wise influence factors is analysed and presented in **Table 2.33.**

Table 2.33: Zone-wise influence factors at Vataman toll plaza

Zone no.	Name of zone	LCV	2A	3A	MAV	Car	Bus
1	Ahmedabad	1%	-	1%	1%	1%	-
3	Dholera	3%	1%	-	-	2%	-
5	Barwala	-	-	-	-	1%	-
6	Bavla	2%	2%	2%	1%	4%	-
8	Dholka	3%	2%	2%	2%	7%	-
11	Amreli	3%	3%	2%	1%	3%	-
17	Kundla	-	1%	-	-	-	-
26	Anand	6%	4%	3%	1%	3%	-
27	Borsad	2%	1%	-	-	1%	-
29	Tarapur	6%	4%	3%	2%	8%	-

Zone no.	Name of zone	LCV	2A	3A	MAV	Car	Bus
30	Khambhat	1%	1%	1%	1%	1%	-
31	Petlad	-	-	-	-	1%	-
34	Ankleshwar	-	0%	1%	1%	2%	-
35	Bharuch	1%	1%	1%	1%	1%	-
37	Jambusar	-	-	1%	-	-	-
39	Vagra	-	2%	2%	2%	-	-
43	Bhavnagar	7%	5%	7%	8%	9%	20%
48	Mahuva	-	-	-	-	-	2%
66	Dwarka	-	2%	1%	1%	1%	-
70	Jamnagar	5%	7%	5%	6%	1%	3%
80	Junagadh	-	1%	1%	-	-	-
88	Una	-	-	-	-	-	1%
91	Kodinar	-	-	1%	-	-	-
95	Patan-Veraval	2%	-	1%	1%	-	1%
113	Navsari	-	-	-	-	1%	-
134	Morbi	9%	6%	9%	11%	3%	-
137	Rajkot	11%	12%	9%	9%	10%	19%
141	Surat City	9%	10%	8%	7%	11%	35%
143	Mahuva-1	-	1%	-	-	-	-
155	Chotila	-	1%	1%	1%	1%	-
161	Limbdi	-	1%	1%	-	1%	-
163	Muli	-	-	-	-	1%	-
164	Sayla	-	-	2%	1%	1%	-
165	Wadhwan	1%	2%	1%	1%	1%	-
182	Vadodara	9%	8%	7%	8%	11%	8%
187	Vapi	1%	1%	2%	2%	1%	-
190	Diu	-	-	-	-	-	1%
193	External-1 (Mumbai, Pune, South India)	10%	11%	12%	15%	2%	7%
195	External-3 (NH-360, Ahmed nagar, Aurangabad, Beed, Hingoli, Jalna, Latur, Nanded, Osmanabad)	3%	4%	5%	4%	-	-
200	External-8 (SH-26, Amaravati(MH), Nagpur, Rest of Chhattisgarh & UP)	-	-	-	-	2%	-
201	External-9 (NH-47, Indore, Bhopal, Rest of MP & UP)	-	-	1%	1%	-	-
204	External-12 (SH-59, Morena)	-	-	-	1%	-	-
205	External-13 (NH-48 (Gandhinagar, Sabar Kantha and Mahesana dist & Udaipur, Delhi, Rest of UP))	-	-	1%	-	-	-
207	External-15 (Kachchh District)	1%	2%	3%	2%	1%	-
208	External-16 (Kachchh District)	1%	1%	1%	1%	-	-

It is observed that **Surat, Ahmedabad District, Vadodara, Bhavnagar,** and **Rajkot zones** have significant influence as compared to other zones.

- **Trip frequency distribution**

Based on O-D surveys data, mode wise trip frequency distribution is analysed and presented in **Table 2.34.**

Table 2.34: Trip frequency distribution at Vataman toll plaza

Frequency	Car	LCV	2 axle	3 axle	MAV
Daily Once	-	13%	8%	10%	10%
Daily Twice (Up & Down)	10%	23%	12%	18%	20%
Multiple Trips a day	-	11%	11%	17%	14%
Alternate Day	4%	9%	12%	9%	7%
Weekly	28%	24%	23%	16%	18%
Monthly	29%	16%	24%	26%	25%
Others	28%	5%	10%	4%	6%

- **Trip purpose**

Trip Purpose of Passenger Vehicles are arrived at based on O-D survey data and presented in **Table 2.35.**

Table 2.35: Trip purpose distribution of passenger vehicles at Vataman toll plaza

Trip purpose	Vataman toll plaza (SH 8)
Work	8%
Business	42%
Education	5%
Shopping	2%
Social/ Religious/ Recreation	16%
Health/ Hospital	7%
Tourism	14%
Other Purpose	5%

- **Commodity distribution**

Mode wise commodity distribution is analyzed based on O-D survey carried out at Vataman Toll Plaza and is presented in **Table 2.36**.

Table 2.36: Commodity distribution for commercial vehicles at Vataman toll plaza

Commodity type	Both directions			
	LCV	2A	3A	MAV
Empty	37%	36%	32%	31%
Vegetables/ Fruits/ Milk/ Fish	1%	4%	2%	1%
Food Grains (Rice/ Wheat/ etc.)	2%	3%	5%	3%
Salt	-	-	1%	-
Sand/Cement/Aggregate/Steel/ Brick/Tiles	12%	11%	15%	25%
Wood	4%	1%	2%	2%
Textile Materials/Cotton	1%	-	1%	1%
Leather	-	-	-	-

Commodity type	Both directions			
	LCV	2A	3A	MAV
Plastic Products	-	2%	2%	1%
Iron coils/pipes/cables/wire	-	2%	3%	3%
Minerals (Limestone/Lignite, etc.,)	-	-	-	1%
Petrol/ Diesel/Gas/LPG/Sulphur	2%	3%	4%	5%
Fertilizer	-	-	-	-
Finished consumer Goods	3%	2%	3%	4%
Paint/dyes/chemicals	6%	5%	8%	8%
Machine & Machine Parts	1%	2%	3%	2%
Container	-	-	-	-
Others	4%	3%	2%	2%
Coal	1%	2%	2%	2%
Animal Feed, Chara	8%	2%	3%	3%
Cartoon, Courier, Bag, boxes, Jute Bag	15%	20%	11%	4%
Tyres	-	-	-	1%
Animals	-	-	-	-
Danger/ Hazardous	-	-	-	-
Debris/ Waste	-	-	1%	-
Total	100%	100%	100%	100%

- **Willingness to pay survey for car users**

Willingness to pay survey for car users is carried out at Vataman, Bagodara and Borsad Toll Plaza. Users are requested to reveal their willingness to pay given the current and proposed toll rates and savings in distance and time due to the Kalpasar road link. The proposed toll rates are fixed as 50% of the perceived benefits to Road users as per the Govt. of Gujarat Policy. The surveys revealed that around 89% users are willing to pay the toll proposed for the Kalpasar project.

- **Estimation of East–West traffic**

Kalpasar project will attract Traffic between Saurashtra and South Gujarat i.e. East-West Traffic. At present East-West passes through Vataman Toll Plaza. Based on O-D data collected at Vataman Toll Plaza, the total potential E-W traffic is estimated considering zones in Saurashtra, Kutch and South Gujarat who will benefit from reduced travel time and distance.

Based on O-D data analysis, it is revealed that around 58% of the traffic at Vataman is East-West traffic and remaining traffic is either local or North-South traffic. This traffic can be taken as potential divertible traffic on to the Kalpasar and the same is presented in **Table 2.37.**

Table 2.37: Total potential East–West traffic at Vataman toll plaza

Vehicle type	East-West traffic	Total traffic at Vataman	% Share potential diverted traffic
Car	4,865	10,706	45.4%
Bus	1,186	1,351	87.8%
Minibus	40	54	75.0%
Tata Ace	155	267	58.2%

Vehicle type	East-West traffic	Total traffic at Vataman	% Share potential diverted traffic
LCV	1,513	2,111	71.7%
2 Axle Truck	633	787	80.4%
3 Axle Truck	592	1,148	51.6%
MAV	3,007	4,386	68.6%
Total Vehicles	11,992	20,810	57.6%
Total PCUs	28,193	43,949	-

- **Speed and delay survey analysis**

Speed delay surveys are carried out major roads within the project influence area and section wise average speed is presented in **Table 2.38.**

Table 2.38: Section-wise average speed (Kmph)

Road section	Distance (Km)	Lane configuration	Average speed (Km/hr)
Bharuch Railway Junction to Jambusar Bypass	4.3	4L D	17.2
Jambusar Bypass to Dahej	40.2	6LD	52.4
Bharuch to Amod	33.8	2L+PS	43.1
Dahej to Muler	21.3	2L+PS	42.6
Bhelsli to Vagara	19.6	2L UD	28.0
Vagara to Muler	16.8	2L+PS	48.0
Muler to Amod	24.6	2L+PS	38.8
Amod to Vagara	18	IM L	41.5
Vagara to Derol	12.6	2L+PS , 4L D	32.9
Dayadra to Nabipur	11.5	4L D	28.8
Bharuch to Karjan	39.7	6L D	59.6
Amod to Karjan	26.6	2L UD	38.0
Amod to Jambusar	8.9	2L+PS	33.4
Jambusar to Devla	24.8	2L UD	34.6
Devla to Jantran	24	2LUD / IM L	55.4
Jantran to Kavi	22	2L UD	36.7
Kavi to Jambusar	26.6	2L UD	28.0
Jambusar to Mahuvad	29.6	2L+PS	35.5
Mahuvad to Borsad	28.3	2L+PS	42.5
Borsad to Anand	15.6	2L+PS ,4L D	28.4
Borsad Byepass to Borsad Byepass	5.6	6L D	48.0
Borsad to Tarapur	27.2	6L D	68.0
Dharmaj to Khambhat	21.4	2L UD	42.8
Khambhat to Tarapur	21.4	2L+PS	45.9
Tarapur to Vataman	26.3	6L D	49.3
Vataman to Bagodara	27.3	6L D	65.5
Bagodara to Limbdi	42.8	6L D	45.9
Tarapur to Anand	33.7	2L UD	46.0
Anand to Nadiad	24.4	6L D	47.2

Road section	Distance (Km)	Lane configuration	Average speed (Km/hr)
Nadiad to Kheda	19.1	6L D	49.8
Kheda to Dholka	25.9	4L D	51.8
Dholka to Vataman	22.9	4L D	42.9
Vataman to Pipali	23.9	2L+PS	47.8
Pipali to Fedara	11.9	4L D	47.6
Bagodara to Fedara	21.2	4L D	50.9
Fedara to Dhanduka	22.1	2L+PS	51.0
Dholera to Dhanduka	26.8	2L+PS	50.3
Dhanduka to Muldhari	43.2	2L+PS	46.3
Muldhari to Vartej	43.1	2L UD	44.6
Vartej to Bhavnagar	8.5	4L D	30.0
Bhavnagar to Bhuteshwar	13.9	2L+PS	46.3
Bhudel to Gogha	5.6	2L+PS	48.0
Budhel to Trapaj	32.6	4L D	43.5
Trapaj to Mahuva	55.8	4L D	49.2
Mahuva to Amreli	87.7	2L UD	43.9
Amreli to Chavand	29.7	2L UD	54.0
Chavand to Limbda	25.5	4L D	54.6
Limbda to Ramdhari	20	4L D	50.0
Ramdhari to Vartej	26.2	4L D	44.9
Bhavnagar to Adhelai	34.8	4L D	45.4
Adhelai to Pipali	41.4	2L+PS	57.8

Note: L-Lane; D-Divided; PS-Paved Shoulder; IM-Intermediate Lane

- **Trip generation survey analysis**

Trip Generation Surveys are carried at around 50 industrial units in the project Influence area to understand trip generation rates of various types of industries. Following Information is collected as part of the survey:
(1) Type of Industry, Product;
(2) Gross Area and Net Area;
(3) Total Trucks per day (In and Out); and
(4) O-D pattern (no. of trips per week, seasonal variation, origin, destination) of raw material and finished products.

Trip Generation Surveys are carried out to assess the trip generation rate of various types of industries in the project Influence area. Around 50 Industrial units are contacted. Major Industrial Activities in the Project Influence area based on the sample survey is presented in **Table 2.39.**

Table 2.39: Categorisation of major industrial activities

Industrial activity	Code
Food Processing Industry (Food grains, fruits, vegetables, fish, milk, eggs etc.,)	1
Fertilizers	2
Chemicals	3
Construction Material (Cement/Aggregate/Steel/ Brick/Tiles)	4

Industrial activity	Code
Iron coils/pipes/cables/wire	5
Alloy Materials	6
Steel Fabrication (Rolling/Cutting)	8
Ship Building Yard	9
Ship Breaking/Repairing Yard	10
Container/Bulk Movement (includes Loading & Unloading)	11
Storage/Cylindering unit of Gas	12
Petrol/ Diesel/Gas/LPG/Sulphur	13
Thermal Power Generation Unit	14
Processing of Cotton	15
Textile/ Apparel	16
Coloring/Dyeing/Embroidering of Clothes	17
Soda/Iodized Salt/Vacuum Salt/Bathing Soap/Detergent Powder & Cake/Glycerin/Bleaching Powder	18
Extraction of Salt (Salt pans)	19
Wood (includes Veneers)	20
Plastics	21
Automobiles / Automobile Components	22
Heavy Construction Machineries	23
Production of Leather Materials	24
Diamond Cutting	25
Metals/forging	26
Pharmaceuticals	27
Electrical/ Electronics	28
Other Manufacturing	29
Others (Specify)	30

Following Information is collected:
(1) Type of Industry;
(2) Type of Product;
(3) Gross Area and Net Area;
(4) Total Trucks per day (in and out); and
(5) Raw material and finished products OD pattern

The above information is used to estimate generated traffic from the proposed developments in project influence area. Based on sample survey, Sector-wise Trip Generation Rates are worked out for 13 industrial sectors and presented in **Table 2.40.**

Table 2.40: Sector wise Trip Generation Rates

S. no.	Sector	Trip generation rate (Trucks/Acre)
1	Food processing	2.50
2	Manufacturing-Cement	0.41
3	Manufacturing-Chemicals	2.13
4	Manufacturing-Pharmaceuticals	2.17
5	Manufacturing-Fertilizers	0.10
6	Manufacturing-Engineering goods	0.43

S. no.	Sector	Trip generation rate (Trucks/Acre)
7	Manufacturing-Metals	0.85
8	Manufacturing-Paints	0.70
9	Manufacturing-Plastic	0.74
10	Manufacturing-Textile	0.82
11	Petroleum/Gas	0.03
12	Power Generation	-
13	Shipbuilding	0.18

Considering appropriate weightages to various types of land uses, Average trip generation rate works out to be **0.80 trucks per acre per day or 1.98 trucks per hectare per day**. This generation rate is used for all the developments proposed in the project Influence Area.

- **Transport operators' interview survey analysis**

Truck operator survey is carried out to assess the willingness to pay the toll for the proposed Kalpasar. In addition to willingness to pay toll information, other related information such as fleet size, major origin-destinations, the route followed, present toll rates, fuel consumptions per kilometre are also collected. Around 250 Transport agencies/roadways/carriers are contacted for the survey.

The objective of the Truck operators' survey is to assess the Willingness to pay for Kalpasar project. In addition to willingness to pay toll information such as fleet size, major origin-destinations, the route followed, present toll rates, fuel consumptions per kilometre are also collected. About 250 Transport agencies/roadways/carriers are contacted for the survey. The survey is carried out at following locations:
(1) Ankleshwar;
(2)Bharuch;
(3)Surat;
(4) Ahmedabad;
(5) Vadodara;
(6) Alang;
(7) Amreli;
(8) Bhavnagar;
(9) Jamnagar;
(10) Portbandar;
(11) Rajkot; and
(12) Surendranagar

Region-wise sample size collected from truck operators are presented in **Figure 2.10.**

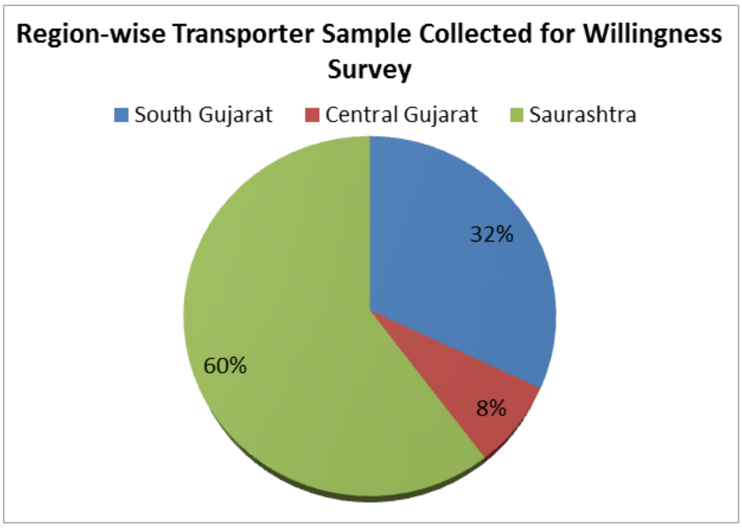
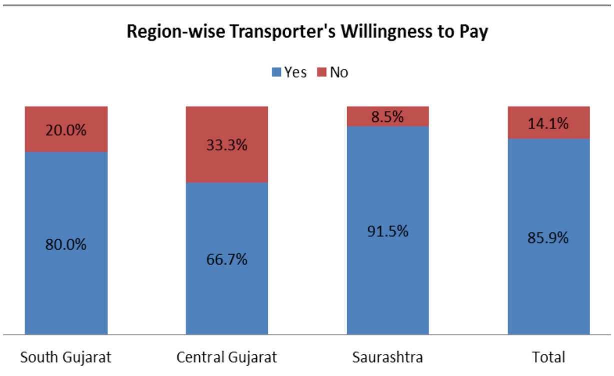


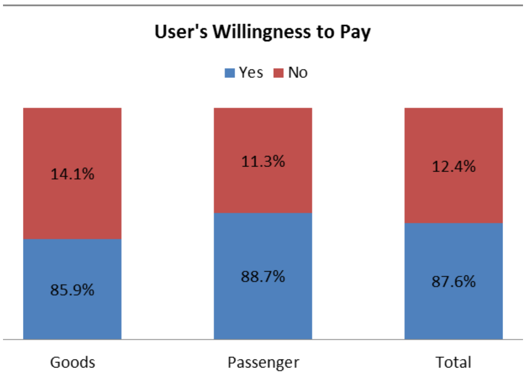
Figure 2.10: Region-wise sample size of truck operators

- **Willingness to pay the toll**

Truckers are informed about potential savings if they choose to use Kalpasar link and asked their willingness to pay the toll. The results of willingness to pay of truck operators are shown in **Figure 2.11**. Around 92% of the truck operators interviewed in Saurashtra and 80% of the truck operators interviewed in South Gujarat reported their willingness to pay the proposed toll.



Willingness to Pay the Toll of Truck Operators



Willingness to Pay the Toll of Truck & Car Operators

Figure 2.11: Willingness to pay the toll

- **Fuel mileage**

The operators are asked for the fuel consumptions and the results are presented in **Table 2.41.**

Table 2.41: Mode wise mileage as reported by truck operators

S. no.	Vehicle type	Fuel mileage (Km/litre)
1	LCV	6.0
2	2-Axle Truck	3.9
3	3-Axle Truck	3.4
4	MAV	2.9

(b) Socio-economic profile

The current section presents the Socio-Economic trends of Gujarat state with focus on Kalpasar project influence area. The state of Gujarat located on the western coast of India is spread over an area of 1.96 lakh sq.km (about 6% of India's geographical area) and has a population of about 604.39 lakhs (about 5% of India's total population) as per 2011 census and the current population is close 700 lakhs. Among the states in India, Gujarat is fifth in term of GDP. The profile of project influence area is given below in **Table 2.42**.

Table 2.42: Profile of districts within Kalpasar project's influence area

No.	District	Area (Sq.km)	Taluka	Villages	Towns	Sectors
Saurashtra Region						
1	Dev bhoomi Dwarka	4,051	4	249	6	Tourism, Agriculture, Industry and Ports
2	Jamnagar	5,846	7	421	5	Agriculture, Industry and Ports
3	Porbandar	2,316	3	149	1	Agriculture, Industry and Ports
4	Rajkot	8,156	11	583	15	Agriculture and Industry
5	Junagadh	5,093	10	547	7	Agriculture and Industry
6	Amreli	6,760	11	619	9	Agriculture, Industry and Ports
7	Gir Somnath	3,775	6	345	5	Tourism, Agriculture and Industry
8	Bhavnagar	7,034	11	699	6	Agriculture, Industry and Ports
9	Botad	2,564	4	190	3	Agriculture and Industry
10	Morbi	4,872	5	349	1	Industry and Ports
11	Surendranagar	10,489	10	574	7	Industry
South Gujarat						
12	Vadodara	7,546	8	934	5	Agriculture and Industry
13	Chhota Udaipur	3,436	6	894	1	Agriculture and Tourism
14	Bharuch	5,246	9	647	4	Agriculture, Industry and Ports
15	Narmada	2,755	5	552	1	Agriculture, Industry and Tourism
16	Surat	7,657	14	802	6	Agriculture, Industry and Ports
17	Tapi	3,139	7	523	2	Agriculture
18	Navsari	2,196	6	368	4	Industry and Ports
19	Dang	1,766	3	311	1	Agriculture
20	Valsad	2,947	6	466		Agriculture, Industry and Ports

➢ Demography

- **State profile**

As per the Census of India 2011, the population and workers of Gujarat was 604.39 lakh and 247.67 lakh respectively. The average decadal population and employment growth rate from 1971 to 2011 is estimated to be 22.7% and 31.6% respectively.

The population and employment density in 2011 was about 3.08 person per hectare (pph) and 1.26 pph respectively. Further, the sex ratio was 954, and literacy rate was 78% as per 2011 census. The demographic profile of Gujarat State from 1971 to 2011 is presented in **Table 2.43**. It can be noted that on an average, employment growth rate has been higher as compared to the population growth rate. **The estimated population of Gujarat state in 2021 is 697 lakhs.**

Table 2.43: Demographic profile of Gujarat state (1971-11)

No	Year	Population	Employment	WFPR	Growth Rate		Density (pph)		Sex Ratio	Literacy
					Pop	Emp	Pop	Emp		
1	1971	2,66,97,475	83,96,356	31.5%	-	-	1.36	0.42	941	35.8%
2	1981	3,40,85,799	1,09,82,444	32.2%	27.7%	30.8%	1.73	0.56	945	43.7%
3	1991	4,13,09,582	1,66,06,452	40.2%	21.2%	51.2%	2.10	0.84	944	61.3%
4	2001	5,06,71,017	2,12,55,521	41.9%	22.7%	28.0%	2.58	1.08	946	69.1%
5	2011	6,04,39,692	2,47,67,747	41.0%	19.3%	16.5%	3.08	1.26	954	78.0%
Average				-	22.7%	31.6%	-	-	-	-

- **Project influence area profile**

The comparison of the demographic profile of the state Gujarat and Project Influence Area (1991-2011) is presented in **Table 2.44**. It can be noted that share of population in project influence is about three forth of Gujarat State Population.

Table 2.44: Comparison of demographic profile of Gujarat and project influence area (1991-2011)

No.	Year	Population			Employment		
		Gujarat	PIA	Share of PIA	Gujarat	PIA	Share of PIA
1	1991	4,13,09,582	3,09,84,507	75.0%	1,66,20,519	1,21,82,959	73.3%
2	2001	5,06,71,017	3,80,67,476	75.1%	2,12,55,521	1,53,00,322	72.0%
3	2011	6,04,39,692	4,56,02,184	75.4%	2,47,67,747	1,83,29,336	74.0%

As per the Census of India, the population and employment in the project influence area in 2011 were 456.02 lakh and 183.29 lakh respectively; similarly, the WFPR was estimated to be 40.2%. The sex ratio and literacy rate in 2011 were 909 and 77.2% respectively. Further, the population and employment density were 3.10 pph and 1.26 pph respectively.

The average decadal growth rate of population and employment from 1991 to 2011 were about 21.3% and 22.7% respectively. The demographic profile of the project influence area from 1991 to 2011 is presented in **Table 2.45**.

Table 2.45: Demographic Profile of Project Influence Area (1991-11)

No	Year	Population	Employment	WFPR	Growth Rate		Density (pph)		Sex Ratio	Literacy
					Pop	Emp	Pop	Emp		
1	1991	3,09,84,507	1,21,82,959	39.3%	-	-	2.03	0.81	938	60.75%
2	2001	3,80,67,476	1,53,00,322	40.2%	22.9%	25.6%	2.55	1.05	918	68.7%
3	2011	4,56,02,184	1,83,29,336	40.2%	19.8%	19.8%	3.10	1.26	909	77.2%
Average				-	21.3%	22.7%	-	-	-	-

District-wise Demographic profile of project influence for 2011 is summarised and presented in **Table 2.46** and **Figure 2.12**.

Table 2.46: District-wise Demographic profile of project influence area (2011)

No.	District	Population	Employment	WFPR	Density (pph)		Sex Ratio	Literacy
					Pop	Emp		
1	Amreli	15,14,190	6,57,139	43.4%	2.05	0.89	964	74.3%
2	Bharuch	15,51,019	6,27,124	40.4%	2.38	0.96	925	81.5%
3	Bhavnagar	28,80,365	11,50,632	39.9%	2.87	1.15	933	75.5%
4	Dang	2,28,291	11,825	5.2%	1.29	0.07	1006	75.2%
5	Jamnagar	21,60,119	8,47,440	39.2%	1.52	0.60	939	73.7%
6	Junagadh	27,43,082	11,23,709	41.0%	3.11	1.27	953	75.8%
7	Kutch	20,92,371	7,76,228	37.1%	0.45	0.17	907	59.8%
8	Narmada	5,90,297	2,94,795	49.9%	2.10	1.05	961	72.3%
9	Navsari	13,29,672	5,91,834	44.5%	5.92	2.64	961	83.9%
10	Porbandar	5,85,449	2,31,169	39.5%	2.53	1.00	950	75.8%
11	Rajkot	38,04,558	14,79,050	38.9%	3.40	1.32	927	81.0%
12	Surat	60,81,322	25,53,542	42.0%	13.37	5.61	787	85.5%
13	Surendranagar	17,56,268	7,23,500	41.2%	1.68	0.69	930	72.1%
14	Tapi	8,07,022	4,50,902	55.9%	2.57	1.44	1007	68.3%
15	Vadodara	41,65,626	16,93,473	40.7%	5.52	2.24	934	78.9%
16	Valsad	17,05,678	7,43,245	43.6%	5.67	2.47	922	78.6%
Total/Average		4,56,02,184	1,83,29,336	40.1%	3.10	1.26	909	77.2%

*Botad, Chhota Udaipur, Dwarka, Gir Somnath, and Morbi Districts were formed post the Census 2011.

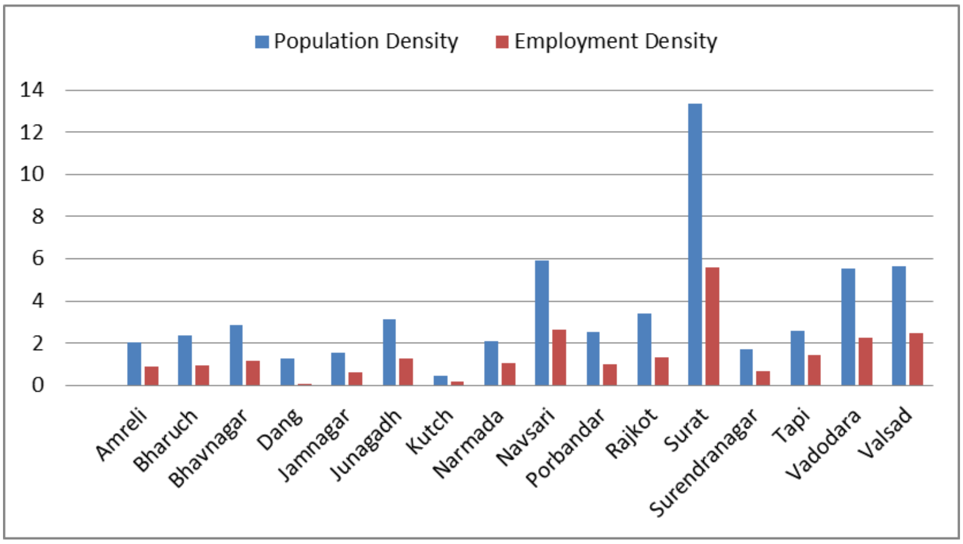


Figure 2.12: Population and employment density (2011) in project influence area

➢ **Economy**

- **Net State Domestic Product**

As per the Directorate of Economics and Statistics, Government of Gujarat, the population share of Gujarat only around 5% of the country- but contributes 8.11% share in the national GDP. Gujarat is a gateway for the international market due to large cargo handling at ports that has increased from 27.8 lakh tonnes in 1981 to 4118 lakh tonnes in 2020, a rise of about 150 times in a span of 40 years.

The GSDP and NSDP of Gujarat state at the current prices in 2019-20 were Rs. 16.49 lakh crore and Rs. 14.63 lakh crore respectively. **The average annual growth rate of GSDP and NSDP from 2015-16 to 2019-20 were 12.5% and 13.1% respectively.** Prominent sectors performing and contributing towards GSDP and NSDP (2015-16 to 2019-20) are Industries, Services, and Manufacturing. The annual details of Gujarat's GSDP and NSDP are presented in **Figure 2.13**, **Figure 2.14** and **Figure 2.15**.

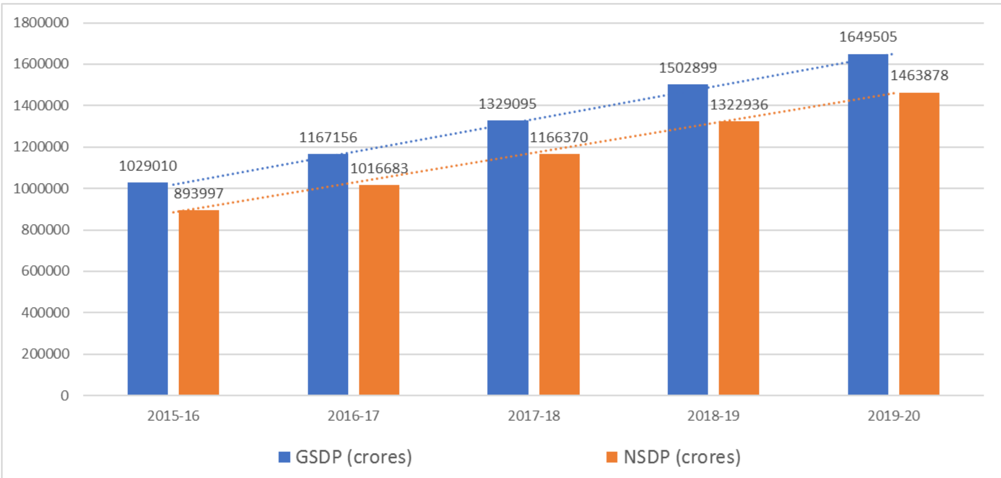


Figure 2.13: Gross and Net State Domestic Product (G&NSDP) of Gujarat state (2015-19)

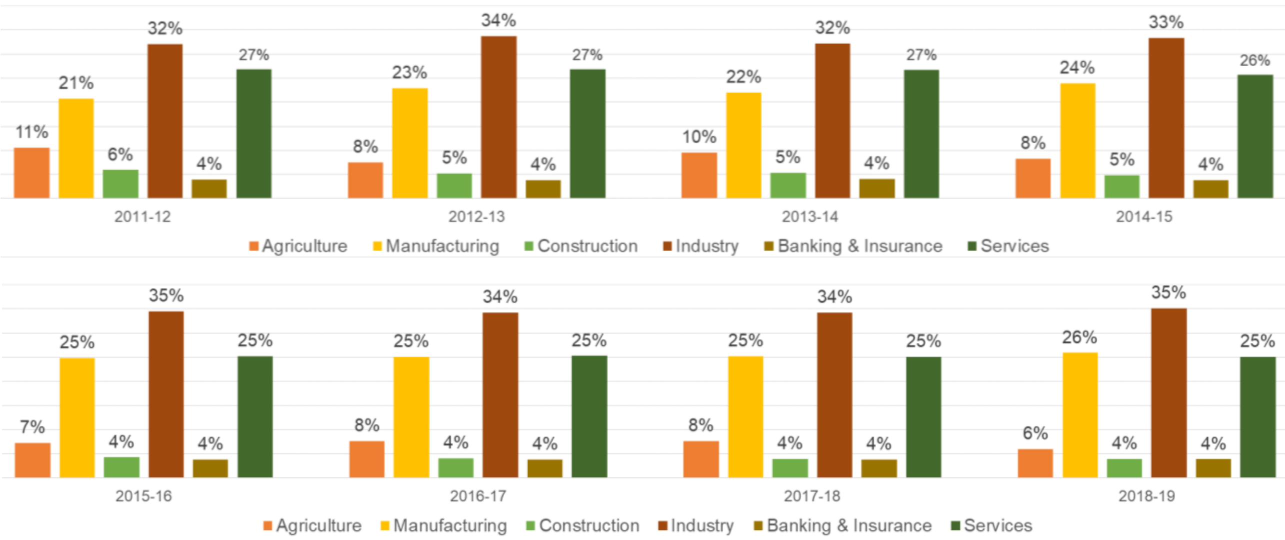


Figure 2.14: Sector wise Gross State Domestic Product (GSDP) of Gujarat state (2011-19)

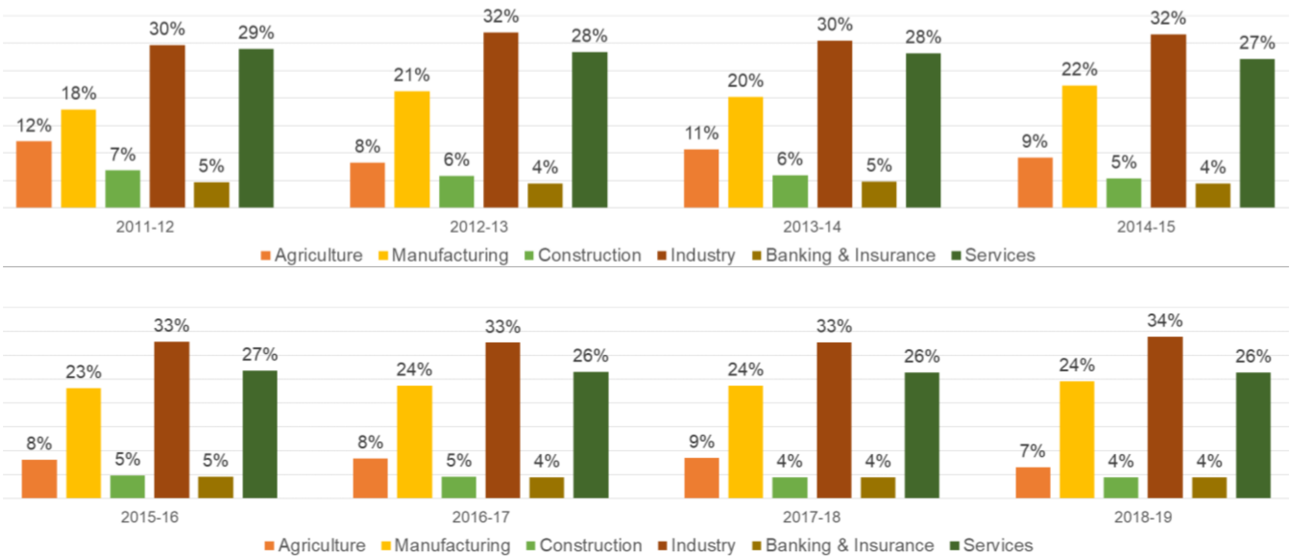


Figure 2.15: Sector wise Net State Domestic Product (NSDP) of Gujarat State (2011-19)

In 2019-20, the share of the primary, secondary and tertiary sectors in Gujarat state economy is 19.4%, 44.5% and 36.1% respectively as shown in Figure 2.16.

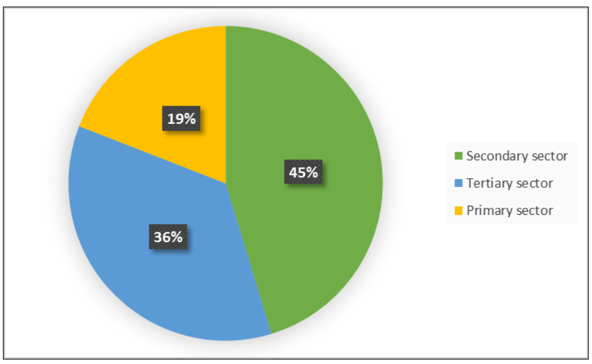
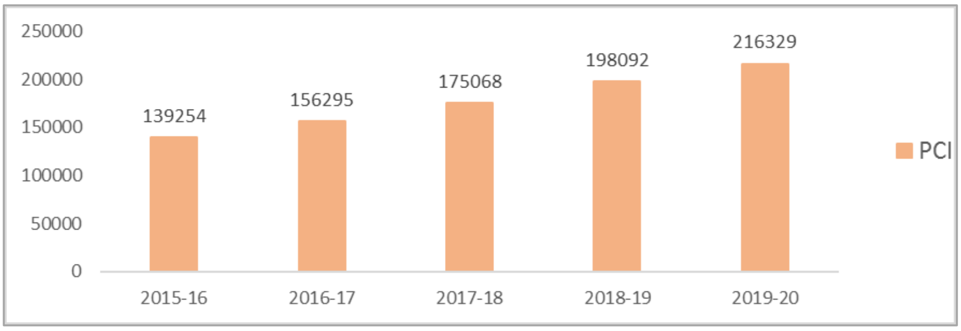


Figure 2.16: Share of various sectors in Gujarat economy (2019-20)

- **Per Capita Income (PCI)**

The per capita income of the state Gujarat as per the statistical overview report of Gujarat in 2019-20 was Rs. 2,16,329. **The average annual per capita income growth from 2015-16 to 2019-20 was 11.7%.** The details of the per capita income in the state of Gujarat from 2015-16 to 2019-20 are presented in **Figure 2.17**. Gujarat with its 2.16 lakh PCI stands higher than national average per capita income of 1.35 lakh in 2019-20.

Figure 2.17: Per capita income of Gujarat state (2015-19)



- **Industry**

Gujarat is a leader in industrial sector such as in chemicals, petrochemicals, dairy, drugs and pharmaceuticals, cement and ceramics, gems and jewellery, textiles, and engineering. The industrial sector comprises of over 800 large industries and 453,339 micro, small and medium enterprises. **Gujarat's manufacturing sector accounts for 37.5% of State GDP, which is higher than the national average of 17%**.

Gujarat has been a preferred destination among domestic and foreign investors to establish businesses due to many reasons i.e. (i) strategic location, (ii) fastest growing economy, (iii) business friendly policies, (iv) robust physical, social, and industrial infrastructure, (v) quality manpower, and (vi) high quality and low cost of living. Some of the industries contributing towards economic growth are:

(1) Agro-based and Food Processing Industry;
(2) Chemical and Petrochemicals;
(3) Information Technology;
(4) Mineral-Based and Allied Industries;
(5) Plastic and Allied Industries;
(6) Port-Related Activities and Infrastructure;
(7) Textile and Apparels Industry; and
(8) Gems and Jewellery

Gujarat state contributes:
(1) 5% of India's population;
(2) 8% of India's GDP;
(3) 17% of India's Industrial output;
(4) 20% of the India's exports;
(5) 23% of India's annual milk production;
(6) 25% of India's Cotton production;
(7) 40% of India's silk production;
(8) 62% of India's Petrochemical Production;
(9) 70% of India's Denims fabric;
(10) 80% of India's processed diamonds production & 85% Silver Jeweller;
(11) 78% of India's Salt production; and
(12) 90% of India's Soda Ash production

As per the statistics of 2011, Gujarat has emerged as a major contributor of economic growth of the country. About 17% fixed capital investment, 22% is the exports, and 12% is the net manufacturing value of the country is contributed by the state. The details of the Gujarat's contribution towards the country's production are presented in Figure 2.18.

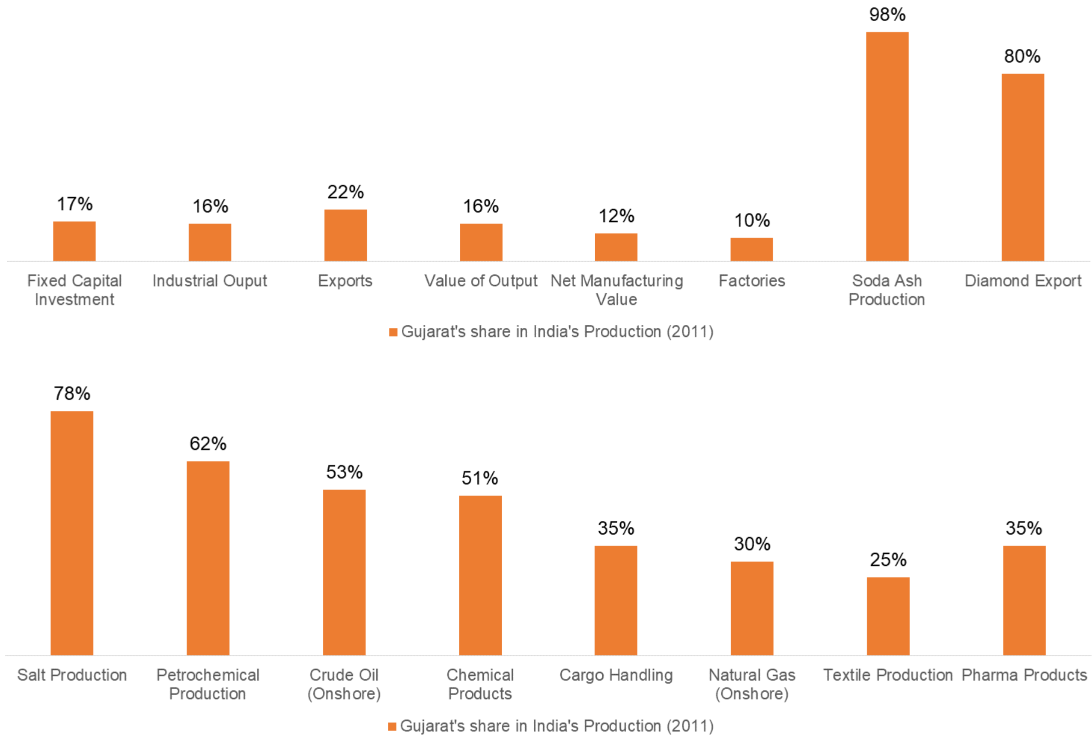


Figure 2.18: Share of Gujarat's industrial contribution in India's total production (2011)

- **Agriculture**

The success of agriculture sector in Gujarat has been due to the diversified crops and cropping patterns, climatic diversity, and existence of agricultural universities, which promote research in agricultural efficiency and sustainability. Out of the total state's geographical area, about 103.02-lakh hectare (2015-16) is under net cultivable area, which is around 52.5% of total area. The total gross crop area is about 115.22 lakh hectare (2015-16) in the state and the gross and net irrigated areas (2015-16) are 60.37 lakh hectare and 42.33 lakh hectare respectively.

Gujarat is one of the major producers of Tobacco, Cotton, Castor, and Groundnuts in India. Some of the other crops produced in the state are Rice, Jowar, Bajara, Maize, Ragi, Soyabean, Banana, Wheat, Gram, Mustard, Sugarcane, Onion, Garlic, Potato, Chillies etc. The details of production of food and non-food grains in Gujarat from 2011-11 to 2018-19 are presented in **Figure 2.19**.

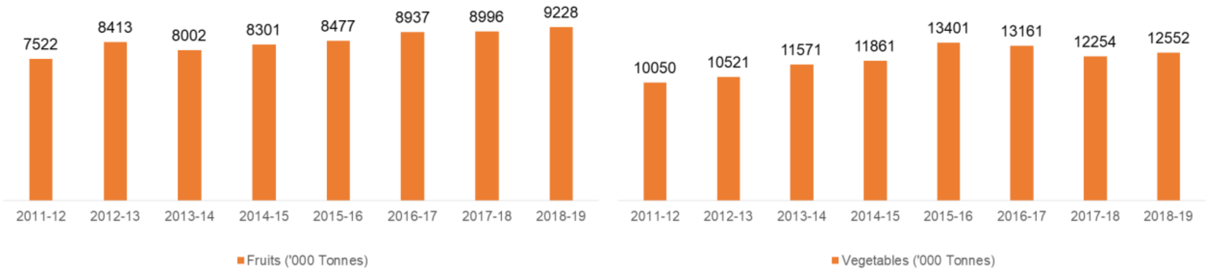


Figure 2.19: Food grains and non-food grains production in Gujarat state (2011-19)

In 2018-19, about 68.03 lakh tonnes of food grains, 213.39 lakh tonnes of non-food grains, 92.28 lakh tonnes of fruits and 125.52 lakh tonnes of vegetables were produced in the state of Gujarat. In comparison to the country's total production, in 2017-18, about 18.62% and 13.05% of Pulses and Oil Seeds is contributed by state whereas in 2018-19, around 22.39% and 11.84% of Pulses and Oil Seeds is contributed by state. Share of agricultural production in Gujarat towards India's production in 2017-18 and 2018-19 is presented in **Figure 2.20**.

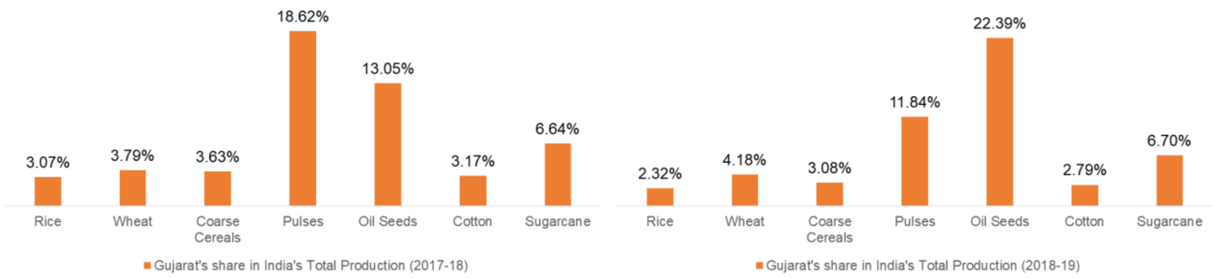


Figure 2.20: Share of Gujarat's agricultural production in India's production (2018-19)

- **Irrigation**

From Kalpasar Project 10000 Mm3 water with 50% dependability will be available; out of this 6500 Mm3 is earmarked for irrigation. **Three garland canals at about EL 50 m, EL 70 m and EL 100 m are planned to irrigate about 10.40 lakh hectares of agricultural land in 6 districts and 39 Talukas of Saurashtra.** Map showing the areas of Saurashtra region that are benefitted by Kalpasar Project is given below in

.

Table 2.47: Area under irrigation in districts of Saurashtra (2014)

No.	District	Area(Sq. Km)	Gross Irrigated Area(Ha)	% of irrigated area
1	Amreli	7397	189171	25.60%
2	Bhavnagar	7034	189341	26.90%
3	Jamnagar	14184	278208	19.60%
4	Junagadh	5093	398614	78.30%
5	Rajkot	11203	303702	27.10%
6	Surendranagar	10489	383546	36.60%
7	Porbander	2316	78597	33.90%

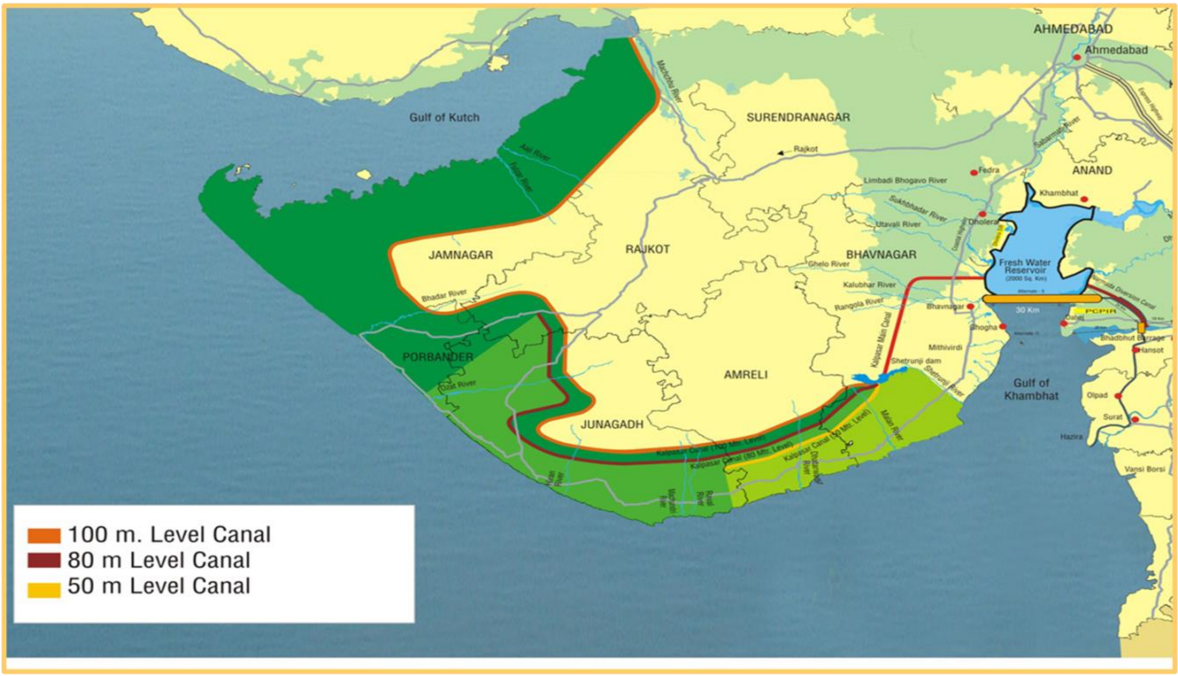


Figure 2. 21: Area getting irrigated in Saurashtra due to Kalpasar project

The surplus good food grains produced in Saurashtra is expected to be transported to rest of India i.e., South Gujarat, Central, Eastern as well as south India via the Kalpasar Road and Rail link.

- **Minerals**

The mineral extraction and production scenario in the state is categorized under (i) Petroleum and Natural Gas, (ii) Major Minerals; Bauxite, Limestone, Lignite, Manganese, and Coal, and (iii) Minor Minerals; Agate, Soap Stone, Quartz, Laterite, Ball Clay, Base Metal Ore, Bentonite, Calcite, Chalk, Graphite, gypsum, Marble, Mica, Perlite, Slate, Talc etc.

As per the average annual value of mineral production in Gujarat (2011-2017), the average share of Petroleum and Natural Gas is 59%, of Major Minerals is 15%, and of Minor Minerals is 27%. The details of the Value of Mineral Production in Gujarat from 2011-17 is presented in **Figure** 2.22.

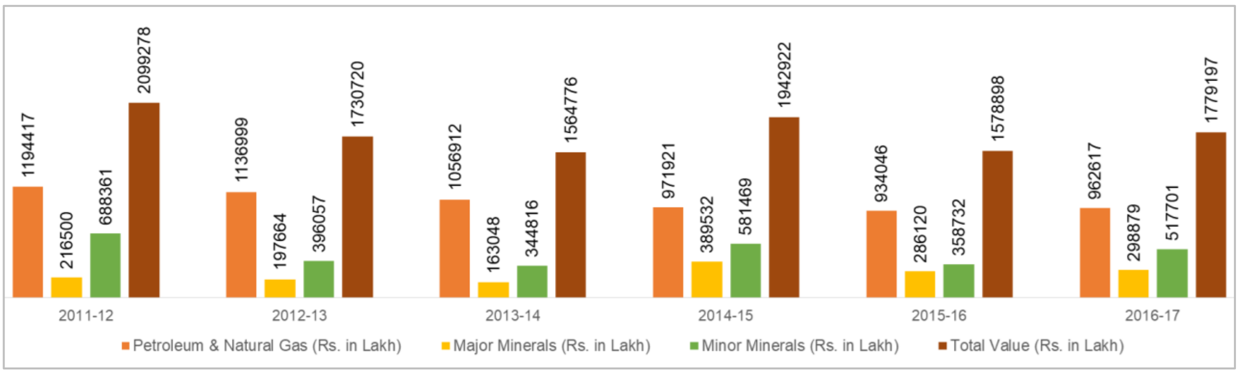


Figure 2.22: Value of mineral production in Gujarat state (2011-17)

The average annual growth of the mineral production in Gujarat (2011-17) was positive for Major minerals (18%) and Minor minerals (4%) whereas negative for the

Petroleum and Natural Gas (-4%). The average annual growth of the value of mineral production was negative (-2%) for the same period.

Gujarat has about 181 mines of the country's total mines (1,430). In comparison to the country's total production in 2017-18, the state has contributed about 28.78% towards Lignite Production, 13.45% towards Petroleum Production, 8.75% towards Bauxite Production etc. Share of mineral production in Gujarat towards India's production in 2017-18 is presented in **Figure 2.23**.

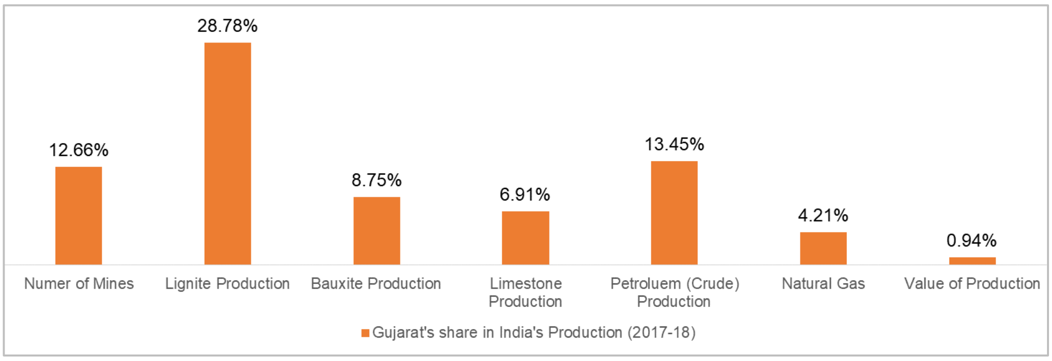


Figure 2.23: Share of Gujarat's mineral production in India's production (2017-18)

Gujarat is home for mineral deposits such as Lignite, Bauxite, Flourspar, Manganese, Limestone, Silica Sand, Bentonite and Ball Clay. Locations of different mineral projects are shown in **Figure 2.24**.

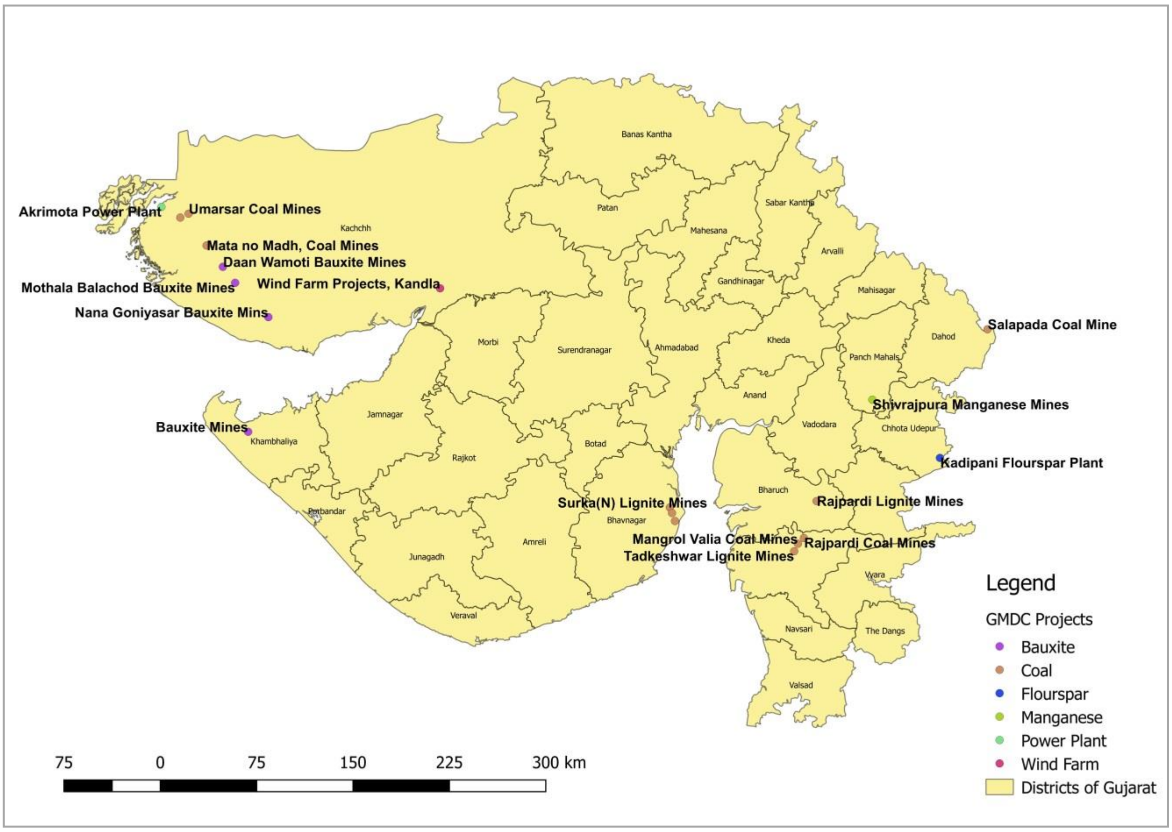


Figure 2.24: List of various Mineral projects

Gujarat Mineral Development Corporation (GMDC) has announced some upcoming projects all over the state for developing the mineral resources within the state and thus achieve vast array of Mineral portfolio by utilizing its rich basket. List of Upcoming projects are shown in **Table 2.48.**

Table 2.48: List of upcoming GMDC projects

No.	Name of the Project	Location
1	Fluorspar Beneficiation plant	Kadipani, Taluka Kawant, Dist. Chhotaudepur
2	Lignite based 500 MW Power Plant at Bhavnagar	Bhavnagar
3	Zeolite plant	Kutch
4	Silica Sand Beneficiation Project	Choki, Jagadia Taluk, Dist. Bharuch
5	Bio-Fertilizer Plant	-
6	Upcoming Lignite Blocks and Future Lignite Mines	Panandhro Extension (Kutch)
		Bharkandam (Kutch)
7	Reserved Lignite Blocks	EFG-Valia (Bharuch)
8		Damkai Padal (Bharuch)
9		Ghala (Surat)
10		Lakhpat (Kutch)

- **Tourism**

Gujarat has wide range of tourism places such as (i) multi-cultural heritage and monuments (ii) longest coastline with 16 beaches (iii) 22 sanctuaries and 4 national parks (iv) desert i.e. Runn of Kutch (v) religious and heritage circuits, (vi) festivals, art and craft, and (vii) cuisine. List of various tourism attraction spots within the state are:
(1) Rann of Kutch;
(2) Dwarka;
(3) Porbandar;
(4) Gir National Park;
(5) Somnath;
(6) Diu;
(7) Daman;
(8) Palitana Temple;
(9) Statue of Unity;
(10) Nishkalank Shiva Temple; and
(11) Blackbuck National Park

The various tourism assets in the state of Gujarat are presented in **Figure** 2.25.

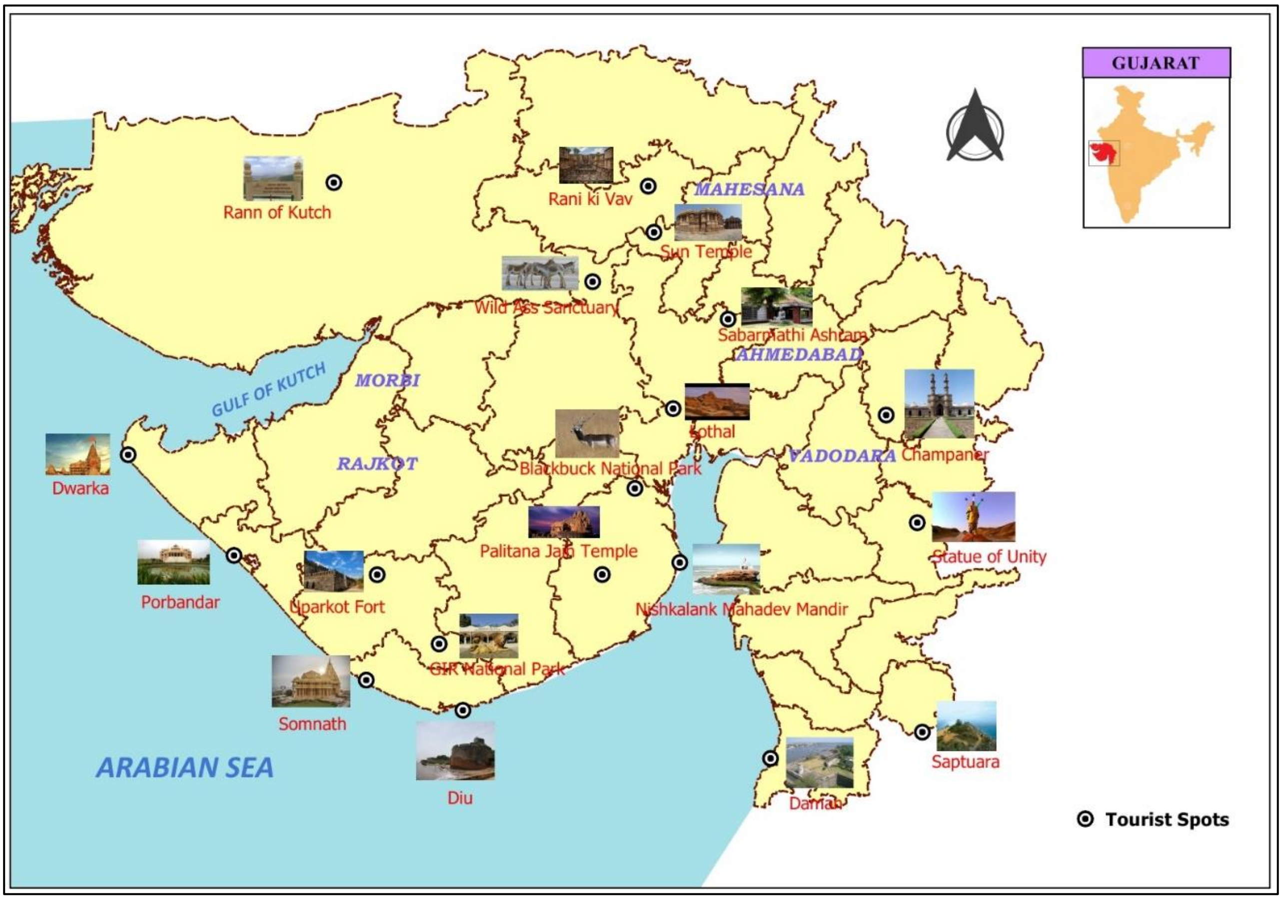


Figure 2.25: Tourism assets in Gujarat state

Based on the statistics, in 2018-19 the state of Gujarat had a tourism footfall of about 548.82 lakh with a predominant share of domestic tourists (99%). The average annual growth of domestic and international tourists from 2009 to 2018 is 14.7% and 19.9%. The details of the tourist footfall in the state of Gujarat are presented in **Table 2.49**.

Table 2.49: Tourist footfall in Gujarat state (2009-19)

No.	Year	Domestic	International	Total	Growth		
					Domestic	International	Total
1	2009-10	1,59,09,931	1,02,747	1,60,12,678	-	-	-
2	2010-11	1,88,61,296	1,30,739	1,89,92,035	18.6%	27.2%	18.6%
3	2011-12	2,10,17,478	1,66,042	2,11,83,520	11.4%	27.0%	11.5%
4	2012-13	2,41,70,100	1,90,948	2,43,61,048	15.0%	15.0%	15.0%
5	2013-14	2,74,12,517	1,98,773	2,76,11,290	13.4%	4.1%	13.3%
6	2014-15	3,09,12,043	2,35,524	3,11,47,567	12.8%	18.5%	12.8%
7	2015-16	3,62,88,463	2,75,563	3,65,64,026	17.4%	17.0%	17.4%
8	2016-17	4,17,31,732	3,85,788	4,21,17,521	15.0%	40.0%	15.2%
9	2017-18	4,83,43,121	4,48,853	4,87,91,974	15.8%	16.3%	15.8%
10	2018-19	5,43,69,873	5,13,113	5,48,82,986	12.5%	14.3%	12.5%
Average					14.7%	19.9%	14.7%

As per 2018-19 statistics, 72% of the tourists are from within the state, 26% of the tourists from outside Gujarat state whereas 2% of the tourists are foreigners.

Business remained the dominant purpose of visit, at 55% of tourist inflow, followed by spiritual tourists at 36% and leisure tourism at 9%. The scope further growth is very high for leisure and spiritual tourism once Kalpasar project become operational with shorter connections as well as better infrastructure. Kalpasar itself will become a major leisure spot in the state of Gujarat. There is a strong possibility that tourists' inflow will continue to record high growth rate (double digit growth rates) in coming years.

Kalpasar project will create a freshwater reservoir of 2000 sq.km which is huge considering anywhere in the World. Tourism potential exists on the Dam (i.e. Dam View points) as well as water frontage on the periphery of the reservoir (i.e. Boating, hotels, and recreational activities).

Statue of Unity located in the backdrop of Satpura hills which is about 100 km from Kalpasar project is attracting around 30 lakhs per annum. Tourism potential of Kalpasar dyke is estimated to be 20 to 25 lakh per annum based on the review of similar projects as listed in **Table III-50**.

Table III-50: Tourism potentials: Dams

No.	Name of Dam	Location	Purpose of Dam	Length (Km)	Surface Area of Reservoir (sq km)	Tourists per year in Lakhs
1	Three Gorges Dam	China	Hydropower	2.335	1045	12.5
2	La Race	France	Tidal Power	0.33	22	2
3	Hoover	UK	Hydropower	0.379	640	70
4	Annapolis Dam	Canada	Tidal Power	0.046	15	0.4
5	Bhakra Nangal Dam	India	Hydropower	0.518	168.35	NA

- **Foreign Direct Investment**

During FY21, Gujarat has emerged as the top FDI destination, accounting for 37% total inflows. Maharashtra (27%) and Karnataka (13%) were second and third in terms of inflows received. Gujarat has bagged the top spot for the fourth consecutive year in a row. The state saw total FDI inflow of $30.23 billion in FY21. The Gujarat will continue to attract investments due to business-friendly environment. The FDI Investments are shown in **Figure 2.26** below.

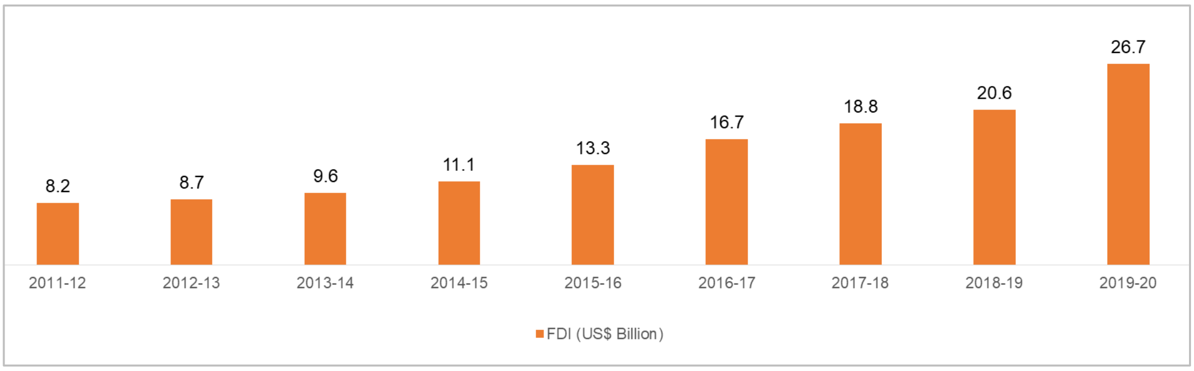


Figure 2.26: Foreign Direct Investment inflows in Gujarat state

(c) Infrastructure assessment

The infrastructure has played a vital role in the socio-economic development of the state Gujarat. Transport Infrastructure comprising of Road, Rail, Airports, Ports as well as power, water, etc. have been briefly reviewed in the following section.

- **Road network**

In 2017-18, the total road network in the state was about 1.80 lakh km: consisting of about 5,456 km of National Highways and 18,784 km of State Highways. The average annual growth rate of the total road network, National Highways and State Highways from 2011-2017 was about 2.5%, 9.6%, and 0.4% respectively. Gujarat share in the India's total road network has been predominantly constant from 2011-17 i.e. about 3.9%. The details of road network in Gujarat and India from 2011-17 is presented in **Table 2.51** and the share of Gujarat's Road network in the India's road network is presented in **Figure 2.27.**

Table 2.51: Road network in Gujarat state (2011-17)

No.	Year	National Highway (km)	State Highway (km)	Total (km)	Growth		
					NH	SH	Total
1	2011-12	3,245	18,421	1,56,188	-	-	-
2	2012-13	4,032	18,480	1,63,149	24.3%	0.3%	4.5%
3	2013-14	3,828	18,506	1,65,640	-5.1%	0.1%	1.5%
4	2014-15	4,694	18,017	1,79,063	22.6%	-2.6%	8.1%
5	2015-16	4,971	18,017	1,82,287	5.9%	0.0%	1.8%
6	2016-17	4,971	17,201	1,79,144	0.0%	-4.5%	-1.7%
7	2017-18	5,456	18,784	1,80,927	9.8%	9.2%	1.0%

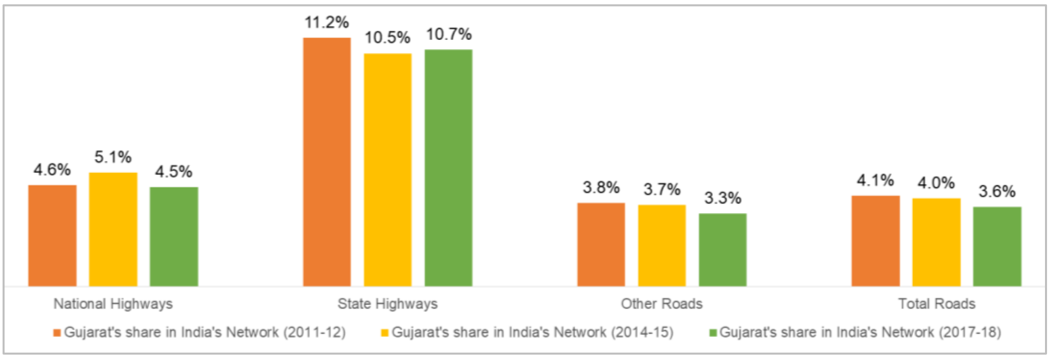


Figure 2.27: Share of Gujarat's Road network in India's network (2011-17)

As per the recent statistics, the major road network in the state is about 29,962 km out of which 8,307 km are under NH, 14,882 are under SH and remaining 6,773 km are other major roads. Thus, the share of NH,SH and other Roads is 28%, 50% and 23% respectively. **Figure 2.28** shows the current road network in Gujarat.

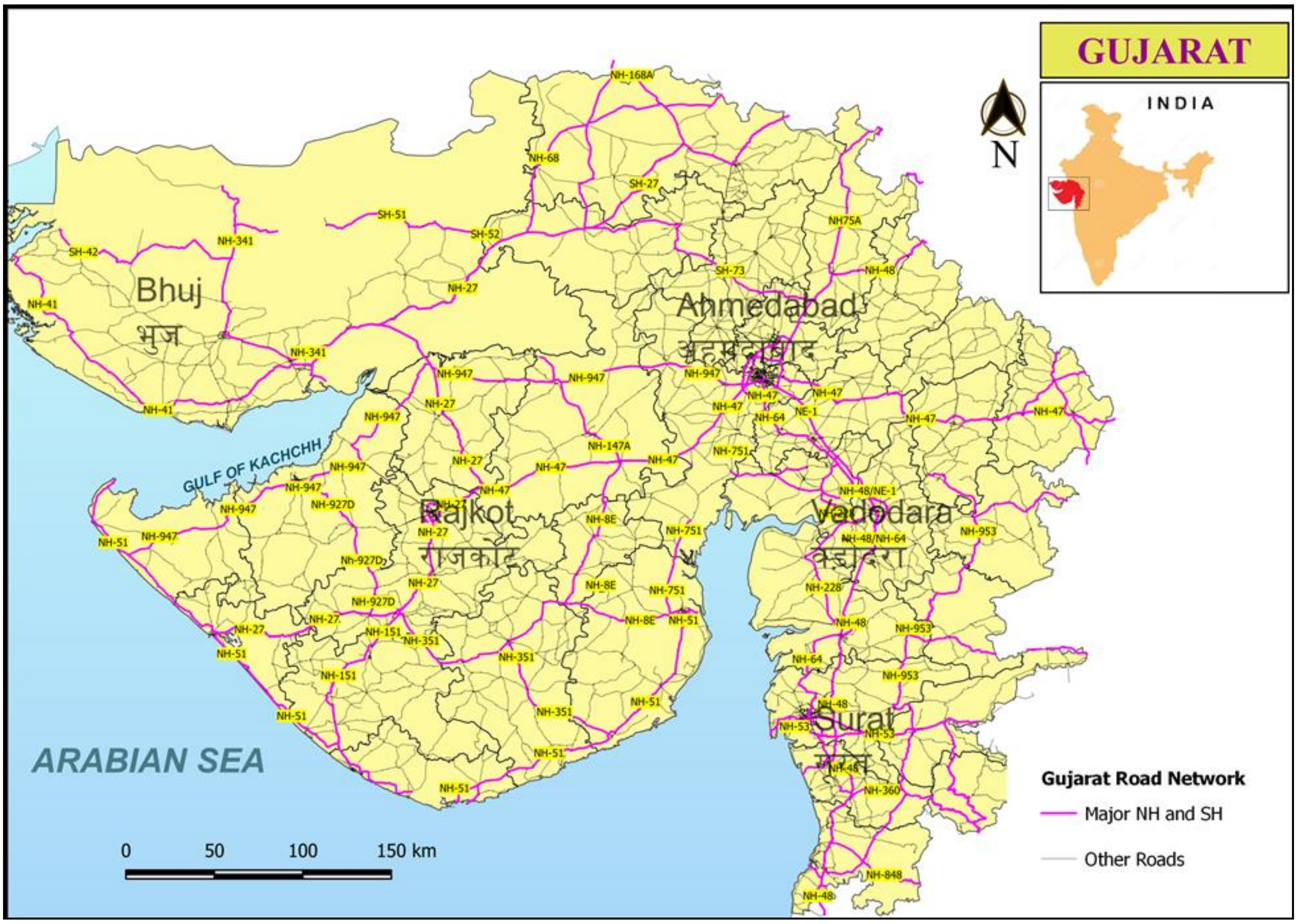


Figure 2.28: Map depicting road network of Gujarat state

- **Railway network**

The entire rail network of Gujarat is under the jurisdiction of the Western Railways, which also serves parts of the Madhya Pradesh, Mumbai, and Rajasthan. The Western Railways has six operating divisions i.e. Ahmedabad, Vadodara, Rajkot, Bhavnagar, Ratlam, and Mumbai WR.

In 2018-19, the Western Indian Railways has a railway network of about 8,354 km, which included 6,640 km of broad gauge, 1,155 km of meter gauge, and 559 km of narrow-gauge networks. Further, the state of Gujarat had a total railway network of about 6,098 km, which included 4,523 km of broad gauge, 1016 km of meter gauge, and 559 km of narrow-gauge networks. **Table 2.52** shows the division wise spread of running track kilometres within Gujarat State.

Table 2.52: Running track kilometres within Gujarat state

No.	Division	Running Track Kilometres			
		BG	MG	NG	Total
1	Mumbai	1318.13	-	62.72	1380.85
2	Vadodara	1133.23	-	496.18	1629.41
3	Ratlam	1403.78	138.46	-	1542.24
4	Ahmedabad	1365.68	445.98	-	1811.66
5	Rajkot	660.93	-	-	660.93
6	Bhavnagar	758.54	-	-	1329.06
Total		6640.29	1154.96	558.90	8354.15

Map showing the classification of Broad Gauge, Meter Gauge and Narrow Gauge in Gujarat is presented in **Figure 2.29.**

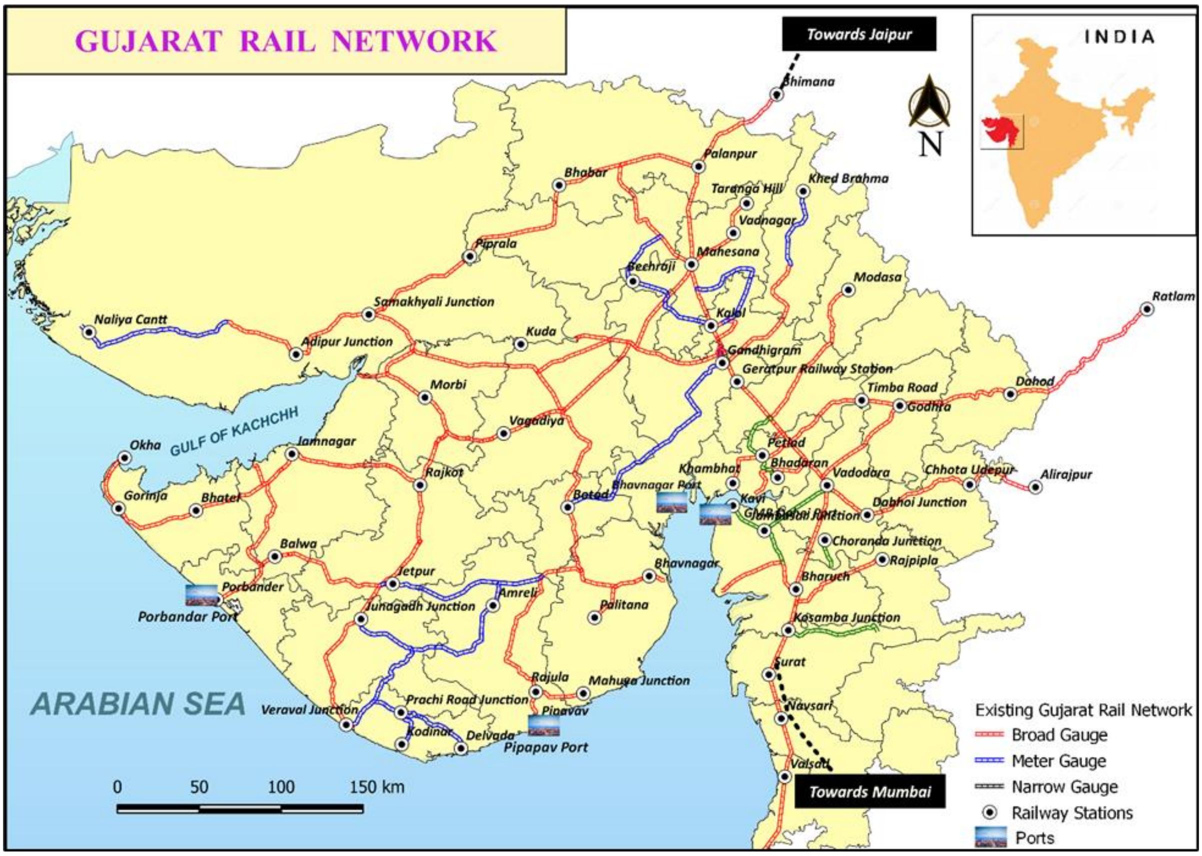


Figure 2.29: Railway network in Gujarat state

- **Passenger traffic**

Passenger and Goods statistics are presented in **Table 2.53**.

Table 2.53: Statistics of Western Railways from 2015 to 2019

No	Parameter	2015-16	2016-17	2017-18	2018-19	2019-20
Passenger Information						
1	Route Kilometres	6439	6449	6465	6520	6508
2	No of passenger trains run	754803	760717	750549	746124	732599
3	No of originating passengers (millions)	1584.22	1604.13	1606.83	1591.49	1523.72
Goods Information						
4	Average no of goods train running per day	562	527	562	596	601
5	Total Tonnes originating (million)	79.83	70.06	76.96	83.63	77.28
No	Parameter	2015-16	2016-17	2017-18	2018-19	2019-20
6	Net Tonne Km	52905	45791	53693	59989	53157

- **Freight traffic**

Western Railways has handled around 80.71 million Tonnes of cargo in the year 2020-21. Details of Commodity wise Cargo handled is presented in **Table 2.54**.

Table 2.54: Commodity wise no of million tonnes carried by WR network

No.	Commodity	2017-18		2018-19		2019-20		2020-21	
		Wagons Loaded Daily	MT	Wagons Loaded Daily	MT	Wagons Loaded Daily	MT	Wagons Loaded Daily	MT
1	Coal	551	14.22	616	15.48	368	9.22	245	6.1
2	Fertilizer	650	15.25	721	16.6	763	17.41	813	18.49
3	Container	1227	18.70	1409	20.36	1564	21.68	1817	21.73
4	POL	447	7.30	426	7.95	475	8.89	464	8.57
5	Cement	469	10.40	452	11.32	379	9.42	501	12.38
6	FG	30	0.28	13	0.3	11	0.26	42	0.94
7	Iron & Steel	28	1.09	58	1.19	37	0.85	73	1.66
8	Other Goods	407	9.44	447	10.28	417	9.33	484	10.84
Total		3809	76.68	4142	83.48	4014	77.06	4439	80.71

** Salt & Gypsum are the major components of ' Other Goods'. De-Oilcake, Chemicals are also included in Other Goods*

The statistics shows that Container, Coal, Fertilizer, Cement have the major share among the various commodities that are carried by Rail which clearly indicates the industrialization. Also, different Ports in the state are well connected by rail network which helps in the increase in handling cargo tonnages over the years. Containers, Fertilizers, Cement followed by other goods, POL and Cement are the major commodities. These commodities constitute 97% of the commodities on the Western Railway. Share of various commodities on Western Railway network is shown in **Table 2.55**.

Table 2.55: Share of commodity on WR network (2020-21)

No.	Commodity	2020-21		
		Wagons Loaded Daily	MT	Share
1	Coal	245	6.1	8%
2	Fertilizer	813	18.49	23%
3	Container	1817	21.73	27%
4	POL	464	8.57	11%
5	Cement	501	12.38	15%
6	FG	42	0.94	1%
7	Iron & Steel	73	1.66	2%
8	Other Goods	484	10.84	13%
Total		4439	80.71	100%

** Salt & Gypsum are the major components of ' Other Goods'. De-Oilcake, Chemicals are also included in Other Goods*

- **Capacity Utilization of Railway Network in Gujarat**

The capacity utilization of Railway Network in Gujarat from 2017-18 to 2024-25 (forecasted by WR) is presented below in **Table 2.56**.

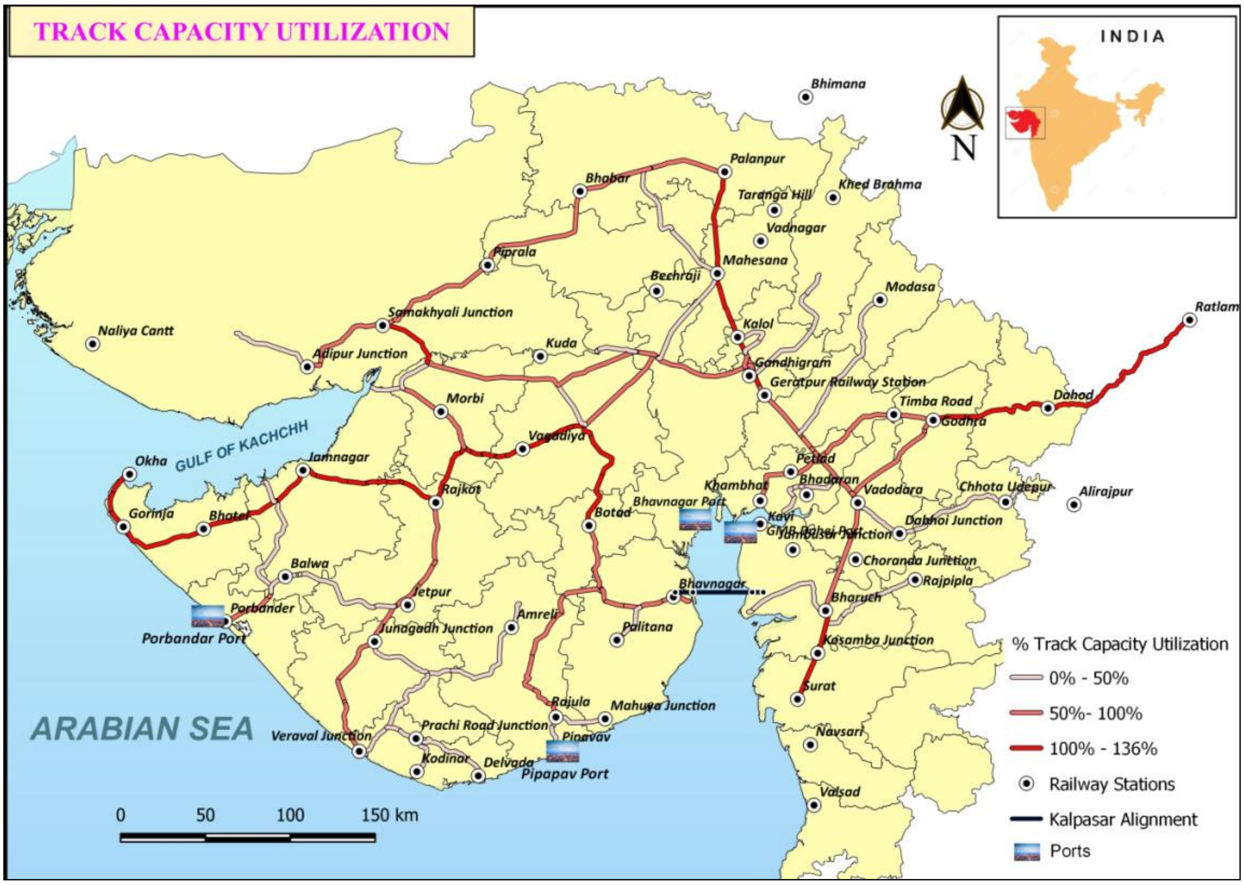


Figure 2.30: Track capacity utilization of railway network in Gujarat state (2019-20)

From **Figure 2.30** it can be noted that 47% of the rail network in Gujarat is saturated.

Table 2.56: Distribution of line capacity utilization on Western railway

Line Capacity Utilization	% of Rail Sectional Length					
	2017-18	2018-19	2019-20	2021-22	2022-23	2024-25
Less than 80%	53.6%	28.9%	42.4%	47.8%	40.0%	56.6%
81% to 90%	6.9%	5.2%	6.4%	5.0%	14.8%	6.6%
91% to 100%	10.1%	13.6%	12.9%	0.6%	1.5%	0.1%
101% to 150%	29.3%	48.8%	38.0%	39.9%	36.7%	32.7%
151% to 200%	0.1%	3.5%	0.3%	6.6%	7.0%	4.0%
Total	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%
> 100%	29.4%	52.3%	38.3%	46.6%	43.7%	36.7%

- **Air network**

Presently as per the Airports Authority of India (AAI), Gujarat has 19 airports i.e. 3 international (Ahmedabad, Surat, Vadodara), 6 domestic (Rajkot, Bhavnagar, Kandla, Porbandar, Keshod, Amreli), 3 Domestic Civil Enclaves (Jamnagar, Naliya and Bhuj), 4 Private (Mundra, Mithapur, Daman and Diu), 3 Airstrips (Deesa, Mandvi and Mehsana). Further, the state government has envisaged a green field airport at Dholera Special Investment Region (DSIR) to aid the logistics requirement of the Delhi-Mumbai Industrial Corridor Project; the airport is expected to be functional by 2023. Due to the unavailability of land for expansion of current airport, AAI has proposed a new Greenfield airport at Rajkot named as Hirasar Greenfield Airport. Design for terminal building is in inception stage and planning is in process to make the terminal equipped with all type of passenger facilities.

AAI manages 9 airports which include 3 international airports and 6 domestic airports namely Rajkot, Bhavnagar, Deesa, Kandla, Porbandar and Keshod. However, Deesa and Porbandar are not operational. India Air Force (IAF) manages Bhuj, Nalia, Jamnagar, and the Gujarat State government manages Mehsana, Amreli, and Mandvi. **Figure 2.31** shows various categories of airports present in the state.

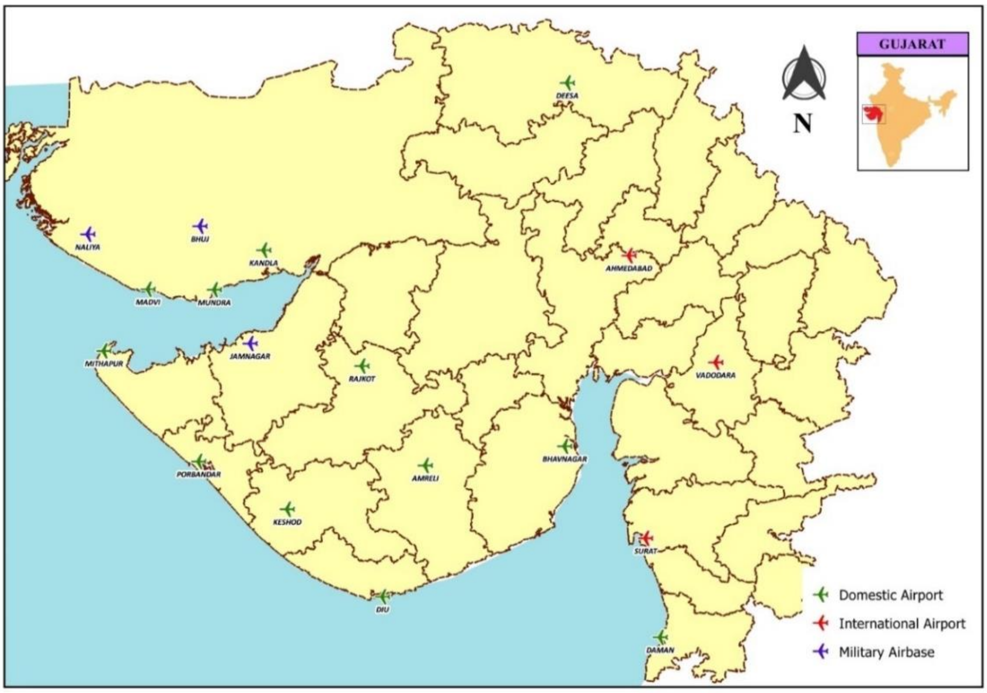


Figure 2.31: Airports in Gujarat state

Among the 16 airports, major airports in terms of passengers handled in the state are Ahmedabad, Vadodara, Surat, and Rajkot. In 2018-19, the Ahmedabad International Airport catered to about 7.36 lakh domestic and 1.74 lakh international passengers monthly (average) whereas Vadodara, Surat and Rajkot airports catered to about 0.92 lakh, 0.92 lakh and 0.28 lakh passengers monthly (average). The details of passengers catered by airports in the state of Gujarat are presented in **Table 2.57**.

Table 2.57: Details of passengers catered by Airports in Gujarat state (2011-19)

No.	Airport	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	Average
Domestic Passengers - Monthly Average										
1	Ahmedabad	3,30,996	2,73,062	2,97,849	3,07,343	3,93,909	4,53,905	5,95,854	7,36,089	-
		-	-18%	9%	3%	28%	15%	31%	24%	13%
2	Vadodara	54,468	56,114	54,834	59,878	75,360	92,757	81,921	92,814	-
		-	3%	-2%	9%	26%	23%	-12%	13%	9%
3	Rajkot	20,511	22,725	24,943	59,878	34,095	33,101	29,481	28,802	-
		-	11%	10%	140%	-43%	-3%	-11%	-2%	14%
4	Surat	-	-	-	14,063	6,489	14,496	54,666	92,365	-
		-	-		-	-54%	123%	277%	69%	104%
5	Bhuj	-	-	-	-	12208	15101	13222	15450	-
		-	-	-	-	-	24%	-12%	17%	9%
International Passengers - Monthly Average										
1	Ahmedabad	59,001	62,068	78,868	96,681	1,24,181	1,47,408	1,49,775	1,74,077	-
		-	55%	27%	23%	28%	19%	2%	16%	17%

- **Ports**

Gujarat is strategically located along the western coast of India having longest coastline of 1600 Kilometres among the Indian States, Gulf of Cambay and Gulf of Kutch provide natural navigational safety and logistical advantage. Talking about foreland, Gujarat is nearest maritime outlet to Middle East, Africa, and Europe while it has Vast and fertile hinterland, constituting 40% of the total Indian Maritime trade. Hinterland covers

Gujarat, Rajasthan, Haryana, Delhi-national capital region, Punjab, and Western Uttar Pradesh. The cargo hinterland for the ports of Gujarat stretches from the areas of Gujarat, Rajasthan, western Uttar Pradesh, and Madhya Pradesh up to NCR, Punjab, and Haryana.

Gujarat has 48 ports spread across the regions of Saurashtra Region, Kutch, and South Gujarat. Among minor ports, 17 handle cargo whereas the remaining are utilized predominantly for fishing activities; All the ports of Gujarat are shown in **Figure** 2.32 and the details are tabulated below in **Table 2.58**.

Table 2.58: Details of ports in Gujarat state

No.	Port	Type	District	Owner	Remarks
1	Kandla	Major	Kutch	Deendayal Port Trust	Largest multiple-product SEZ in India
2	Jakhau	Minor	Kutch	Gujarat Marine Board	Commodities handled: Salt and Clinker
3	Mundra	Minor	Kutch	Adani Group: Ports	Largest container port in India
4	Navlakhi	Minor	Kutch	Gujarat Marine Board	98% of Cargo handled is Coal
5	Jamnagar	Minor	Jamnagar	Gujarat Marine Board	Commodities handled: multi-product
6	Sikka	Minor	Jamnagar	Sikka Ports & Terminals Ltd.	Captive jetty for GSFC liquid cargo
7	Positra	Minor	Jamnagar	Guj. Positra Port Plantations Ltd.	Agricultural and Fishing activities
8	Okha	Minor	Dwarka	Gujarat Marine Board	Aluminium, Bauxite Coal and Chemicals
9	Porbandar	Minor	Porbandar	Gujarat Marine Board	Coal, LPG, Bauxite, Cotton, Fly Ash etc.
10	Chhara	Minor	Junagadh	Simar Port Private Ltd.	LNG Terminal
11	Jafrabad	Minor	Amreli	Gujarat Marine Board	Coal, Coke, Clinker and Salt
12	Pipavav	Minor	Amreli	APM Terminals	Multi-user and commodity port
13	Bhavnagar	Minor	Bhavnagar	Gujarat Marine Board	Phosphate, Coal, Fertiliser, Clay etc.
14	Dahej	Minor	Baruch	GMB & Adani Group: Ports	Petronet LNG jetty & multi-cargo port
15	Magdalla	Minor	Surat	Gujarat Marine Board	GMB & Captive jetties, shipyard & ports
16	Hazira	Minor	Surat	Adani Group: Ports	Chemicals, petrol, edible oil, crude etc.

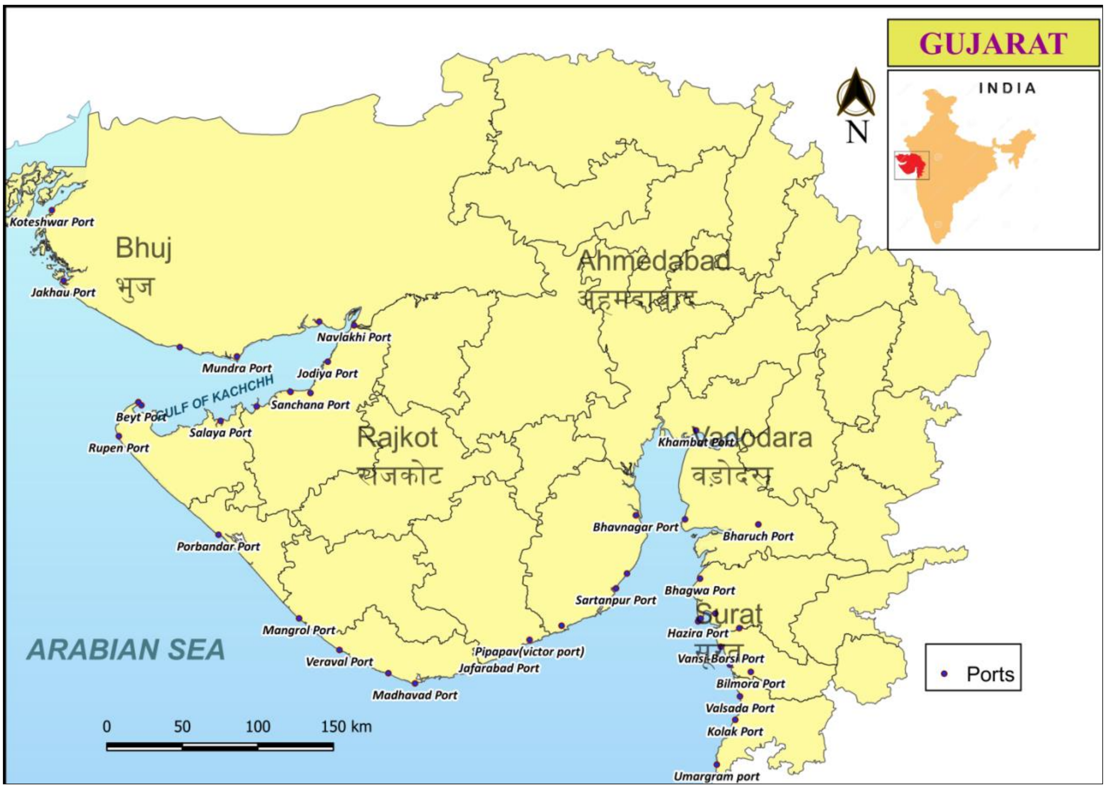


Figure 2.32: Major and minor ports in Gujarat state

As per the Gujarat Infrastructure Development Board (GIDB) in 2018-19, the traffic handled by the ports in Gujarat was about 399 MMT against the capacity of 542 MMT. The details of capacity and traffic of the various categories of the ports in Gujarat is presented in **Table 2.59**.

Table 2.59: Details of capacity, traffic, and revenue from ports in Gujarat state (2014-19)

No.	Category		2014-15	2015-16	2016-17	2017-18	2018-19	Average
1	Capacity	(MMT)	422	466	501	523	542	-
			-	10%	8%	4%	4%	6%
2	Traffic (MMT)	GMB Jetties	23.6	24.2	22.7	24.4	22.6	-
			-	3%	-6%	7%	-7%	-1%
3		Captive Jetties	149.5	154.9	159.9	167.7	170.9	-
			-	4%	3%	5%	2%	3%
4		Private Ports	151.5	149.9	155.4	172.0	195.3	-
			-	-1%	4%	11%	14%	7%
5		Private Jetties	11.5	10.7	7.7	6.6	10.3	-
			-	-7%	-28%	-14%	56%	2%
6		Total	336	340	246	371	399	-
			-	1%	-28%	51%	8%	8%
Utilization Rate			80%	73%	49%	71%	74%	69%

Pipavav port hinterland includes Gujarat (mainly Saurashtra), Rajasthan, Delhi/NCR, and Punjab. The key cargo markets in Gujarat which use the Pipavav port include Rajkot, Jamnagar, Porbandar, Veraval, Amreli, Ahmedabad, Surat, Baroda, Bhavnagar and Mahuva. In addition to Pipavav's immediate hinterland, there are the abundant northwest markets of Rajasthan, Delhi/NCR and Punjab which use Pipavav port. Pipavav port will contribute traffic on Kalpasar Road and Rail Links.

Hazira Port attracts cargoes from Northern hinterland as well as Northern Maharashtra and Central India. Hazira port, a liquid cargo port, the main cargo handled being LNG is situated in the chemical belt of the state. The major industrial clusters located in the Vadodara – Ankaleswar – Hazira – Vapi belt (within 200 km reach of the port) serve as potential cargo market for Hazira port.

Bhavnagar port handles cargo originating/destined to Gujarat (mainly Saurashtra), Rajasthan, Bhopal, Indore, and Mumbai.

Considering the cargo markets and the hinterland connectivity, it can be noted that the hinterland of all the ports is predominantly Gujarat (mainly Saurashtra), Rajasthan, Delhi and Punjab. Therefore, the impact of existing and proposed ports in the project influence area on Kalpasar transportation link is less.

- **Power**

Gujarat is second most power consuming state in the country. The states' electricity demand has grown with a CAGR of about 6.1% from 2008 to 2018. In 2018-19, the state consumed about 116.3 TWh of electricity and the per capita consumption was 1,733 kWh. The state's power generation capacity in 2018-19 was 32.3 GW; main source is Coal (48.8%), followed by Renewables (26.8%) and Gas (20.3%). The total power generation from the different sources in the state in 2018-19 was about 116.6 TWh. The details of Gujarat's power capacity, generation, and utilization from different sources in 2018-19 are presented in **Table 2.60**.

Table 2.60: Power sector composition in Gujarat state (2018-19)

No.	Source	Capacity (GW)		Generation (TWh)		Utilization	Additional (GW)
1	Coal	15.8	48.8%	81.7	70.1%	59.5%	0.2
2	Gas	6.6	20.3%	12.8	11.0%	22.3%	0.0
3	Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
4	Nuclear	0.6	1.7%	1.0	0.9%	20.4%	0.0
5	Hydro	0.8	2.4%	1.0	0.9%	15.4%	0.0
6	Renewables	8.6	26.8%	13.8	11.8%	19.7%	1.3
7	Net Imports	-	-	6.2	5.3%	-	-
Total		32.3	100%	116.6	100%	-	1.5
Off-Grid		2.3	-	-	-	-	-

As per the power sector forecast for 2029-2030, it is estimated that the state's total power capacity will be 78.4 GW and further, that there will a major shift from Coal power to Renewables based. The forecasted power sector composition for Gujarat in 2029-30 is presented in **Table 2.61**.

Table 2.61: Power sector composition forecast in Gujarat state (2029-30)

No.	Source	Capacity (GW)		Generation (TWh)		Utilization	Additional (GW)
1	Coal	14.0	17.8%	68.7	33.8%	56%	-1.8
2	Gas	6.6	8.4%	14.4	7.1%	25.0%	0.0
3	Diesel	0.0	0.0%	0.0	0.0%	0.0%	0.0
4	Nuclear	2.0	2.5%	13.7	6.8%	80.0%	1.4
5	Hydro	0.8	1.0%	1.4	0.7%	20.0%	0.0
6	Renewables	55.1	70.3%	97.7	48.1%	24.0%	46.5
7	Net Imports	-	-	7.2	3.6%	-	-
Total		78.4	100%	203.1	100%		46.1

- **Water supply**

Unequal distribution of water in Gujarat is evident as it only accounts to about 2.03% of the country's total water availability. The total water available in the state is about 50 BCM of which 38 BCM is surface water and rest is ground water. About 80% of the surface water is primarily used for irrigation, resulting in limited availability for uses like drinking, industries etc.; therefore, the state is majorly dependent on the ground water.

Further, the water available in the five regions of the state is unequal where the Central and South Gujarat Regions have more that 70% of fresh water available, the Saurashtra, and Kutch regions have only 17% and 2% respectively.

Kalpasar Project will improve the water availability to Saurashtra through development of Irrigation Canals from the dyke.

(d) Major infrastructure projects in project influence area

The various major ongoing and proposed infrastructure projects ranging from road, rail, industrial corridors, SEZs etc., within the project's influence have been reviewed and presented. These projects will have a significant impact on Kalpasar project.

- **Road projects**

The major on-going and future road projects are summarised below:
(1) Delhi-Mumbai Expressway;
(2) Ahmedabad -Dholera Expressway; and
(3) Bhavnagar-Somnath-Dwarka Coastal Highway is being widened to 4-lane configuration which length is 473.2 km.

- **Delhi-Mumbai expressway**

The NHAI has been implementing the Delhi-Mumbai Expressway, which is a 1,350 km, 8-lane access-controlled expressway connecting the two major most metropolitan cities of India i.e. Delhi and Mumbai. The expressway will be passing through Delhi (10 km), Haryana (140 km), Rajasthan (370 km), Madhya Pradesh (240 km), Gujarat (420 km), and

Maharashtra (170 km) and has been executed by the National Highways Authority of India (NHAI).

The major cities and towns along the proposed expressway alignment are Delhi, Gurgaon, Mewat, Kota, Ratlam, Godhra, Vadodara, Surat, Dahisar, and Mumbai. The alignment of the Delhi-Mumbai expressway is presented in **Figure 2.33**.

For ease of implementation, the proposed alignment has been segregated into 4 sections:
(1) Section-1: Delhi-Faridabad-Sohna: 60 km
(2) Section-2: Sohna-Vadodara Section: 844 km
(3) Section-3: Vadodara-Mumbai (Virar) Section: 354 km
(4) Section-4: Mumbai (Virar) to JNPT: 92 km

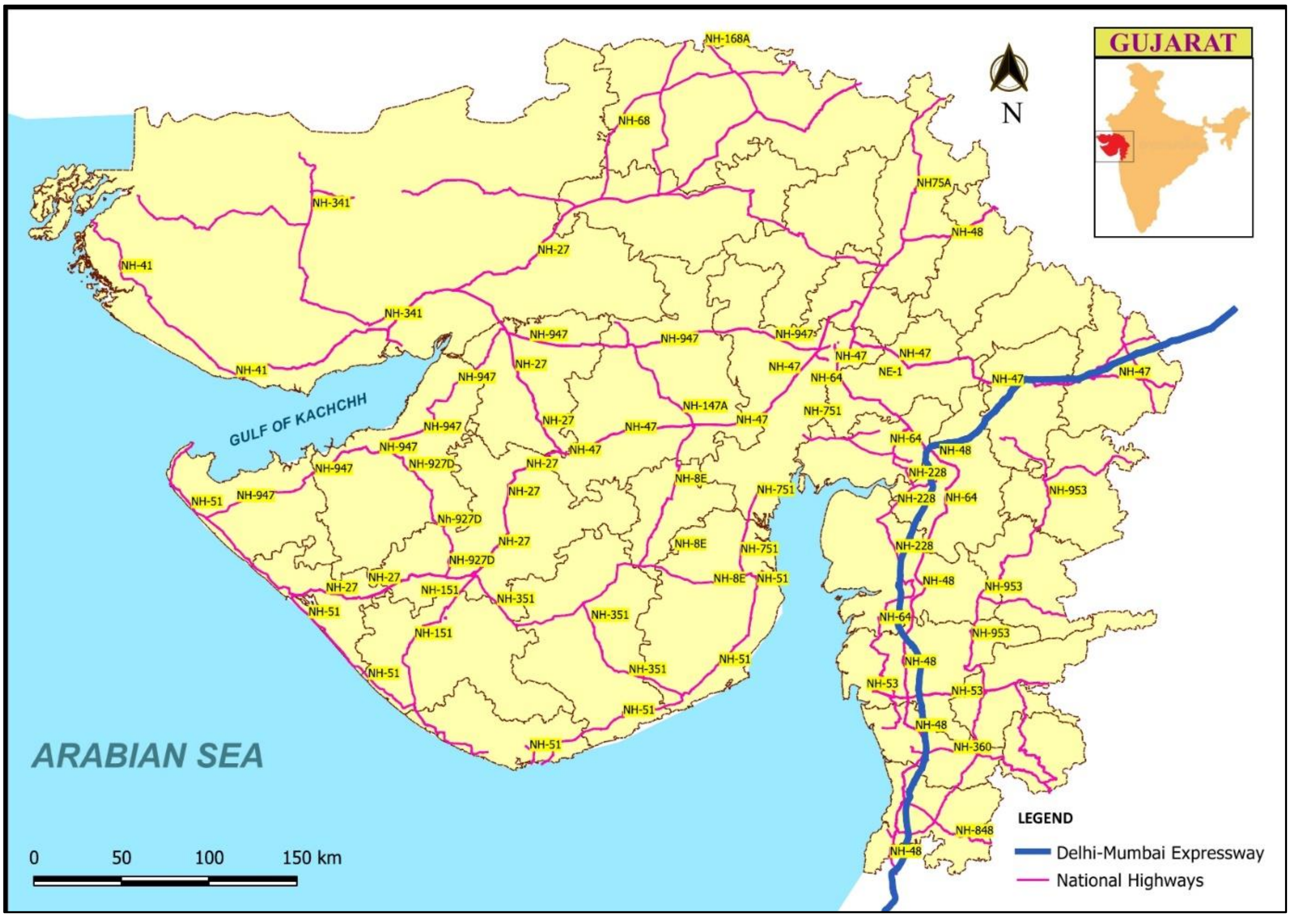


Figure 2.33: Alignment of Delhi-Mumbai expressway

Some of the salient features of the Delhi-Mumbai Expressway project are:
(1) The expressway will reduce the distance between Delhi and Mumbai by 160 km;
(2) Expressway which is eight-lane access-controlled expressway can be expanded to a 12-lane expressway depending on the traffic volume;
(3) Out of the total expressway length, about 31% of the expressway length is within Gujarat state;
(4) Major towns within the expressways and project influence areas are Vadodara, Surat, and Navsari;
(5) Other towns in Gujarat within the expressway's influence area are Dahod and Godhra; and

(6) The expressway will cater to inter-state movement of cargo from ports, nodes, and DFC.

- **Road network proposals**

Road network proposals that are in various stages of implementation are summarised below and depicted in **Figure 2.34**.

- Delhi-Mumbai Expressway
- Ahmedabad Dholera Expressway
- Coastal Road from Dahej to Valsad
- Widening of roads connecting Sanand, Bagodra, Dhanduka, Barwala, Vallabhipur, Limbda, Bhavnagar, Amreli, Mahuva, Veraval, Porbandar, and Dwarka.
- Necklace Road along sea connecting Bhavnagar-Dahej, Dahej to NH-48 via Vagara and coastal road along Tarapur-Bhilad-Tithal-Ubhrat-Khambhat.

- Few roads that are considered for road widening are: Widening of Coastal Road between-Bhavnagar-Somnath-Dwarka, Mahuva to Amreli, Amreli to Bhavnagar, Dandi to Kalamsar via Surat, Hansot and Jambusar, Tourist corridor connecting Saputara, Ukai, Devmogra, Zarvani and Statue of Unity.

Figure 2.34: Map depicting future road network of Gujarat state

- **Railway**

List of on-going and future projects are presented based on Pink Book by Indian Railways and other Railway sources and the same is presented in **Figure 2.35**.

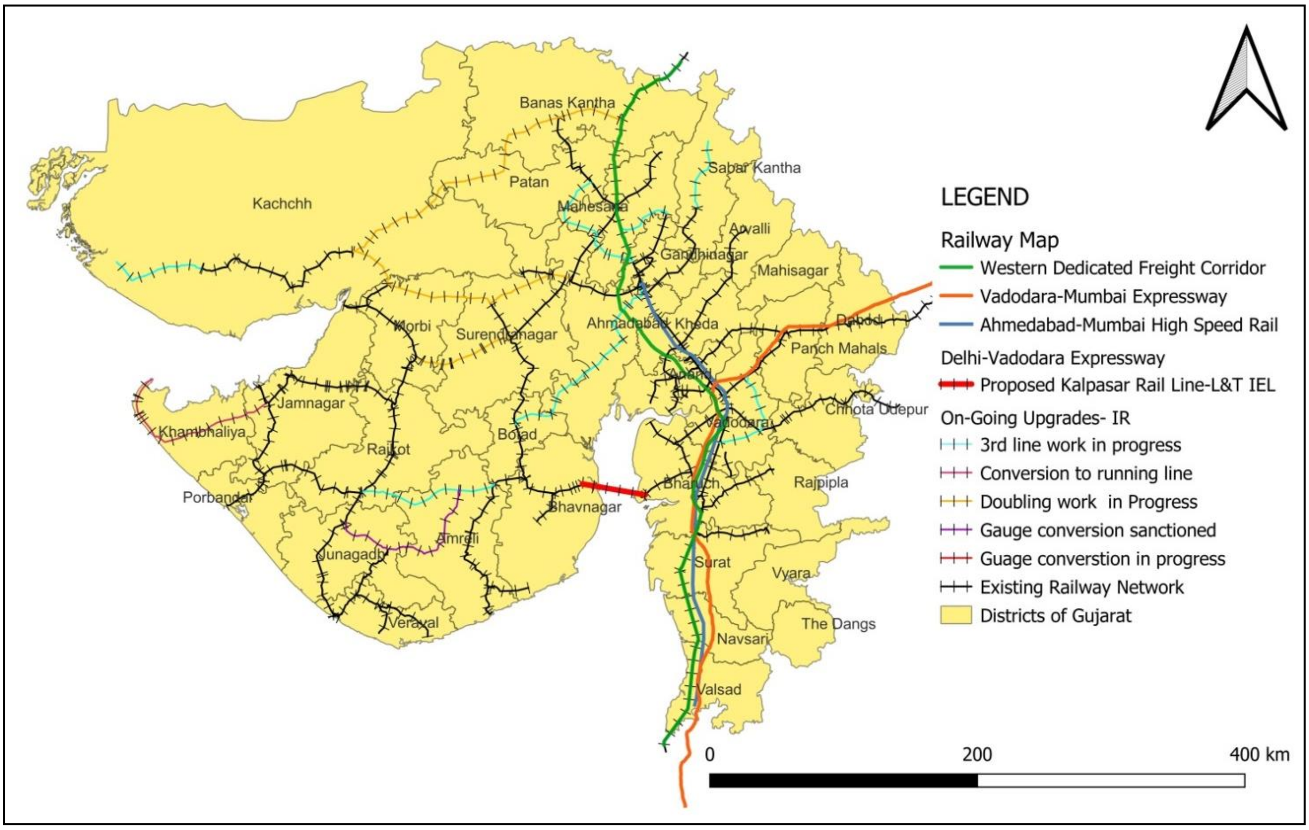


Figure 2.35: On-going and future railway projects

- **Western Dedicated Freight Corridor (WDFC)**

The Western DFC covers a distance of about 1,504 km of double line electric track from JNPT, Navi Mumbai to Dadri, Uttar Pradesh via Vadodara, Ahmedabad, Palanpur, Phulera, and Rewari; passing through five states i.e. Uttar Pradesh, Haryana, Rajasthan, Gujarat, and Maharashtra. The DFC alignment is parallel to the existing railway lines except the detour at Diva, Surat, Ankleshwar, Bharuch, Vadodara, Anand, Ahmedabad, Palanpur, Phulera, and Rewari. The corridor has been divided into two phases i.e. (i) Rewari to Vadodara, and (ii) Vadodara to JNPT, Navi Mumbai. WDFC starts from Dadri in Uttar Pradesh to JNPT in Mumbai covering a length of 1504 km. By the mid of 2020, 56% length of WDFC has been completed for construction and operation.

The prime objective of DFC (Dedicated Freight Corridor) is to integrate the freight traffic with important focal points of the state and its impact would be very prominent on the Kalpasar. Considering the connectivity of Southern and Western parts of the state by Kalpasar, the magnitude of impact caused by DFC on transport link over the dyke would be very crucial. Different feeder routes that are getting connected from DFC are a) Palanpur-Adipur Junction, b) Mahesana – Jamnagar, c) Mahesana – Pipavav, d) Bharuch – Dahej, e) Gothangam – Valsad. With Kalpasar Project, Bharuch-Dahej section is likely to be extended to Bhavnagar.

Map showing the DFC alignment along with existing rail network of Gujarat state is shown in **Figure 2.36** below.

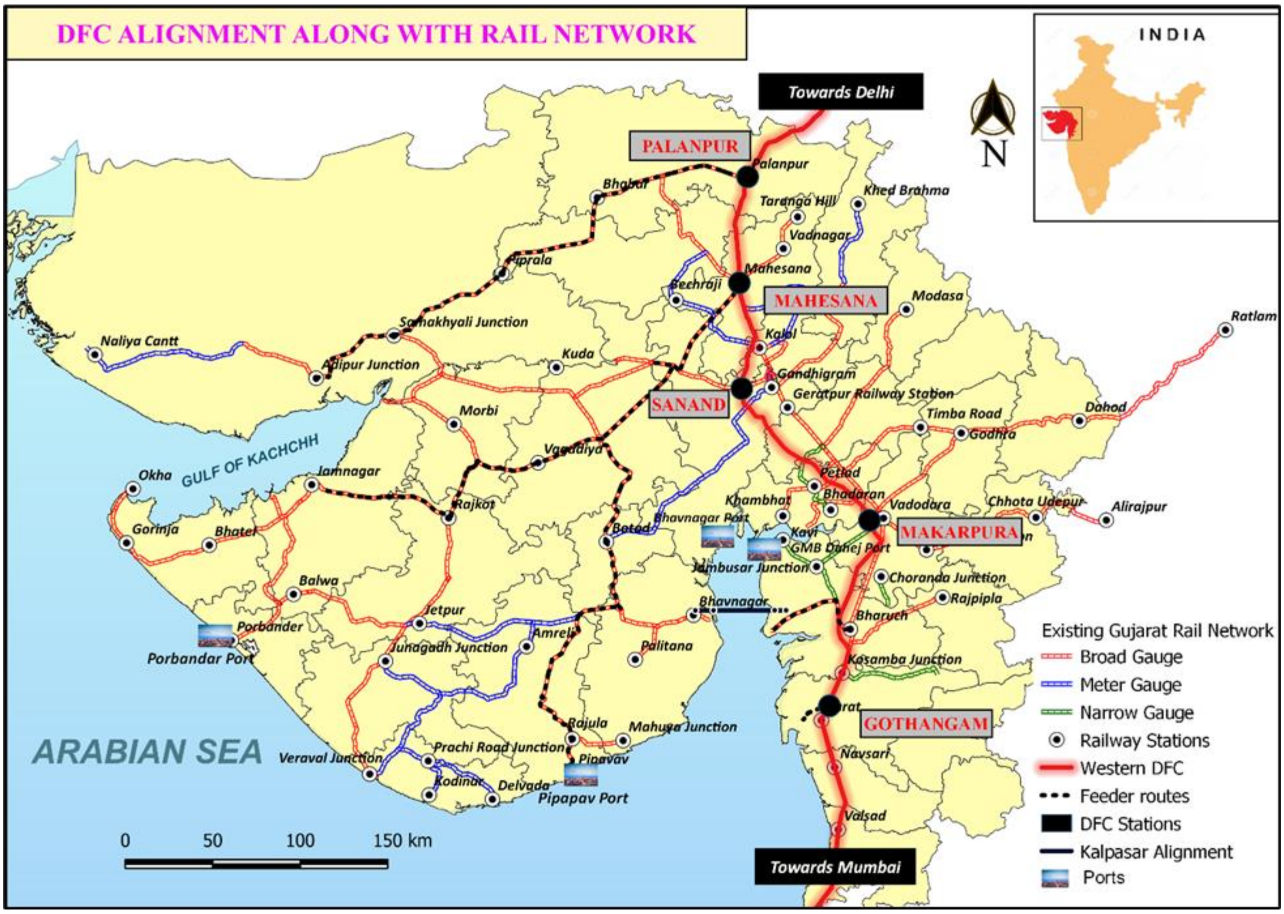


Figure 2.36: Alignment of Western DFC along with stations

As per estimates, the rail share of container traffic on the Western DFC is expected to increase from 0.69 million TEUs (2005-06) to 6.2 million TEUs (2021-22). Other commodities are projected to increase from 23 million tonnes (2005-06) to 40 million tonnes (2021-22). Further, the maximum number of trains in the section is projected as 109 trains each way. DFC is expected to complete within next one or two years. Three feeder routes are identified to DFC where one is Dahej-Bharuch (62.36 km) developed by RVNL under PPP scheme and other is Hazira – Surat (40 km) which is yet to be executed. Third feeder route is connecting Pipavav-Surendra Nagar – Viramgam – Mehsana (400.2 km).

Impact on Project's Influence Area:
(1) Logistics Parks to be developed in Palanpur, Ahmedabad, Vapi and Vadodara in Gujarat; will boost infrastructural development in general and power sector in particular.
(2) DFC has potential to trigger western industrial corridor i.e., Delhi-Mumbai Industrial Corridor.
(3) Kalpasar Project will benefit due to increased economic activity in the project influence area.

- **Delhi Mumbai Industrial Corridor (DMIC)**

The DMIC is proposed to be developed on either side along the alignment of the 1,504 km long Western DFC between Dadri, UP and JNPT, Navi Mumbai. The project seeks to create a strong economic base with a competitive environment and state-of-the-art infrastructure to activate local commerce, enhance investments, and attain sustainable development. The vision is to develop a Global Manufacturing and Trading Hub. Most projects envisaged along the DMIC are to be implemented through Public Private Partnership.

Around 62% of the total area in Gujarat is under the influence of **Delhi-Mumbai Industrial Corridor (DMIC)**. The influence area of DMIC is spread to 18 districts & 74% of population are directly benefitted. Major investment regions that are potentially getting attracted because of DFC are Palanpur-Mehsana Industrial Area, Ahmedabad Dholera Special Investment Region, Vadodara-Ankleshwar Industrial Area, Bharuch-Dahej Investment Region, Surat Navsari Industrial Area, Valsad Umbergaon Area. Map showing influence area of DMIC is shown in **Figure 2.37**.

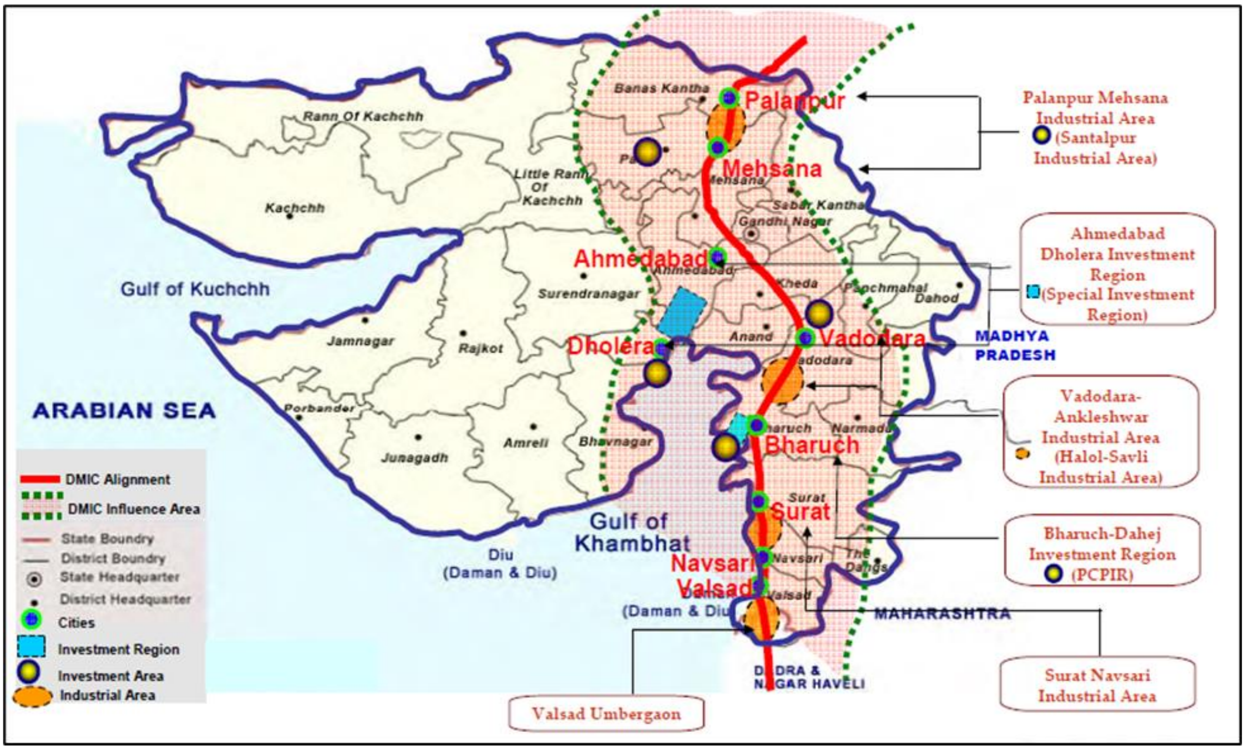


Figure 2.37: Influence area of DMIC within Gujarat state

As part of the project proposal, 24 investment regions/industrial areas have been proposed and segregated into two phases. Investment regions/industrial areas to be developed under Phase-1 and 2 are as follows:

Phase-1: Investment Regions
Dadri-Noida-Ghaziabad Region (UP) as General Manufacturing Investment Region
Manesar-Bawal Region (Haryana) as Auto Component/ Automobile Investment Region
Kushkhera-Bhiwadi-Neemrana Region (Raj.) as General Manufacturing/Automobile/Auto-Component IR
Dholera Investment Region (Gujarat) as General Manufacturing/Automobile/Auto-Component IR
Pitampura-Dhar-Mhow (Madhya Pradesh) as General Manufacturing Investment Region
Shendra-Bidkin Industrial Park city near Aurangabadin (Maharashtra)
Phase-1: Industrial Areas
Meerut-Muzaffarnagar Zone (Uttar Pradesh) as Engineering & Manufacturing Industrial Area

Faridabad-Palwal Zone (Haryana) as Engineering & Manufacturing Industrial Area
Jaipur-Dausa Zone (Rajasthan) as Marble/Leather/Textile Industrial Area
Vadodara-Ankleshwar Region (Gujarat) as General Manufacturing Industrial Area
Industrial Area with Greenfield Port at Dighi (Maharashtra)
Nimach-Nayagaon (Madhya Pradesh) as Engineering and Agro-Processing Industrial Area
Phase-2: Investment Regions
Kundli-Sonepat (Haryana) Investment Region
Ajmer-Kishangarh (Rajasthan) Investment Region
Bharuch-Dahej (Gujarat) Investment Region
Dhule-Nardhana (Maharashtra) Investment Region
Ratlam-Nagda (Madhya Pradesh) Investment Region
Phase-2: Industrial Areas
Rewari-Hissar (Haryana) Industrial Area
Rajsamand-Bhilwara (Rajasthan) Industrial Area
Pali-Marwar (Rajasthan) Industrial Area
Surat-Navsari (Gujarat) Industrial Area
Valsad-Umbergaon (Gujarat) Industrial Area
Pune-Khed (Maharashtra) Industrial Area
Shajhapur-Dewas (Madhya Pradesh) Industrial Area

Some of the salient features of the DMIC project are:
(1) The influence area of the DMIC houses country's 14% population and 17% area;
(2) Population and workers within DMIC influence area are 173.4 and 68.36 million respectively; and
(3) The goals of the projects are (i) double the employment potential in five years (14.87% CAGR), triple industrial output in five years (24.57% CAGR), and quadruple exports from the region in five years (31.5% CAGR).

Among the 24 identified projects under DMIC, 5 projects are proposed within the project influence area: 2 under Phase-1 i.e. Ahmedabad-Dholera Investment Region and Vadodara-Ankleshwar Zone, and 3 under Phase-2 i.e. Bharuch-Dahej Investment Region, Surat-Navsari Industrial Area, and Valsad- Umbergaon Industrial Area.
The summary of the impact of the proposed projects in Gujarat are:
(1) Dholera SIR is the first node taken up for development as part of the project in Gujarat;
(2) DMIC project influence area includes 62% of the area as Gujarat state;
(3) Major cities within Gujarat as part of the DMIC are Ahmedabad, Vadodara, and Surat;
(4) 1/3rd of total DMIC project investment has been estimated to be poured Gujarat;
(5) The estimated employment in the Gujarat's share of DMIC influence area is 8 lakhs;
(6) Gujarat's ports to cater to foreign and hinterland markets in the state and DMIC influence area;
(7) As part of DMIC project world-class connectivity is proposed between ports, nodes, and DFC;
(8) To improve air connectivity, Dholera International Airport has received approval from Ministry of Civil Aviation;
(9) Out of total 423 sq.km., only 52 sq.km. has been activated under Phase 1, still 5 Phases are yet to be activated; It is envisaged that by 2040, Dholera SIR targets approx. 2 Lakh people, generating employment for 80,000 people;
(10) Under Vadodara-Ankelshwar General Manufacturing Hub being developed by DMIC, Manufacturing Industries have come up in parts in various GIDCs around Vadodara and Bharuch-Ankelshwar;

(11) SurSEZ and DREAM City (Surat Diamond Bourse) projects along with various Industrial Estates along Surat-Navsari Highway have been developed under Surat-Navsari Industrial Area of DMIC; and

(12) Various Large Scale Industrial Units have recently come up in the Valsad-Umbergaon Industrial Area under DMIC.

- **Mumbai- Ahmedabad High Speed Rail (HSR)**

As per the vision for regional passenger transit by the Ministry of Railway, India, several corridors have been identified for promoting and developing High-Speed Rail (HSR) in India. First among them is Mumbai- Ahmedabad High Speed Rail (HSR). The average speed of HSR is 320 km/hr covering 508 Km in 1 hr 58 min. 35 trains per day in one direction are planned with a frequency of 20 min in peak hours and 30 min in non-peak hours.

As per the proposed alignment, the HSR corridor of about 510 km length will have 12 stations at Mumbai, Thane, Virar, and Boisar in Maharashtra, and Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad, and Sabarmati in Gujarat. Further, 3 maintenance depots are proposed along the corridor i.e. 1 in Maharashtra (Thane) and 2 in Gujarat (Surat and Sabarmati). The objective of the project is to reduce the existing travelling time from 7 hours to 2-3 hours. The proposed alignment of the Mumbai-Ahmedabad HSR Corridor is presented in **Figure 2.38.**

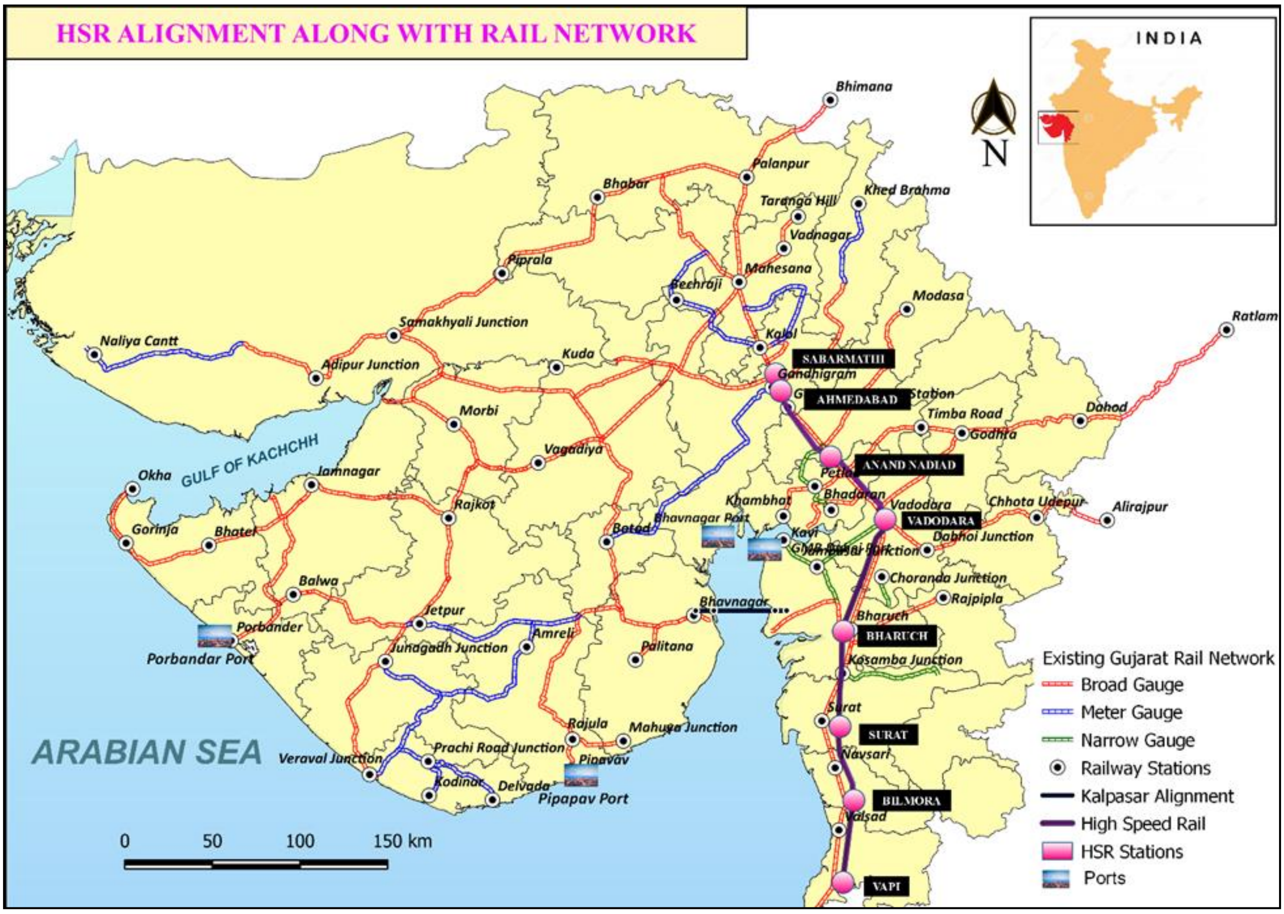


Figure 2.38: Alignment of Mumbai-Ahmedabad HSR corridor

- **Impact on Project's Influence Area:**

The major cities and towns which will be benefited and are common to the HSR corridors and project's influence area are Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad, and Sabarmati.

The corridors will boost tourism, employment and economies of the cities and towns within the project's influence area due to development of world-class stations and maintenance depots.

- **Special Investment Regions (SIR)**

With an objective of creating large size investments that help in developing the state economy, Government of Gujarat has enacted the Special Investment Region (SIR) act in 2009. The main intention of this is to promote global hubs for enhancing the economic activities within the state by providing and supporting with world class global infrastructure. Being the first such state in bringing such act, Gujarat Government has identified 11 such regions that catalyse unprecedented economic growth of the state which are presented in **Table 2.62**.

Some of the common characteristics of SIRs are:
(1) It enables the State Government to establish, develop, operate, and regulate SIRs;
(2) The Government is empowered to declare an Investment Regions or an industrial area;
(3) An SIR has a minimum area of 100 sq. km. (10,000 hectare). An industrial area has a minimum area of 50 sq. km. (5,000 hectare); and
(4) A 4-tier administrative mechanism set up for establishment, operations, regulations and management of SIRs.

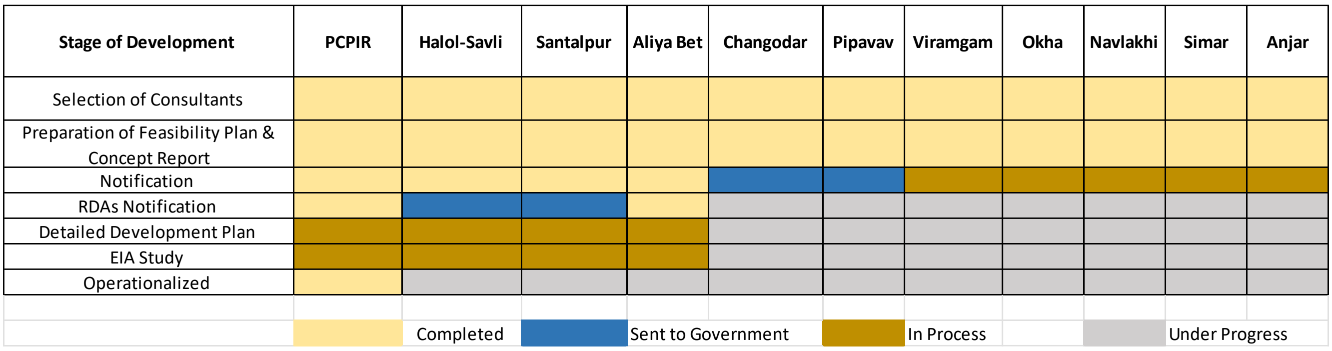
Table 2.62: Details of Proposed Special Investment Regions (SIRs) in Gujarat

No.	SIR	Area (Sq. Km)	Proposed Industries
1	Anjar Special Investment Region	630	Port and Port based industries, Mineral & Agro based and Engineering
2	Aliyabet Special Investment Region	169	Entertainment (eco zone, film city, amusement zone, golf course, aqua culture, and marine engineering
3	Changodar Special Investment Region	319	Agro based, Steel & metal, Plastic, Pharmaceutical and Oil & Gas
4	Halol_Savli Special Investment Region	123	Engineering, automobile ancillaries, engineering plastics, electrical and electronics
5	Navlakhi Special Investment Region	182	Ceramic, Engineering & Automobiles, Food processing & Electronics, Textile and Chemical and Petrochemicals
6	Okha Special Investment Region	196	General Manufacturing, Pharmaceutical, CRO, Biotechnology and Biopharma, Auto and Auto ancilliares
7	Petroleum, Chemical & Petrochemical Investment Region	453	Refinery downstream products, high performance chemicals, pigments and coating products, nanotechnology, bio-refineries, mineral resource-based products
8	Pipav Special Investment Region	145	Logistics based industries, Pre-Cast Structure and Textile – Only spinning
9	Santalpur Special Investment Region	186	Agro-based (spices and seed processing, vegetable and fruit processing, dairy, cotton

No.	SIR	Area (Sq. Km)	Proposed Industries
			ginning), contract farming, solar power, logistics
10	Simar Special Investment Region	83	Engineering, Energy, Port & Port related activities, Food & Fish Processing, Cement
11	Viramgam Special Investment Region	138	Automobile & Engineering, Healthcare, Pharmaceuticals & Fertilizers

Out of the 11 Investment Regions, Feasibility Report and Concept Plan are prepared for all the SIRs, whereas 4 are notified, 2 are sent to Government for notification and 5 are under process for notification. Detailed Development Plan and EIA Study are carried out for 4 regions. PCPIR is the sole SIR which is operational at present. The status of development stages for each SIR is presented below in **Table 2.63.** These costal SIRs are proposed as part of Sagarmala project

Table 2.63: Details of Special Investment Regions (SIRs) in Gujarat



Out of the 11 SIRs, it was observed that 7 SIRs which are highlighted below are having prominent impact within the project influence regions and those are highlighted in **Figure 2.39**.

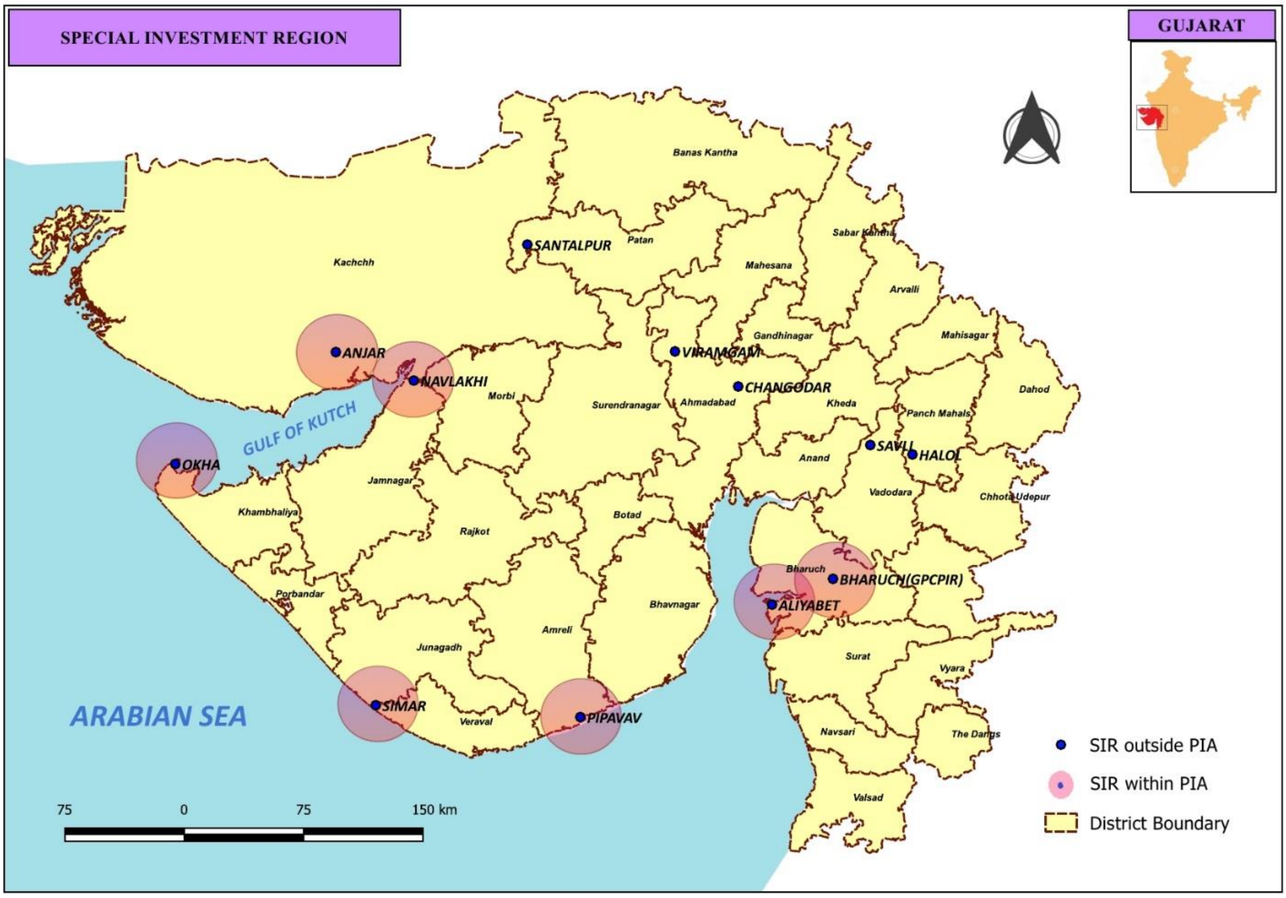


Figure 2.39: Location of SIR in Gujarat

- **Anjar Special Investment Region**

Anjar Special Investment Region (ASIR) is located Anjar and Bhachau talukas in the eastern part of Kachchh district, north of Kandla Port surrounded by the towns of Bhuj, Anjar, Gandhidham and Bhachau and well connected by NH 8A, SH-42 & 46. Having a good connectivity by means of Road, Port and Air, Water and Power are the sectors which are predominantly focused in this region. With the existing water supply by GWSSB and from Narmada Canal, there is a proposal of desalination in this region for large scale water supply. With the existing power supply by lignite power station at Panandhro and substation at Anjar connected by 220 KV lines, there is a proposal of harnessing wind and tidal energy.

- **Aliyabet Special Investment Region (ASIR)**

Aliyabet Special Investment Region (ASIR) is located on the Aliyabet peninsula at the confluence of river Narmada and the Arabian Sea in Gulf of Khambhat, in Bharuch district. Area of this region is 16800 hectares. Aliyabet is well connected through Ankleshwar by means of road and rail; an independent airstrip is also proposed for this region. Currently, water is sourced from Narmada River, Ukai canal water network; existing gas supply is through Dahej Uran pipeline; and a 220 KV (GETCO) power line through Hansot caters to its power requirement. Some of the potential sectors identified for this region are Film City & Entertainment, Aquaculture, Water Sports & Recreation and Marine Engineering.

- **Navlakhi Special Investment Region (NSIR)**

Navlakhi Special Investment Region (NSIR) is located in Rajkot district, in Morbi and Maliya talukas. It has an area of 18200 hectares. SH 24 passes through the SIR connecting Navlakhi to Morbi via Dahisara; and also has access to SH 22. The site is close to some ports such as Close to Kandla, Mundra, Sikka and Navlakhi. Nearest railway station is Wankaner which connects Morbi to Ahmedabad and Rajkot. Broad gauge railway line passes through the SIR which connects Navlakhi to Morbi and Maliya. The SIR gets water form Narmada. Existing power supply is catered by 4 sub stations located at Morbi, Maliya, Dungar and Rajula.

- **Okha Special Investment Region (OSIR)**

Okha Special Investment Region (OSIR) is in Okhamandal taluka, in the west of Jamnagar district. Okha is a busy port town situated in north west coast of Saurashtra peninsula, at the mouth of Gulf of Kutch. It is located on the road connecting Jamnagar and Okha, having a close proximity to the holy town of Dwarka. SIR spreads over an area of 19600 hectares. NH8 and SH6 bound the south and west sides of the proposed site. The site is connected to Delhi-Okha Western Rail Route via Jamnagar. Hapa Junction is a convenient railhead on broad gauge terminus connecting Okha & Porbandar.

The region is well-connected to some intermediate ports, such as Bedi, Okha & Sikka; and some minor ports, such as Salaya, Jodiya, Pidara, Bet (Dwarka). Sikka is an all-weather direct berthing port connected by rail and road (SH-92) to Jamnagar. Okha port is connected by SH6A and 6B to Jamnagar & Porbandar. Urban areas in the region source water from Sani dam, perennial water storage reservoir, while water supply for industry is provided by GWSSB and individually sourced from bore wells and check dams. Electricity is supplied by PGVCL from the thermal power plant at Sikka. Some of the major potential sectors in this region are Marine Biotechnolgy and R&D, Pharmaceutical, CRO, Auto and Ancilliaries, Mineral based Industries and Food Processing.

- **Petroleum, Chemical & Petrochemical Investment Region (PCPIR)**

Petroleum, Chemical & Petrochemical Investment Region (PCPIR) is a specifically delineated Investment Region planned for the establishment of production facilities for petroleum, chemicals and petrochemicals. PCPIR located at Dahej, is spread over the blocks of Vagra and Bharuch, South Gujarat. It is surrounded by the Gulf of Khambhat in the west, Narmada river & Aliyabet island in the south, villages of Vagra and Bharuch block in the east and Bharuch-Dahej railwayline in the north. It has spread over an area of 45300 hectares.

The site is connected to 50 km of four-lane Dahej-Bharuch SH, and Delhi – Mumbai Broad Gauge railway line through Bharuch. A Greenfield airport is proposed for PCPIR. Several ports are operated in the region such as, GMB port, 1.8 MMTPA chemical terminal of GCPTCL, 10 MMTPA LNG port, 4.5 MMTPA solid cargo jetty, 3.5 MMTPA liquid cargo jetty etc. Apart from that, GMB has proposed Marine Shipbuilding Park and Ro-Ro Ferry Service and Common User Jetty. GIDC supplies 33 MGD raw water drawn from Narmada river. GWSSB provides drinking water through Narmada Canal. Power is available through Gujarat Urja Vikas Nigam Ltd. from 220 KV sub-station, linked with the state grid. GSPL state-wide gas grid covers the PCPIR region.

The land-use mix of the investment region is dominated by the processing zone i.e., 45%, which includes industrial, and warehousing and ports. The residential and commercial land-use are about 30% and 5% respectively. About 10% of the total area is under green/open space. Further, the implementation plan for the investment region has been prepared which includes 4 phases from 2011-2040. The land-use mix of the investment region is presented in **Table 2.64** and the phasing plan of the investment region is presented in **Table 2.65**.

Table 2.64: Land-use break-up of Bharuch-Dahej investment region in Gujarat

No.	Zone	Land-Use	Area in Ha	% of Total
1	Processing	Industrial	20,383	45%
2		Warehousing & Ports		
3	Non-Processing	Residential	13,588	30%
4		Institutional	2,265	5%
5		Green	4,529	10%
6		Commercial	2,265	5%
7		Utilities	2,265	5%
Total			4,52,95	100%

Table 2.65: Phasing plan of Bharuch-Dahej investment region in Gujarat

No.	Phase	Year	% of Area
1	Phase-0	2021-25	5%
2	Phase-1	2025-30	20%
3	Phase-2	2031-35	45%
4	Phase-3	2035-40	30%

The employment scenario of the investment region indicates that more than two lakh people will be employed in the industrial units: including direct and indirect employment. Additionally, thousands of people are employed in construction activities of the industrial units, residential townships, and infrastructure works.

- **Pipav Special Investment Region (PSIR)**

Pipav Special Investment Region (PSIR) is a proposed SIR located in Rajula Taluka of Amreli District of Gujarat on the Arabian Sea. Amreli District has Bhavnagar district in the North east, Jafrabad and Savar Kundla taluka in the North west, and Arabian sea in the South. Area of the SIR is 145 sq. km (12500 hectares). Pipavav Port, which lies in the SIR, is ambitiously named as the “gateway to North-West India”. It houses India’s largest private sector port and world’s third largest container terminal operating port.

The SIR is connected to Saurashtra region via NH-8E, SH-31, SH-25, SH-110, SH-30, SH-96, and SH-106. Pipavav-Surendranagar Freight Corridor also connects the SIR to Surendranagar thereby providing further connectivity to Ahmedabad. There is an existing 264 km Broad Gauge railway line from Pipavav Port to Surendranagar. Ports of Jafrabad, Pipavav and Victor are in Amreli District providing sea-based connectivity to the SIR. Pipavav is one of the largest cargo handling terminals across in the country.

Potential Growth sectors of the Pipavav SIR are Cement, Glass, Ceramic, Prefabricated Structures, Agro and Food Processing, Textile, Marine Biotechnology, Logistics, Thermal Power Plant, Engineering, Chemical, Ship Building, and Iron and Steel. Existing Major units in Pipavav SIR are Aditya Birla Group, Pipavav Shipyard, Torrent Power, GHCL Limited.

- **Simar Special Investment Region (SSIR)**

Simar Special Investment Region (SSIR) is located in Sutrapada taluka of Junagadh district, spread over an area of 84 sq. km. (8,400 hectares). Junagadh district is located on the Kathiawar peninsula in Western Gujarat, surrounded by Rajkot district in the North, Porbandar district in the North-west, Amreli district in the East, and Arabian Sea in South and West. NH-8E from Veraval to Bhavnagar via Kodinar and Una passes through the SSIR site. SH-98 connects Kodinar and Una via Delvada and Mandvi. Proposals to widen the existing highways are under process.

Una Railway station is located 3 km North of SSIR while Delvada Railway station is located within the site. Meter Gauge line (Veraval-Talala-Delvada) passes close to the site. Broad Gauge line is proposed from Veraval to Pipavav Port as well as to enhance Delvada Railway station for better Logistics support. Nearest Ports are Veraval (69km), Diu (18km) and Pipavav Port (60km), whereas the nearest international airport is Ahmedabad (350 km), whereas domestic airport are Diu (18km) and Rajkot (275km). Potential Sectors of focus for SSIR are Cement, Chemicals & Speciality Chemicals, Food Processing, and Engineering & Automobile.

To promote the regional economy of the state Gujarat through FDI, exports, imports, developing world-class infrastructure etc., 3 major Special Investment Regions have been proposed under DMIC i.e. (i) Dholera Region, (ii) Vadodara-Ankleshwar Region, and (iii) Bharuch-Dahej Region. Dholera SIR is the first one that is being developed and has a major impact in the influence area.

- **Dholera Investment Region**

The Dholera Special Investment Region (DSIR) is a Greenfield Industrial City planned and located about 100 km southwest of the state's capital Ahmedabad and is located about 100 km from the proposed DMIC. The industrial city spans to about 920 sq.km and includes 22 villages of the Dholera Taluka in the district of Ahmedabad. It is strategically located between the cities of Ahmedabad, Baroda, Rajkot, and Bhavnagar. The region is accessible through all transit modes i.e., road, rail, air and water. The strategic location of the DSIR is presented in **Figure 2.40**.

Figure 2.40: Location of Dholera Special Investment Region in Gujarat

As per the implementation plan of the project, 3 phases have been proposed i.e. 2010-20, 2020-30, and 2030-40. It is estimated that the project will generate about 0.83 million of employment; 0.2 million in Phase-1, 0.41 million in Phase-2, and 0.22 million in Phase-3. Further, out of the total developable area, about 40% of the total area has been allocated for industrial activities such as IT, manufacturing etc. The proposed land-use mix plan of DSIR is presented in **Figure 2.41**.

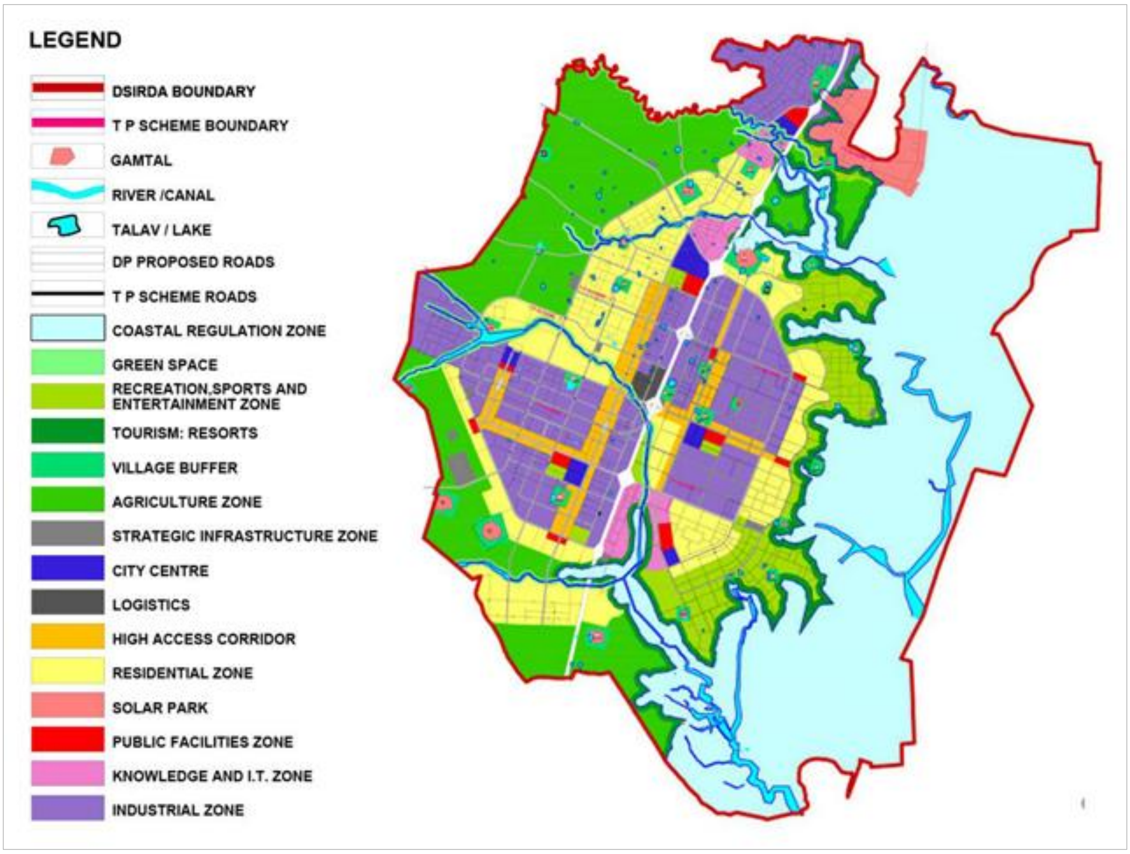


Figure 2.41: Land-use mix plan of Dholera Special Investment Region in Gujarat

As per the economic activity mix proposed for 2040, heavy engineering industries, automobile and auto ancillaries, electronics, pharmaceuticals, and biotechnology are the dominant industries. The proposed land use mix of the project is presented in **Table 2.66** and the proposed economic activity mix by 2040 is presented in **Table 2.67**.

Table 2.66: Land-use break-up of Dholera Special Investment Region in Gujarat

No.	Land-Use	Area in Ha	% of Total
1	Residential	8,400	24%
2	Industrial	14,000	40%
3	Commercial	2,100	6%
4	Institutional	1,400	4%
5	Transport	2,100	6%
6	Open/Green Areas	700	20%
Total		35,000	100%

Table 2.67: Economic activity mix of Dholera Special Investment Region by 2040

No.	Industry	Net Area in Ha	Employment
1	Heavy Engineering	2,250	45,100
2	Automobile & Auto Ancillary	1,990	43,900
3	Electronics, Hi-Tech & Emerging Technologies	1,360	87,300
4	Pharmaceuticals & Biotechnology	1,120	49,100
5	Metals & Metallurgical Products	480	11,400
6	General Manufacturing	440	42,400
7	Agro and Food Processing	340	27,500
8	IT/ITES	20	6,200
Total		8,000	3,12,900

DSIR is going to get significantly benefitted from Kalpasar project as distance to major centres such as Surat, Mumbai will reduce by more than 100 km. There will be other benefits such as availability drinking and industrial water and urbanisation in surrounding areas etc.

- **Vadodara-Ankleshwar Investment Region**

The Vadodara-Ankleshwar Investment Region is strategically located along side of the DFC and spans over an area of 123 sqkm. Halol-Savli site was chosen as the preferred destination for investment region due to factors like low cropping intensity, low population density, not falling in the Narmada Canal etc.

The industries identified to be developed as per the proposal can be segregated into 4 sectors i.e. (i) engineering, (ii) automobile OEM's and ancillaries, (iii) engineering plastics, and (iv) electrical and electronics. Under these sectors, some of the industries related to building materials, machine parts, fabrication, engine and steering parts, plastics use in automobiles, electric and electronic devices, power transmission equipments, power plants etc.

The implementation of the Vadodara-Ankleshwar Investment Region would depend on the land acquisition process of the processing areas. The developers depending on the demand, in the specified zones, would develop the non-processing zone for which no upfront land acquisition would be required. Further, it is estimated that the investment region will generate employment of about three lakhs. The phasing plan for the investment region is presented in **Table 2.68**.

Table 2.68: Phasing of Vadodara-Ankleshwar Investment Region in Gujarat

No.	Phase	Zones	Area in Ha
1	Phase-1	Halol GIDC Estate	461
		Salvi GIDC Estate	614
2	Phase-2	Savli GIDC Estate Expansion	400

No.	Phase	Zones	Area in Ha
3	Phase-3	Halol Estate Expansion	5,875
4	Phase-4	Halol Site	4,943

- **Impact on Project's Influence Area**

Since, these investment regions are located near to the Kalpasar dyke Project, these regions will have direct or indirect impact on the project in terms of savings in logistics cost, improvement in attractiveness of the investment regions which in turn will promote employment, investments in the region etc.

It is estimated that more than 5 lakh employment will be generated by these 3 investment regions; the infrastructure required to support the direct and indirect employment will lead to development of housing and other social infrastructure, therefore leading to overall development of the region.

- **Special Economic Zones (SEZ)**

As per the Ministry of Commerce and Industry, India, the state of Gujarat has identified 47 SEZs in which 20 are functional, 5 are formally approved, 12 are in-principle approved whereas 10 are notified but non-functional as of now. Location of the SEZs in Gujarat are shown in **Figure 2.42.**

Among the 20 functional SEZs, there are 5 major SEZs (primarily based on total notified area) at (i) Mundra (ii) Jamnagar, (iii) Dahej, (iv) Sarod, and (v) Shikara. The details of the 5 major SEZs in Gujarat are presented in **Table 2.70**.

Further, the Jamnagar SEZ, followed by Dahej SEZ and Mundra SEZ, dominated the export and import performance in 2018-19. Performance of SEZs in Imports and Exports is shown in **Figure 2.43**.

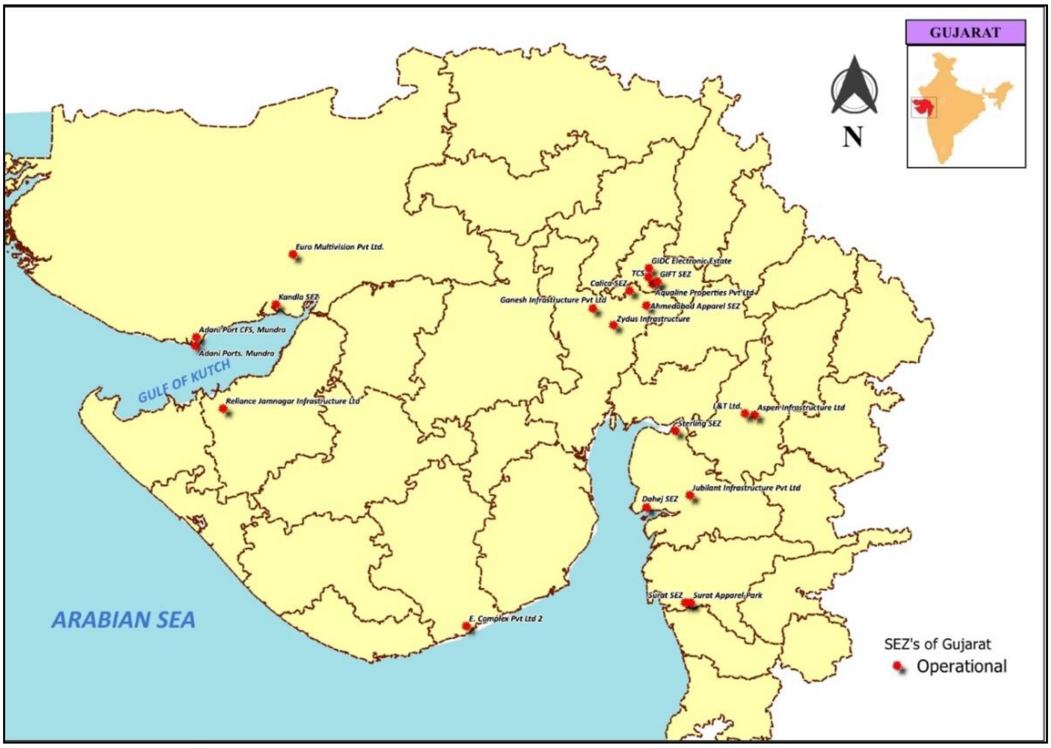


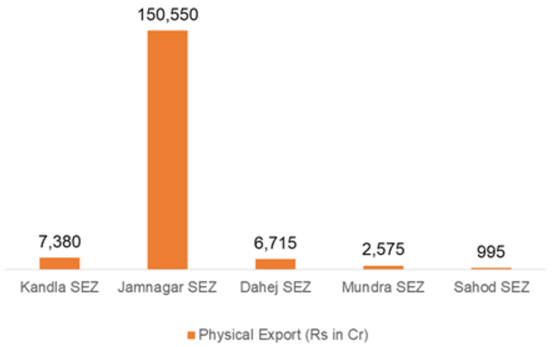
Figure 2.42: Location of operational SEZ in Gujarat state

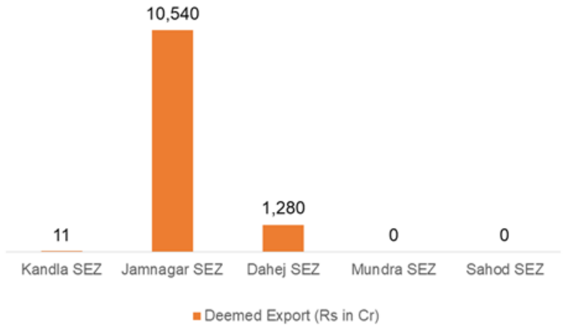
Table 2.69: Special Economic Zones (SEZs) in Gujarat state

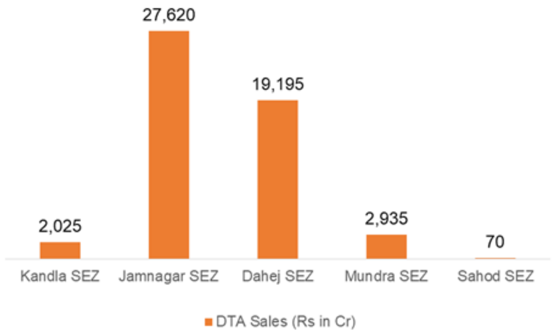
No.	Type of SEZ	Number
1	Functional SEZ	20
2	Formally Approved SEZ	5
3	In-principle approved SEZ	12
4	Notified non-functional SEZ	10
Total SEZs		47

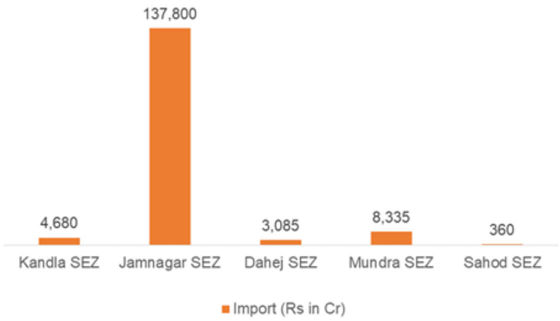
Table 2.70: Details of major SEZs in Gujarat state

No.	Location	Owner	District	Type	Area (Ha)
1	Mundra	Adani Port & Special Economic Zone Ltd	Kutch	Multi-Product	6472.87
2	Jamnagar	Reliance Jamnagar Infrastructure Ltd.	Jamnagar	Multi-Product	4494.00
3	Dahej	Dahej SEZ Limited	Bharuch	Multi-Product	1718.94
4	Sahod	Sterling SEZ Pvt Ltd.	Bharuch	Multi-Product	1263.17
5	Shikara	"Euro Multivision Ltd"	-	Multi-Product	1163.47









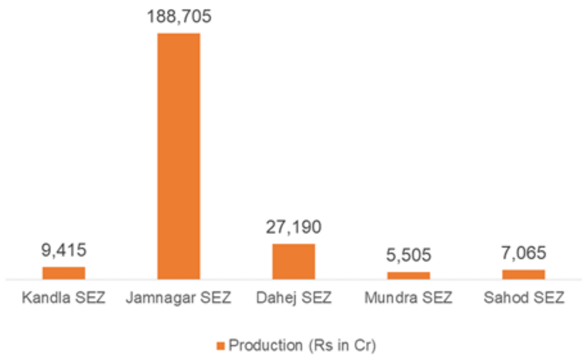


Figure 2.43: Export and import performance of major SEZs in Gujarat state (2018-19)

- **Ship Breaking Yard - Alang**

Alang, the world's largest ship recycling yard is in Gulf of Khambhat, (Bhavnagar District) in Gujarat. The shipyard has an area of about 40 hectares, has more than 180 plots, and has a total capacity of 4.5 million LDT (Light Displacement Tonnage).

As of 2021, Alang shipyard recycled about 175 ships, which are about 27 less than that of the previous year 2020. The annual average growth rate of ships broken/recycled at Alang from 2012-2021 was -8.83% whereas of LDT handled was -9.5%. The details of number of ships broken/recycled and LDT handled by the Alang shipyard during the period 2011-12 to 2020-21 are presented in **Figure 2.44**.

Being a labour-intensive industry, Alang ship recycling hub employs around 20,000 workers in normal circumstances, about 70-80% of them being migrant workers from states like UP, Bihar, Jharkhand, and Odisha.

One of the main reasons for the reduction in number of ships at Alang ship breaking yard can be probably due to the reduced offered prices to the clients coming for dismantling of the ships. On the contrary, neighbouring countries Bangladesh and Pakistan are offering higher rates as high as $460 to $470 per ton as they do not follow the mandate of green shipbreaking guidelines. As per the guidelines, some of the harmful parts of the ship that pose threat to both marine and human lives need to be isolated, and this is a costly process. As a result, the offered rates at Alang were less as compared to those at Bangladesh and Pakistan. This resulted in the annual reduction of ship breaking numbers at Alang ship breaking yard.

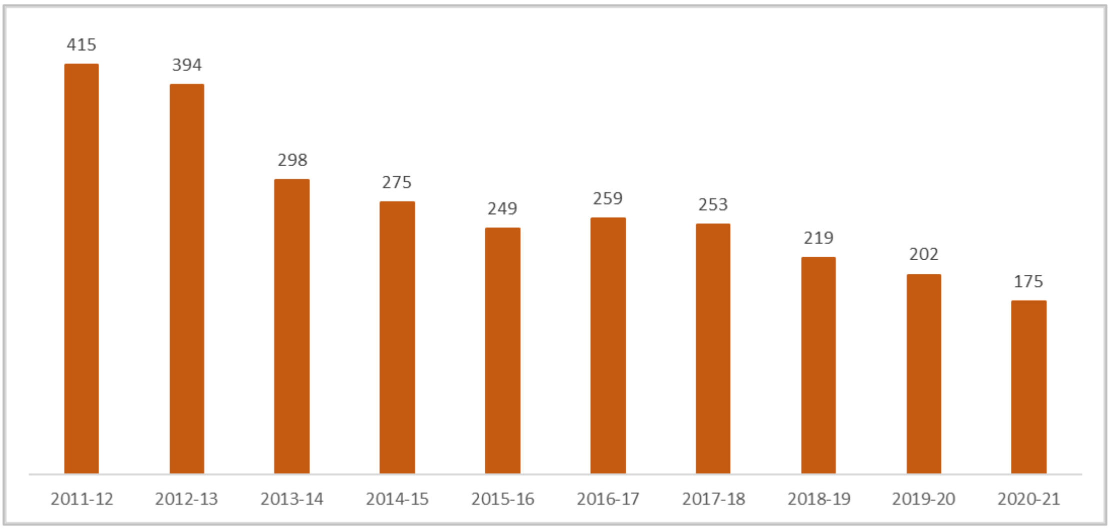


Figure 2.44: Number of ships broken/recycles at Alang ship breaking yard (2012-21)

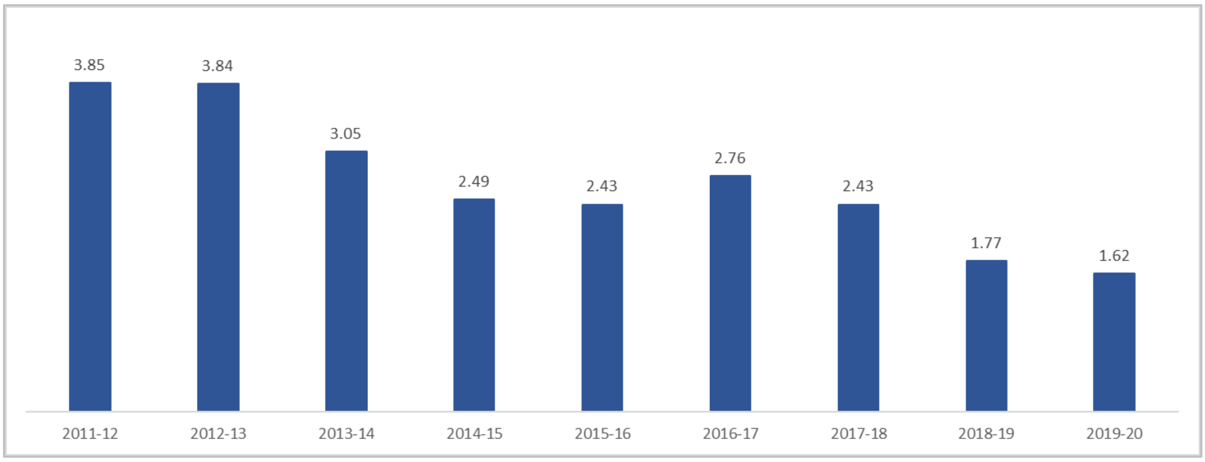


Figure 2.45: Light displacement tonnage handled at Alang ship breaking yard (2012-20)

However, with up-gradation of infrastructure and international certifications, the trend will reverse and there is possibility of increased trend in coming years. Ships can be expected from Japan, Europe etc. However, the influence area of Alang is mainly Saurahstra and Northern states such as Punjab and UP and therefore impact on Kalpsar road and rail will be minimal.

(e) Estimation of traffic growth rates

- **Road**

IRC 108:2015 suggests having multiple approaches for estimation of traffic growth rates such as:
(1) Growth factors based on past traffic trend data on study corridor
(2) Growth factors based on past registered motor vehicles in PIA
(3) Growth factors based on elasticity analysis
(4) Growth factors based on time series analysis

In general, the factors, which influence the growth of traffic are:
(1) Demographic: (i) Population, (ii) Mix of population (urban vs rural), (iii) Income, and (iv) Others (tourism).
(2) Economic: (i) Gross Domestic Product at the National level, (ii) Agricultural Output, (iii) Industrial Output, and (iv) Per capita Income.

Traffic growth rate are established by giving due consideration to the above factors. Most widely used methods for forecasts of the traffic include (i) Trend Analysis, and (ii) Elasticity Approach.
(1) Trend Analysis based on Past Traffic Data: Trend Analysis is a time trend of past traffic. The future trends are derived based on past trends by extrapolation.
(2) Elasticity Method: Elasticity is defined as rate of change of traffic with 1% change in potential variables such as NSDP, per capita income and population. In elasticity method, growth in traffic is obtained by multiplying the Elasticity values with Gross National Product (GNP), per capita income or population of the regions.

- **Forecast of population and economy of India**

Future population and economic trends are critical for forecast the traffic growth rates as traffic is derived demand. Therefore, review of forecast of population and economy of India is carried and presented in this section.

- **Population**

The past decades growth trends of population for India and Gujarat are presented below in **Table 2.71**. It can be noted that during 2001-2011 for which census information was available, India recorded annual average growth rate of 1.64% whereas Gujarat has recorded a higher growth rate of 1.78%. Further, it can be noted that share of population of Gujarat is constant at 5% of the India's population.

Table 2.71: Population growth trends of India and Gujarat

S. No.	Year	India	Gujarat	Share	Past Growth Rate (India)	Past Growth Rate (Gujarat)
1	1981	68,33,29,097	3,40,85,799	5.00%	-	-
2	1991	84,64,27,039	4,13,09,582	4.90%	2.16%	1.94%
3	2001	1,02,87,37,436	5,06,71,017	4.90%	1.97%	2.06%
4	2011	1,21,08,54,977	6,04,39,692	5.00%	1.64%	1.78%

Further, the region-wise population of Gujarat, share and annual growth rate of population is presented below in **Table 2.72**. It can be noted that while growth rate of central Gujarat and Kutch region is increasing whereas growth rate in other regions have declined.

Table 2.72: Region-wise population growth trends of Gujarat

Population						
Year	North Gujarat	South Gujarat	Central Gujarat	Saurashtra	Kutch	Total
1991	7270466	10351418	11199165	11226026	1262507	41309582
2001	8941831	13348781	13359317	13437863	1583225	50671017
2011	10319646	16458927	16124717	15444031	2092371	60439692
Share of Population						
1991	17.6%	25.1%	27.1%	27.2%	3.1%	100%
2001	17.6%	26.3%	26.4%	26.5%	3.1%	100%
2011	17.1%	27.2%	26.7%	25.6%	3.5%	100%
Annual Growth Rates						
1991-2001	2.1%	2.6%	1.8%	1.8%	2.3%	2.06%
2001-2011	1.4%	2.1%	1.9%	1.4%	2.8%	1.78%

As per the population forecast by UN (50% prediction interval i.e. Median), the Indian population is expected to reach a peak of about 165 Crore between 2055-60. Thereafter, population is expected to decline to about 145 Crore by 2100. The trends of population growth for next 8 decades (as forecasted by UN) and the corresponding growth rates are presented in **Table 2.73, Figure 2.46** and **Figure 2.47**. UN Model clearly indicates that population will reach saturation level and decline over the upcoming decades due to manifold reasons such as increase in old age population, decline in fertility rate etc.

Table 2.73: Population forecast for India

Year	Population of India			Growth rates per annum		
	Lower 80 PI	Median PI	Upper 80 PI	Lower 80 PI	Median PI	Upper 80 PI
2020	138	138	138			
2025	143.2	144.5	145.8	0.74%	0.92%	1.11%
2030	147.4	150.4	153.2	0.58%	0.80%	1.00%
2035	150.5	155.4	159.9	0.42%	0.66%	0.86%
2040	152.4	159.3	165.7	0.25%	0.50%	0.72%
2045	153.1	162.1	170.6	0.09%	0.35%	0.58%
2050	152.6	163.9	174.8	-0.07%	0.22%	0.49%
2055	150.9	164.9	178.5	-0.22%	0.12%	0.42%
2060	148.1	165.1	181.7	-0.37%	0.02%	0.36%
2065	144.4	164.4	184.3	-0.50%	-0.08%	0.28%
2070	140.1	162.9	185.9	-0.60%	-0.18%	0.17%
2075	135	160.7	187.2	-0.74%	-0.27%	0.14%
2080	129.3	158	187.6	-0.86%	-0.34%	0.04%
2085	123.5	154.9	187.7	-0.91%	-0.40%	0.01%
2090	117.5	151.6	187.9	-0.99%	-0.43%	0.02%
2095	111.4	148.2	187.8	-1.06%	-0.45%	-0.01%
2100	105.6	144.7	187.3	-1.06%	-0.48%	-0.05%

Note : PI – percentage prediction interval

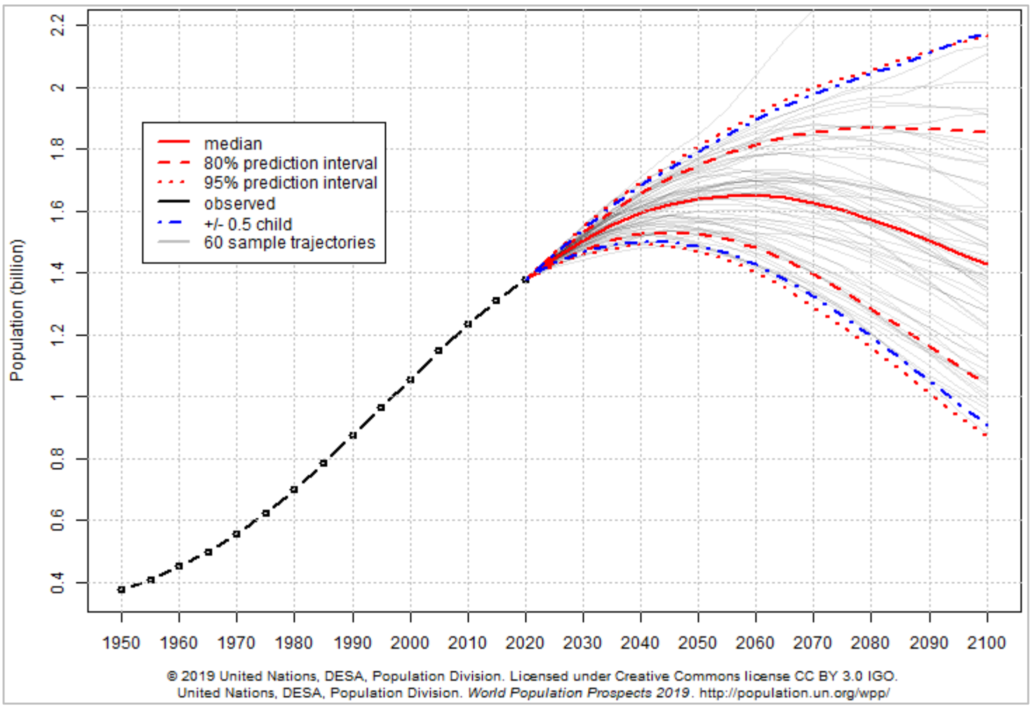


Figure 2.46: Decadal population forecast for India (Source: UN)

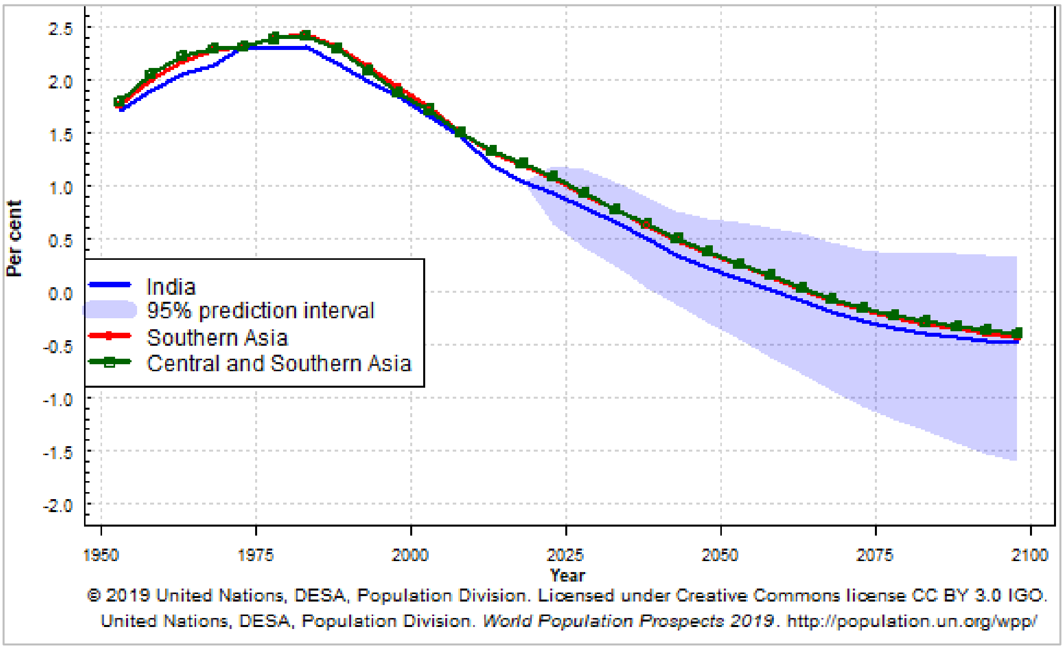


Figure 2.47: Annual growth rate of population in India (Source: UN)

- **Economy**

According to a report by **Observer Research Foundation (ORF)**, the Indian economy will grow at a **long-term compound annual growth rate of around five percent between 2020 to 2050.**

India would become the third largest economy in the world after China and the US by 2050 as per **Lancet Study**. The paper took 2017 as the base year when India was the seventh largest economy. As per the paper, **India would move to become the fourth**

largest economy by 2030 and the third largest by 2050. India is currently the fifth largest economy in the world. The study published in the medical journal said that India would retain the same position in 2100. The result was derived by translating working-age population of countries into scenarios for GDP. **Lancet study** also reveals that there would be huge decline in the working-age population in China and India; the latter would continue to maintain the top spot. By 2100, India is forecasted to still have the largest working-age population in the world, followed by Nigeria, China, and the USA. Despite fertility rates lower than the replacement level, immigration sustained the US workforce as per the paper. Countries like Australia and Israel would rise in global rankings by GDP due to an increase in immigration. Japan that is also likely to see a sharp decline in working-age population, it would remain the fourth-largest economy in the world in 2100.

A global report on economy prepared by **PwC** has estimated the growth of Indian economy as the second largest in the world by 2050. India can surpass US by that time. As per the report, Indian economy is likely to grow at 5% between 2021 to 2030; 4.4% between 2031 to 2040 and 3.9% between 2041 to 2050. GDP growth rate of India is given in **Table 2.74**.

Table 2.74: India's GDP growth rate

Year	GDP in PPP terms (US trillion dollars)	Growth Rate
2016	8.7	-
2020	11.8	7.92%
2025	15.7	7.40%
2030	19.5	5.57%
2035	24.3	5.66%
2040	30.0	5.41%
2045	36.6	5.10%
2050	44.1	4.77%

Source : The World in 2050, The long view: how will the global economic order change by 2050 (Feb, 2017)

As per the "The long term view : Scenarios for the World Economy to 2060, OCED Economic Policy Paper, July,2018" in the Base line scenario, world trend real GDP growth declines from about 3.5% in 2019 to 2% in 2060, mainly due to a deceleration of large emerging economies as these continue to account for the bulk of world growth. India and China take up a rising share of world output as the world's economic centre of gravity shifts toward Asia. China's share of world output peaks during the 2030s at about 27% and declines slowly thereafter, while India's share keeps raising. Each country accounts for fifth to a quarter of the world economy in 2060. The potential GDP per capita growth rate for India is presented below.

Table 2.75: India's potential GDP per capita growth rate in base line scenario

Period	Potential GDP per Capita
2018-2030	5.3%
2030-2060	3.5%

- **Traffic growth rate based on past traffic data**

L&T Ramboll Consulting Engineers Ltd., had carried the Traffic study in 2010. The traffic data of the study is compared with the traffic counts carried out as part of the current study and the derived mode-wise growth rates are presented in **Table 2.76**.

Table 2.76: Road-wise past growth rate (per annum growth rates) from 2010 to 2012

Location Name	Mode-wise Annual Growth Rates						
	Car	Bus	Mini Bus	LCV	2A Truck	3A Truck	MAV
Karjan Toll plaza	5%	2%	7%	5%	-4%	-6%	11%
Padra-Borsad Road (Near Bhadran)	8%	3%	4%	6%	-3%	-9%	15%
Vataman Toll plaza (Non-Operational)	9%	3%	1%	7%	-2%	-6%	17%
Bagodara Toll plaza	7%	2%	2%	7%	-6%	-2%	18%
Amod-Muler Road (Near Amod)	7%	-15%	-100%	6%	-8%	-9%	13%
Bharuch-Vagra Road (Near Vagara)	7%	-2%	-5%	11%	-7%	3%	11%
Kotda Toll Plaza (Non-Operational)	11%	2%	5%	8%	-1%	-7%	12%

The decline in 2-Axle, 3-Axle trucks is due to increased preference for multi-axle trucks as well as LCVs due to economics of operations. Multi-axle trucks have shown double digit growth rate ranging from 11% to 18% on various roads. Decline in Buses is noticed on local roads. Major corridors show positive growth rates.

Among the above-mentioned road sections, the growth trends observed at Vataman Toll Plaza is more appropriate for Kalpasar Project since Vataman captures all the East-West Traffic. Once Kalpasar project is implemented significant proportion of traffic at Vataman Toll Plaza is expected to be diverted to Kalpasar road over the dyke. Therefore, Vataman Toll Plaza growth trend is taken to be past traffic growth for the current study. Traffic growth is observed to be more on State Highways as compared to National Highway sections. There is a general decrease in the number of 2-Axle trucks except on Amod-Jambusar Road and Gandhar-Amod Road.

- **Growth trends of registered vehicles in Gujarat**

To assess the growth of traffic within the project's influence area, the vehicle registration trend data has been analysed. The details regarding the number of vehicles registered and the vehicle composition (2000 to 2018) is extracted from Commissionerate of Transport, Government of Gujarat and the same is presented in **Table 2.77**.

Table 2.77: Registered vehicles in Gujarat (2000-2019)

No.	Year	Transport Vehicles		Non-Transport Vehicles (Private Vehicles)		Total	
1	2000-01	8,26,046	-	47,49,994	-	55,76,040	-
2	2001-02	8,58,113	3.9%	51,49,856	8.4%	60,07,969	7.7%
3	2002-03	8,99,284	4.8%	56,09,086	8.9%	65,08,370	8.3%
4	2003-04	9,51,943	5.9%	61,35,597	9.4%	70,87,540	8.9%

No.	Year	Transport Vehicles		Non-Transport Vehicles (Private Vehicles)		Total	
5	2004-05	10,16,149	6.7%	68,01,123	10.8%	78,17,272	10.3%
6	2005-06	11,12,590	9.5%	75,09,700	10.4%	86,22,290	10.3%
7	2006-07	12,20,632	9.7%	82,76,705	10.2%	94,97,337	10.1%
8	2007-08	13,13,997	7.6%	89,75,059	8.4%	1,02,89,056	8.3%
9	2008-09	13,98,189	6.4%	96,00,462	7.0%	1,09,98,651	6.9%
10	2009-10	14,97,890	7.1%	1,03,74,683	8.1%	1,18,72,573	7.9%
11	2010-11	16,21,857	8.3%	1,13,71,278	9.6%	1,29,93,135	9.4%
12	2011-12	17,77,974	9.6%	1,26,35,743	11.1%	1,44,13,717	10.9%
13	2012-13	19,17,824	7.9%	1,38,54,629	9.6%	1,57,72,453	9.4%
14	2013-14	20,27,243	5.7%	1,50,64,356	8.7%	1,70,91,599	8.4%
15	2014-15	21,56,394	6.4%	1,65,64,173	10.0%	1,87,20,567	9.5%
16	2015-16	22,92,095	6.3%	1,80,69,201	9.1%	2,03,61,296	8.8%
17	2016-17	24,21,032	5.6%	1,96,15,507	8.6%	2,20,36,539	8.2%
18	2017-18	25,66,058	6.0%	2,12,54,759	8.4%	2,38,20,817	8.1%
19	2018-19	26,80,808	4.5%	2,25,20,277	6.0%	2,52,01,085	5.8%
20	2019-20	28,35,574	5.8%	2,39,04,491	6.1%	2,67,40,065	6.1%
Average (Overall)			6.7%		8.9%		8.6%
Average (5 years)			6.0%		8.3%		8.0%

From the observed past traffic data over the years, it is evident that the average growth of vehicles accounts in the range of 6% for transport vehicles and 9% for non-transport vehicles.

In 2019-20, the total registered vehicles in the state of Gujarat were about 267.4 lakh which includes 89.4% of non-transport vehicles i.e. 239.04 lakh and 10.6% of transport vehicles i.e. 28.35 lakh. The average annual growth rate of the registered vehicles in Gujarat from 2000-19 is 8.6% whereas for non-transport vehicles, it is 8.9% and for transport vehicles is 6.7%. Category wise Motor Vehicles registered in the state from 2015 to 2019 are shown in **Table 2.78**.

Table 2.78: Mode-wise registered motor vehicles in Gujarat (2015 to 2019)

No.	Category	2015-16	2016-17	2017-18	2018-19	2019-20
1	Motorcycle/Scooter	126,47,427	137,06,590	145,46,556	158,01,542	168,09,548
2	Moped	22,72,066	24,37,767	25,06,548	26,46,829	27,36,419
3	Motor Car	22,60,084	25,27,537	27,32,316	30,11,656	32,45,517
4	Jeep	1,83,774	1,85,894	1,88,463	1,95,031	1,96,163
5	Police Van	2,563	2,681	2,761	2,829	2,829
6	Tractor	6,41,376	6,87,825	7,24,993	7,73,221	8,17,541
7	Others	61,911	67,213	76,298	89,168	96,474
	Sub Total	1,80,69,201	19615507	2,07,77,935	2,25,20,276	2,39,04,491
8	Truck	3,42,016	3,61,441	3,80,753	4,19,780	4,61,461
9	Tanker	33,249	34,620	35,492	37,519	39,032

No.	Category	2015-16	2016-17	2017-18	2018-19	2019-20
10	Three-Wheeler	7,18,334	7,58,393	7,88,770	8,48,423	9,03,161
11	Other Light Wheeler	295719	3,22,869	3,36,177	3,56,005	3,74,192
12	School Bus	5,579	6,367	7,125	9,187	13,047
13	Bus	58,591	6,1817	64,411	68,171	69,145
14	Maxi Cab	45,324	48,207	49,788	53,111	54,669
15	Private Service Vehicle	6,463	6,671	7,732	8,804	8,934
16	Taxi	70,126	77,254	82,023	89,357	96,682
17	Ambulance	9,535	10,174	10,416	10,812	10,995
18	Trailer	3,69,276	3,79173	3,81,519	3,93,045	3,96,863
19	Tempo	3,37,878	3,54,046	3,64,277	3,86,594	4,07,393
	Sub Total	22,92,090	24,21,032	25,08,483	2,6,80,808	28,35,574
	Total	2,03,61,291	2,20,36,539	2,32,86,418	2,52,01,084	2,67,40,065

Among the total registered vehicles in Gujarat in 2019-20, motorcycles/scooters dominate the total with 62.86%, followed by motor cars with 12% and mopeds by 10.2%. Among the transport vehicles, the total is dominated by auto-rickshaws with 31.85%, followed by trucks with 16.27% and tempo with 14.37%. Detailed RTO wise and District-wise registered vehicles is compiled (for the Year 2020) and presented in **Annexure-2J**. From the observed data, Ahmedabad RTO stands top as the RTO with highest number of registered vehicles in 2020 with 44,31,065 followed by Surat RTO which has 35,46,520 registered vehicles. When observed mode-wise, Ahmedabad stands top in all the modes followed by Surat in 2W, 3W and Cars. Gandhinagar has second highest number of buses registered after Ahmedabad. Interestingly, after Ahmedabad RTO, Bhuj RTO in Kutch district stands second in the number of registered trucks. Mode wise growth rate of registered motor vehicles in Gujarat is given in **Table 2.79**.

Table 2.79: Growth rate of mode-wise registered motor vehicles in Gujarat (2015 to 2019)

		Annual Growth Rate					Overall Growth Rate (For 4 Years)
No.	Category	2015-16	2016-17	2017-18	2018-19	2019-20	
1	Motorcycle/Scooter		8.4%	6.1%	8.6%	6.4%	7.4%
2	Moped		7.3%	2.8%	5.6%	3.4%	4.8%
3	Motor Car		11.8%	8.1%	10.2%	7.8%	9.5%
4	Jeep		1.2%	1.4%	3.5%	0.6%	1.6%
5	Police Van		4.6%	3.0%	2.5%	0.0%	2.5%
6	Tractor		7.2%	5.4%	6.7%	5.7%	6.3%
7	Others		8.6%	13.5%	16.9%	8.2%	11.7%
	Sub Total		8.6%	5.9%	8.4%	6.1%	7.2%
8	Truck		5.7%	5.3%	10.2%	9.9%	7.8%
9	Tanker		4.1%	2.5%	5.7%	4.0%	4.1%
10	Three-Wheeler		5.6%	4.0%	7.6%	6.5%	5.9%
11	Other Light		9.2%	4.1%	5.9%	5.1%	6.1%

No.	Category	Annual Growth Rate					Overall Growth Rate (For 4 Years)
		2015-16	2016-17	2017-18	2018-19	2019-20	
	Wheeler						
12	School Bus		14.1%	11.9%	28.9%	42.0%	23.7%
13	Bus		5.5%	4.2%	5.8%	1.4%	4.2%
14	Maxi Cab		6.4%	3.3%	6.7%	2.9%	4.8%
15	Private Service Vehicle		3.2%	15.9%	13.9%	1.5%	8.4%
16	Taxi		10.2%	6.2%	8.9%	8.2%	8.4%
17	Ambulance		6.7%	2.4%	3.8%	1.7%	3.6%
18	Trailer		2.7%	0.6%	3.0%	1.0%	1.8%
19	Tempo		4.8%	2.9%	6.1%	5.4%	4.8%
	Sub Total		5.6%	3.6%	6.9%	5.8%	5.5%
	Total		8.2%	5.7%	8.2%	6.1%	7.1%

Only drawback of growth rate derived from registered vehicles is that they do not always reflect ground conditions. It only shows the new vehicle registrations and the vehicles phased out from road network are not known. The net effect of both will reveal the actual growth rate of traffic on road network. Moreove, vehicle registration is refelecting economic cycles.

- **Growth rate based on elasticity approach**

The values of elasticity for the past decade (2001-2021) for Car, Bus, Trucks is 1.2, 0.875 and 1.1 as per the Road Transport Demand for 2000 AD revisited and demand forecast for 2021, Journal of the Indian Roads Congress, Oct-Dec, 2009. The elasticity values continue to decline as the economy matures and will decline to 0.5 or even lower. The elasticity values have been considered based on the developed economies and final forecast is made duly considering growth in economy and population.

- **Estimated traffic growth rate**

The final estimated traffic growth rates for the future based on past traffic growth rates and elasticity approach duly considering the growth of population, economy is presented below in **Table 2.80**.

Table 2.80: Estimated mode wise traffic growth rates for Kalpasar project

Year	LCV	2 Axle Truck	3 Axle Truck	Multi-Axle Truck	Car	Bus
2011-2021	6.00%	-2.00%	-2.00%	13.00%	8.00%	2.50%
2022-2030	4.25%	-1.40%	-0.90%	7.50%	7.50%	2.10%
2031-2040	3.50%	-1.30%	-0.70%	5.00%	7.00%	1.80%
2041-2050	3.00%	-1.20%	-0.60%	4.50%	6.00%	1.50%
2051-2060	2.00%	-0.90%	-0.40%	3.50%	5.00%	0.75%

Year	LCV	2 Axle Truck	3 Axle Truck	Multi-Axle Truck	Car	Bus
2061-2070	1.50%	-0.45%	-0.30%	2.50%	3.00%	0.50%
2071-2080	1.00%	-0.20%	-0.10%	1.50%	1.50%	0.25%
2081-2090	0.50%	-0.10%	-0.10%	0.50%	1.00%	0.20%
2091-2100	0.25%	-0.10%	-0.10%	0.25%	0.50%	0.10%

*Source: Consultant Analysis

➢ **Rail**

- **Traffic growth rates for railway passenger traffic**

The trends of annual growth of passenger traffic from 2008 to 2018 is presented in **Table 2.81**.

Table 2.81: Annual growth of passenger traffic (in millions)

Annual Growth of Passenger Traffic (Millions)												
No.	Class	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	CAGR
1	Sleeper Class	232.82	248.12	265.19	316.97	311.22	297.52	315.57	323.84	329.91	342.49	4.38%
2	3rd AC	38.61	45.03	53.25	60.35	70.08	68.6	78.27	84.48	89.08	93.54	10.33%
3	2nd Sitting	73.14	95.85	113.96	107.04	126.8	140.65	142.81	157.07	149.58	155.74	8.76%
4	Chair Car	13.54	14.56	16.69	19.44	22.13	24.46	25.89	26.52	27.42	29.28	8.94%
5	2nd AC	16.21	17.37	19.56	21.68	22.56	23	25.15	25.92	25.27	27.39	6.01%
6	1st AC	1.53	1.66	1.92	2.34	2.39	2.5	2.5	2.54	2.68	2.74	6.74%
7	Exe Chair Car	0.39	0.64	0.7	0.87	0.92	1.01	1.01	0.96	1	1.08	11.93%
8	1st Class	1.34	1.84	1.68	1.32	1.1	0.95	0.68	0.46	0.39	0.37	13.28%
9	Unreserved	2,741	2,945	3,117	3,317	3,387	3,286	3,127	3,027	2,924	2,968	0.89%
	Total	3,118	3,370	3,590	3,847	3,944	3,845	3,719	3,648	3,550	3,620	1.67%

Source: National Railway Plan, Dec, 2020

The Rail passengers have been classified as **Long-Distance AC (LDAC) passengers** and **Long-Distance Non-AC (LDNA) passengers**, and the growth trends are analysed and the same is presented in Table 2.82. It can be noticed that LDAC passengers have recorded significant growth rate of 9.11% as compared LDNC passengers' growth rate of 1.44%. Growth trend observed for Long Distance AC & Non-AC Passengers is presented in **Table 2.82** below.

Table 2.82: Growth trend for long distance AC & Non-AC passengers

Growth Trends in Passenger Traffic in mentioned Categories (Millions)												
No	Class	2008 -09	2009 -10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	CAGR
1	LDAC	70.27	79.27	92.12	104.69	118.08	119.57	132.81	140.41	145.46	154.03	9.11%
2	LDNA	3,048	3,291	3,498	3,742	3,826	3,725	3,586	3,508	3,404	3,466	1.44%
Total		3,118	3,370	3,590	3,847	3,944	3,845	3,719	3,648	3,550	3,620	1.67%
3	Sub Urban	3,802	3,875	4,061	4,377	4,477	4,552	4,505	4,459	4,566	4,665	2.30%
Grand Total		6,920	7,246	7,651	8,224	8,421	8,397	8,224	8,107	8,116	8,286	2.02%

Source: National Railway Plan, Dec 2020

The forecast of the future railway passengers considers past growth rates as well as growth in future population and GDP. The share of AC passengers in 2017-18 is only 4.4% out of total railway passengers. This component is expected to grow faster in future. Therefore, separate traffic growth rates have been considered for AC and Non-AC passengers based on Past trends, National Railway Plan-2020 as well as Consultants 'analysis and the same is presented below in **Table 2.83**.

Table 2.83: Growth rate of passenger traffic by category

Year	Growth Rate of LDAC	Growth Rate of LDNC
2021-2031	8.76%	1.73%
2031-2041	6.47%	1.50%
2041-2051	5.43%	1.41%
2051-2061	3.80%	0.70%
2061-2071	2.47%	0.35%
2071-2081	1.36%	0.18%
2081-2091	0.68%	0.09%
2091-2101	0.27%	0.04%

Source: Consultant Analysis

- **Traffic growth rates for railway freight traffic**

Indian Railways transported the loading of 1232.64 million tonnes for the financial year 2020-21 whereas Western Railway has transported 80.71 million tonnes which is 6.5% of the total loading on Indian Railways.

As per National Railway Plan (Dec, 2020), Ministry of Railways, Government India, the share of freight by Indian Railways in 2018-19 is only 27%. As per the Plan, rail share is expected to increase to 45% of the total freight by 2051, by increasing the speed of the trains and reducing the tariff on certain commodities as well as augmentation of infrastructure. The details of current share of freight by various modes is presented below in **Table 2.84**.

Table 2.84: Share of freight by various modes in India (2018-19)

No.	Mode	Tonnes (in Millions)	Share
1	Rail	1221.5	27%
2	Road	2911.7	64%
3	Coastal Shipping	234	5%
4	IWT	72	2%
5	Pipeline	84	2%
Total		4523.2	100%

The commodity wise past traffic growth rate by Rail is presented below. Overall, the freight traffic is growing at the rate of 3.74%. Among the commodities which recorded high growth rate are RM Steel (9.07%), Pig Iron & Finished Steel (7.4%) and Containers (7% for Exim and 5.2% for Domestic) etc. Growth trends for rail freight are presented below in **Table 2.85**.

Table 2.85: Growth trends of rail freight

Commodity	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	CAGR
Coal	369.63	396.1	420.37	455.81	496.42	508.6	545.81	551.83	532.83	555.2	4.62%
RM for Steel	10.85	11.6	13.3	14.51	15.6	17.33	18.28	20.29	22.75	23.7	9.07%
Pig Iron & Finished Steel	28.58	31.85	32.82	35.15	35.31	38.95	42.84	44.79	52.41	54.36	7.40%
Iron Ore	130.58	132.74	118.46	104.7	111.4	124.27	112.77	116.94	137.55	139.8	0.76%
Cement	86.24	93.15	99.08	107.66	105.87	109.8	109.8	105.35	103.29	112.96	3.04%
Food grains	35.51	38.69	43.45	46.4	49.03	55.1	55.47	45.73	44.86	43.79	2.36%
Fertilizers	41.35	43.68	48.22	52.7	46.21	44.7	47.41	52.23	48.34	48.53	1.79%
POL	38.08	38.88	39.29	39.77	40.61	41.16	41.1	43.24	42.42	43.11	1.39%
Containers-Exim	23.29	25.32	26.58	28.54	31.69	32.61	37.88	36.79	37.01	42.82	7.00%
Containe-Domestic	7.05	9.63	11.01	9.48	9.35	10.93	10.5	9.04	10.34	11.12	5.19%
BOG	62.23	66.1	69.15	74.33	66.6	68.75	73.4	75.28	74.35	84.09	3.40%
Total	833.39	887.74	921.73	969.05	1,008.09	1,052.20	1,095.26	1,101.51	1,106.15	1,159.48	3.74%

Indian railways have handled 921.73 million tonnes of freight in 2010-11; the same has increased to 1232 million tonnes in 2020-21 recording a growth rate of 2.94%.

However, in the previous decade (between 2000-01 to 2010-11), the growth in Cargo was 6.9%.

As per National Rail Plan-2020, the forecast of cargo for 2031, 2041 and 2051 is 3167 million tonnes, 5058 million tonnes and 6885 million tonnes respectively recording a growth of 9.9%, 4.79% and 3.13% (western, eastern and other dedicated freight corridors). The steep growth in freight is forecasted due to proposed dedicated freight corridors as well as emphasis on multi-modal transport and up-gradation of infrastructure. Railway recently started using very long trains to transport the coal and other bulk commodities.

Traffic growth rates by Rail (for freight) considers past growth rates, National Railway Plan-2020 as well as Consultants' analysis. The estimated traffic growth rates for freight through Rail is presented below in **Table 2.86**.

Table 2.86: Growth rate of freight traffic by rail

Year	Growth Rate in Freight Traffic by Rail
2011-2021	2.94%
2021-2031	9.90%
2031-2041	4.79%
2041-2051	3.13%
2051-2061	1.72%
2061-2071	0.86%
2071-2081	0.39%
2081-2091	0.16%
2091-2101	0.05%

Source: Consultant Analysis

- **Discussion on modal shift from road to rail**

Indian Railways determines the charted line capacity manually by master chart method. There are many factors affecting line capacity including mixed mode of traffic (freight & passenger), number of trains, speed differential of rolling stock, terminal constraints, junction and cross movement of trains, weather conditions, maintenance blocks etc.

Following capacity standards have been adopted for planning the railway network based on various established norms.

Configuration	***Capacity (Trains/Day/Direction)***
Single line (mixed operation)	*25*
Double line (mixed operation)	*60*
Double line (mixed operation) with Automatic TCAS + ABS + CTC signalling	*90*
Double line with Automatic TCAS + ABS + CTC signalling (for dedicated passenger operations)	*200*
Single line DFC (for dedicated freight operations)	*40*
Double line DFC (for dedicated freight operations)	*140*

2.3.4 Traffic demand forecast & capacity requirements

(a) Travel demand model

A travel demand model has been developed to forecast the traffic on Kalpasar road link. The model is developed using CUBE software. The modelling procedure followed in CUBE software is presented in **Figure 2.48** below.

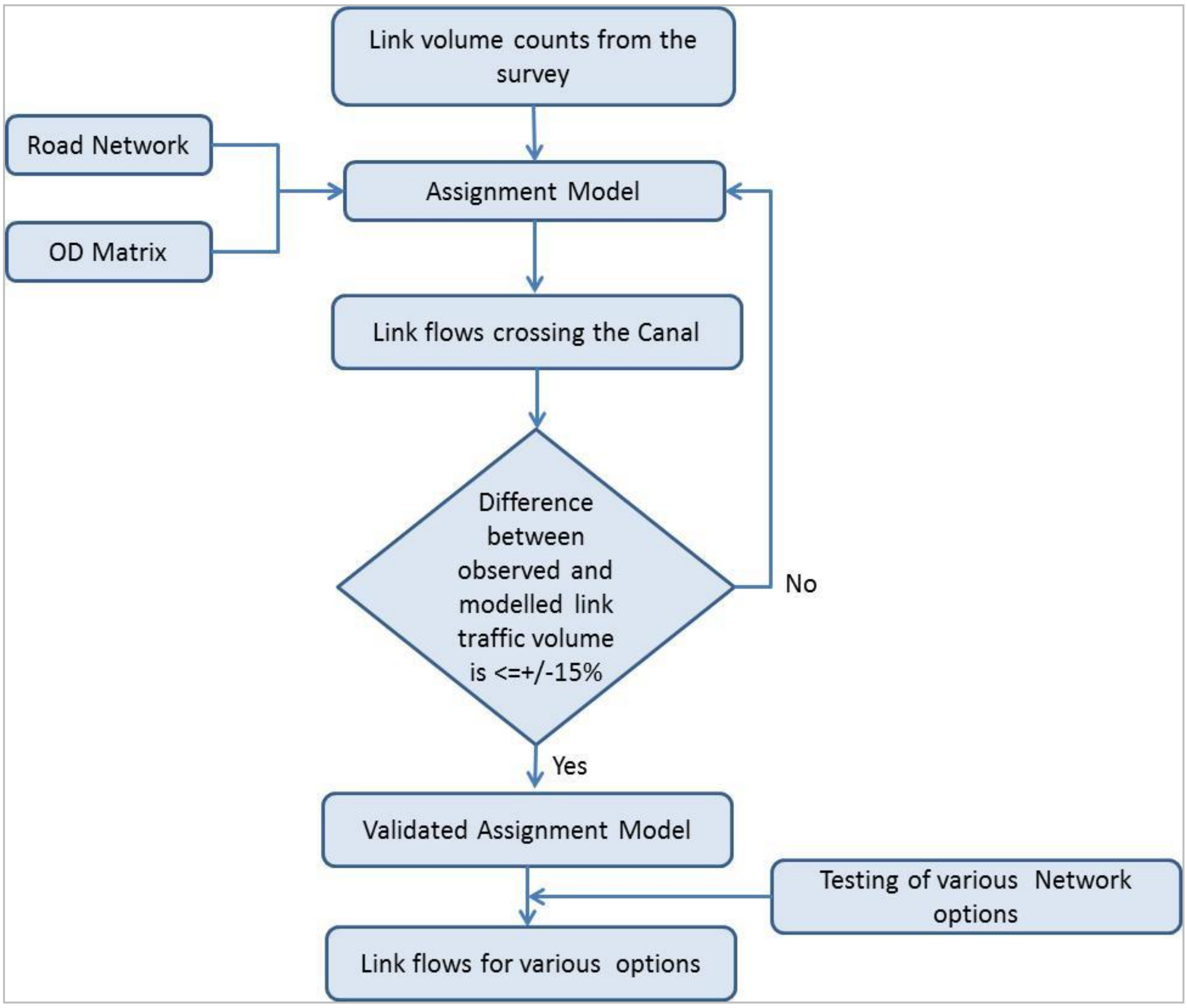


Figure 2.48: Modelling procedure

The modes that are modelled under the study include Cars, IPT (Autos and Taxi) and public transport i.e., Bus, Commercial Vehicles such as Trucks, Multi Axle Vehicles and Light Commercial Vehicles. The model is responsive to congestion, travel costs and travel time savings. Model is calibrated for 24 hours period.

- **Planning period**

Year 2022 is considered as the base year, 2032 is considered as opening year for road over the dyke. 2071 and 2101 have been considered as horizon year for Traffic demand forecast.

- **Zoning**

The study area is divided into number of **Traffic Analysis Zones (TAZ)** for analysing the travel characteristics. Taluk boundaries are considered for dividing the study area into Traffic Analysis Zones. The total number of zoning system adopted for the study is 207 out of which 192 zones are internal and 15 zones are external. The zone map is presented in **Figure 2.49**.

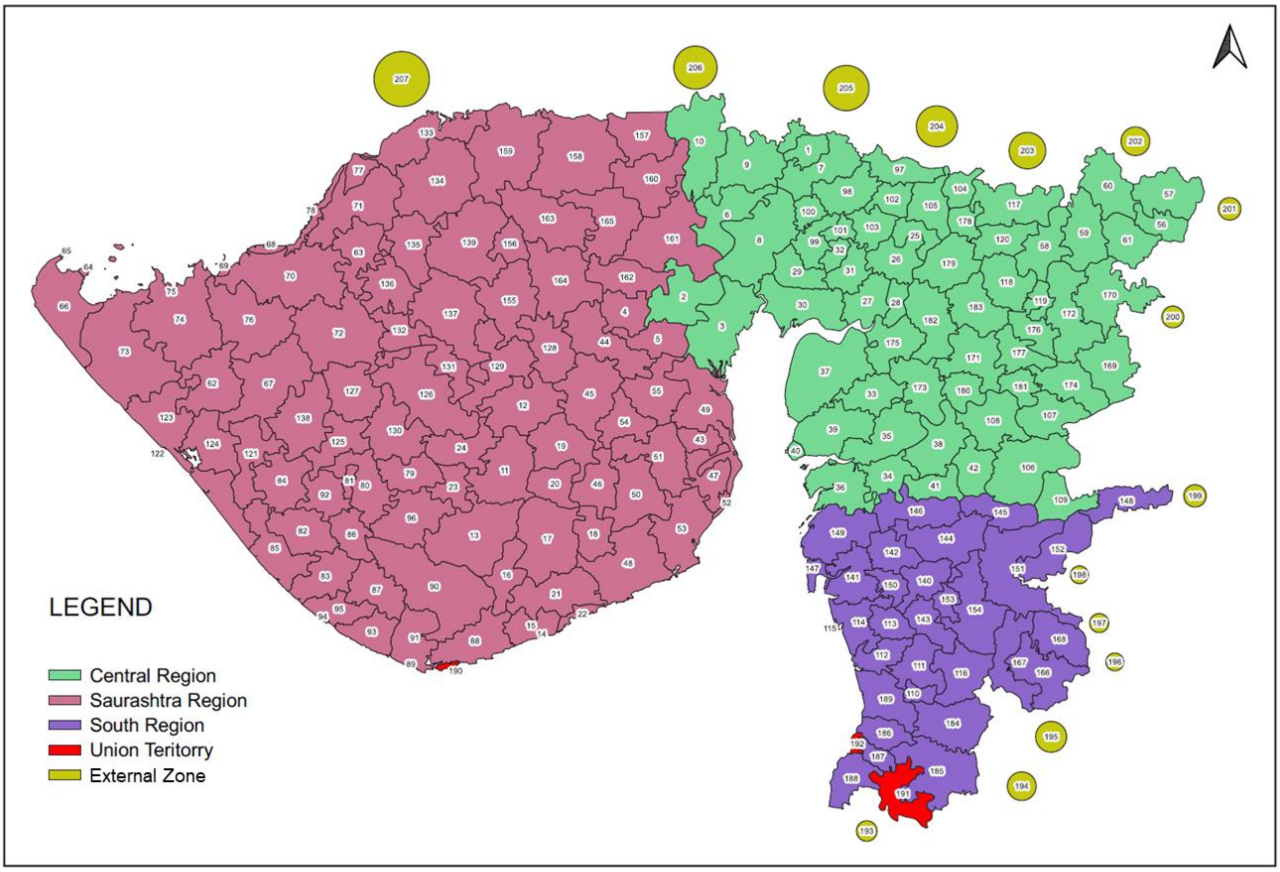


Figure 2.49: Zone map

- **Network development**

The National Highways (NH), State Highways (SH) and Major District Roads (MDR) are considered in the development of the network. Total length of network includes 14,377 Km. All links are coded as oneway links having A – node (after node) and B – node (before node) with its own characteristics.

The link attributes include road names, capacity, lane configuration, length, toll details (if any),volume count information at junction, screen line and cordon locations, free flow speed, bus preload. These link characteristics are compiled and categorized based on functional class for the basic network for study area. The salient features of the coded highway network are presented in **Table 2.87**. There are two capacity values a) for assessing lane requirements b) for capacity analysis purpose. Check.

Table 2.87: Salient features of coded highway network

Functional class	Urban / Inter-Urban	Typology of Road	Lanes	Direction	Capacity (PCU/Day)	Capacity (PCU/ Hr)	Free Flow Speed (Kmph)
1	Urban	Single Lane Undivided	1	2	12000	1200	30
2	Urban	Intermediate Lane Undivided	1.5	2	18000	1800	45
3	Urban	Two Lane Undivided	2	2	24000	2400	48
4	Urban	Three Lane Divided	3	2	43200	4320	52
5	Urban	Four Lane Divided	4	2	54000	5400	55
6	Urban	Six Lane Divided	6	2	84000	8400	63
7	Urban	Single Lane Undivided	1	1	19200	1920	48
8	Urban	Two Lane Undivided	2	1	38400	3840	77
9	Inter-Urban	Single Lane Undivided	1	2	4000	800	50
10	Inter-Urban	Intermediate Lane Undivided	1.5	2	12000	2150	75
11	Inter-Urban	Two Lane Undivided	2	2	30000	3100	80
12	Inter-Urban	Four Lane Divided	4	2	90000	8480	90
13	Inter-Urban	Six Lane Divided	6	2	136000	13580	100
14	Expressway (Inter-Urban)	Four Lane Divided	4	2	99000	10000	100

Source- Indo-HCM 2017

For urban road stretches, daily capacities are derived from Peak Hour capacities adopted from Indo-HCM 2017 manual. For Highways and Expressways, the daily capacities are taken directly from Indo-HCM 2017.

The form of the BPR function for speed flow is:

$$T_C = T_0 * (1+\alpha * (v/c)^{\wedge\beta})$$

Where, T_c – Congested Link Travel time
T_0 – Link Free flow time
v - Link Volumes
c – Link Capacity
α and β – calibrated speed flow parameters

The α and β parameters are calibrated based on the observed speed and traffic volumes for various road categories. The coded highway network is presented in **Figure 2.50**.

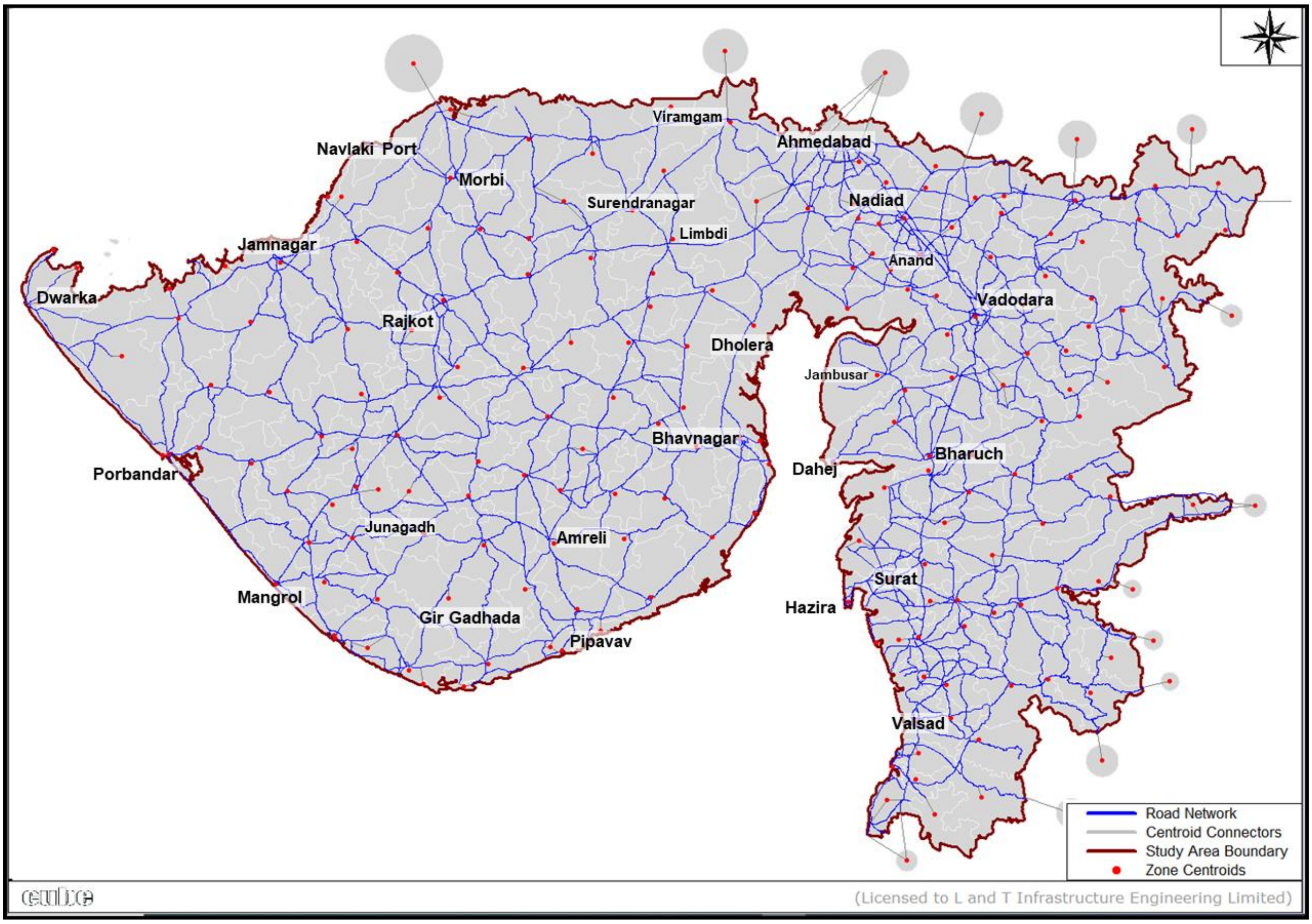


Figure 2.50: Coded highway network

Details about the existing toll road stretches and toll rates are collected and same is coded in the Network.

The centroid connectors are added based on the local road network present in each TAZ level. The coded network is validated for the route selection for the identified zone pairs comparing with the field conditions. The network validation is presented in **Figure 2.51**.

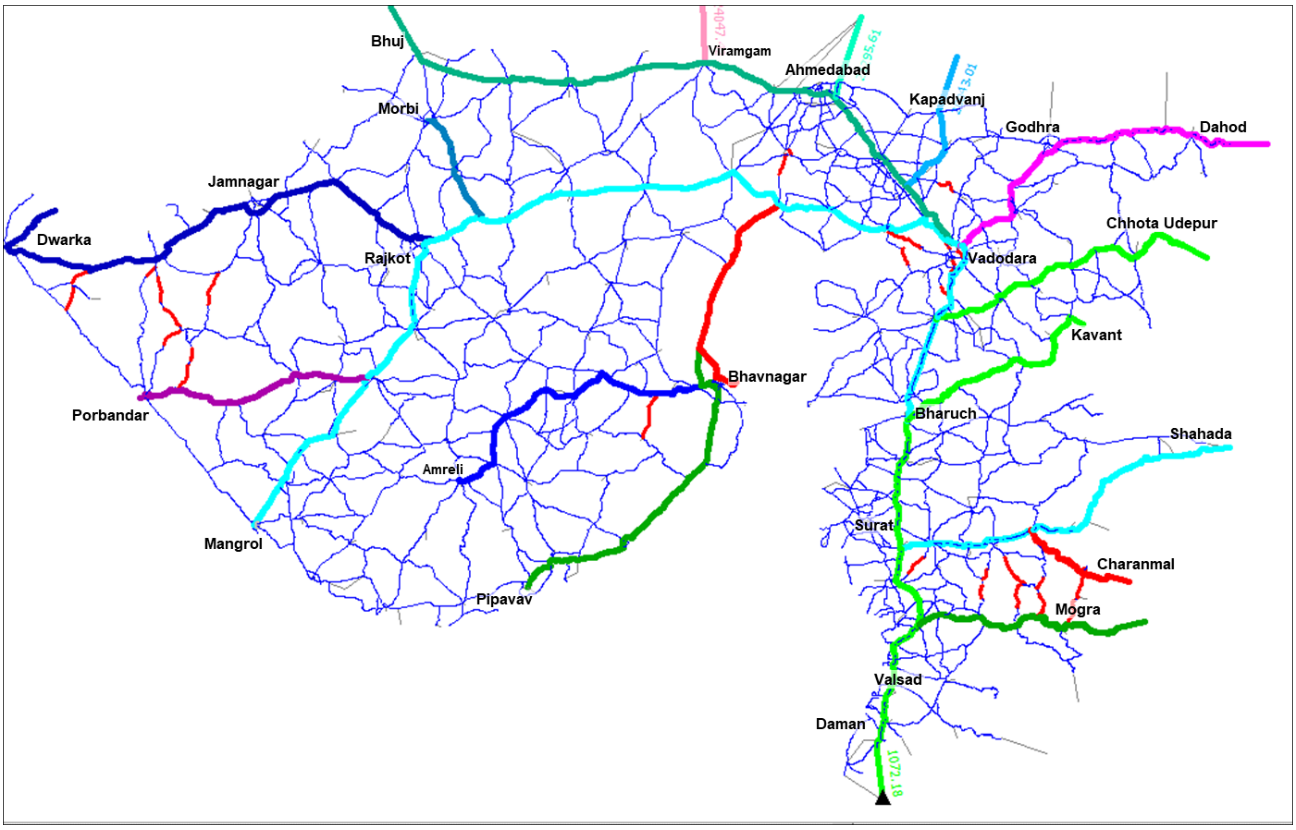


Figure 2.51: Network validation (path validation)

➢ Matrix Development

- **Development of matrices for immediate project influence area**

From the primary traffic surveys, mode-wise matrices are generated for Private vehicles (Car and Two wheeler), Intermediate Public Transport (Taxi and Auto Rickshaw), Public Transport (Bus and Mini Bus), Commercial vehicles (Truck, MAV and LCV).

- **Development of matrices for the rest of Gujarat and other directional movements**

In order to include the impact of other traffic movements apart from East- West traffic movement on the network, consultants have prepared the seed matrix considering the following parameters:

(1) Population
(2) Road Connectivity
(3) Rail Connectivity
(4) Proximity to Major Port
(5) Proximity to International Airport
(6) SEZ and any Industrial Park

Overall rating for each TAZ's have been calculated based on the above parameters. Above factors are further sub-categorized base on size, configuration and infrastructure availability. Score is given to sub-category ranging from zero to 100. Factors considered in order to obtain final seed matrix are listed below.

Population- Based on the population of Taluka's available from census data, score is given to each sub-category of population which is presented in the table below.

Population	Score
<1 lakh	10
1-2 lakhs	25
2-5 lakhs	35
5- 10 lakhs	50
10-25 lakhs	75
>25 lakhs	100

Road connectivity – Accessibility of the each TAZ's are categorized, and score is allotted based on types of road and lane configuration which is presented in the table below.

Road	Score
2 lane	25
4 lane	50
6 lane	75
All Roads*	100

* Note- All roads means all type of road which includes Expressway and National Highway and State Highway

Rail connectivity – TAZ's having railway station will have significant percentage of trips made by rail. 100 score is giving to taluka's having High Speed Rail connectivity. Further detailed score for different categories is presented in the table below.

Rail	Score
No rail	0
Rail	50
Both rail and HSR	100

Proximity of port- Based on the distance of TAZ's from ports, score is allotted which is presented in the table below. All distance of TAZ's are measure from Kandla port.

Port	Score
<100 km	100
100-200 km	80
200-300 km	60
300-400 km	40
>400 km	20

SEZ's and any industrial park – TAZ's having large industries, SEZ's or following under special investment region will generate more trips compare to others. Large number of passenger and commercial trips will be generated based on the type of SEZ's or SIR. Hence, based on number of SEZ's or Industries, score is provided to each category which is presented in the table below.

Number of SEZ's	Score
Not Available	0
1	25
2	50
3	75
>3	100

Based on the above scores of sub- categories, Weightage factor matrix for zone to zone OD pair is calculated and the same is seeded to software for generating the initial matrix preparation.

Seed matrix is input to the Cube Analyst module for generating the Matrix. Traffic census details are collected from National Highways Department and Directorate of Economics and Statistical Department, Govt. of Gujarat. The daily traffic volumes of various roads at strategic locations are input into the Analyst module. Based on the traffic volumes and seed matrix, initial matrix is developed.

The initial matrix is updated by replacing the East -West OD pairs with the OD matrix developed from the Primary surveys. The updated initial matrix is input to the traffic assignment model for Validation process.

- **Validation**

Mode wise matrices of Private vehicles, IPT, Public Transport and Commercial Vehicle modes are assigned on the transport network. The traffic assignment is carried out based on the cost equations presented below

Cost = ((Vehicle Operating Cost (VOC)* Distance)/ Value of Time (VoT)) + Travel Time+ (Toll cost/ Value of Time)

All the costs are converted into time units by Value of Time (VoT). The VOC and VoT values for various modes and various category of roads were considered from **IRC SP-30: 2019**. For commercial vehicles commodity holding cost is considered instead of Value of Time.

***CUBE ANALYST**: CUBE Analyst is a tool used in the validation process for optimising the trip matrices with traffic volume counts observed at major locations.*

The mode-wise assigned traffic volumes are compared with observed traffic volumes collected through primary surveys and secondary information at various locations. The network/ matrices will be checked and calibrated until the difference between assigned traffic volumes and observed traffic volumes comes with in allowable limit of +/-15%. This process will be automated by the CUBE ANALYST software. Base year observed and modelled Traffic Flow on major roads have been compiled and presented in **Table** 2.88.

Table 2.88: Validation results for traffic flow

Passenger Vehicles									
Direction	Observed (PCU/Day)			Modelled (PCU/Day)			% Error		
	Private*	Bus	Mini-Bus	Private*	Bus	Mini-Bus	Private*	Bus	Mini-Bus
East-West	296046	60884	27505	279938	58218	25437	-5%	-4%	-8%
West-East	260430	56965	26575	251851	55413	24976	-3%	-3%	-6%
North-South	102882	17400	8936	100567	18000	8643	-2%	3%	-3%
South-North	100418	17936	9019	95777	18524	8987	-5%	3%	0%

Light Commercial Vehicle and 2 Axle Truck						
Direction	Observed		Modelled		% Error	
	LCV	2Axle Trucks	LCV	2Axle Trucks	LCV	2Axle Trucks
East-West	62399	106535	57513	99636	-8%	-6%
West-East	56275	96807	52082	85221	-7%	-12%
North-South	23508	30789	21993	34266	-6%	11%
South-North	25561	30263	23383	32925	-9%	9%

3-Axle Truck and Multi Axle Vehicles						
Direction	Observed		Modelled		% Error	
	3 Axle Trucks	Multi Axle Vehicles	3 Axle Trucks	Multi Axle Vehicles	3 Axle Trucks	Multi Axle Vehicles
East-West	88431	233385	88001	233705	0%	0%
West-East	76256	220724	76655	220793	1%	0%
North-South	21643	83263	22054	83542	2%	0%
South-North	21483	83635	22023	80027	3%	-4%

* Private mode includes Car, Two-Wheeler & Auto-Rickshaw

The map showing the traffic flow diagram and Desire line diagram for the base year is presented in **Figure 2.52** and **Figure 2.52.**

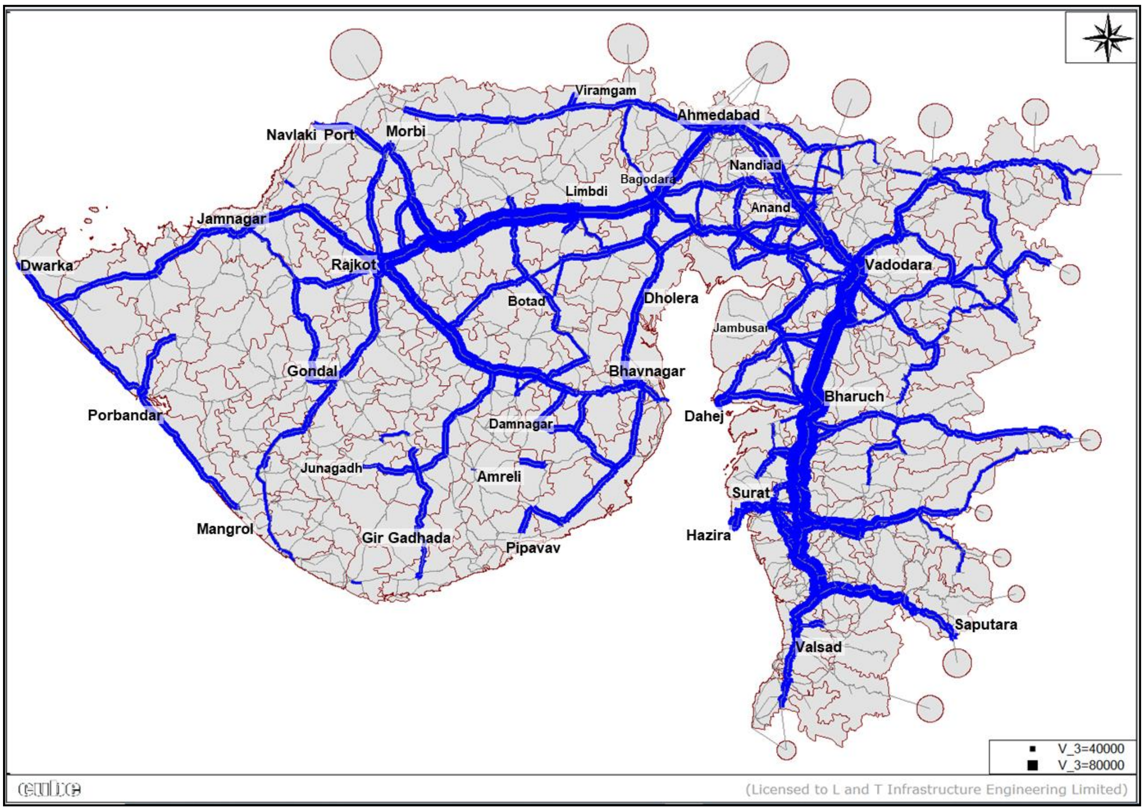


Figure 2.52: Traffic flow diagram for base year (2022)

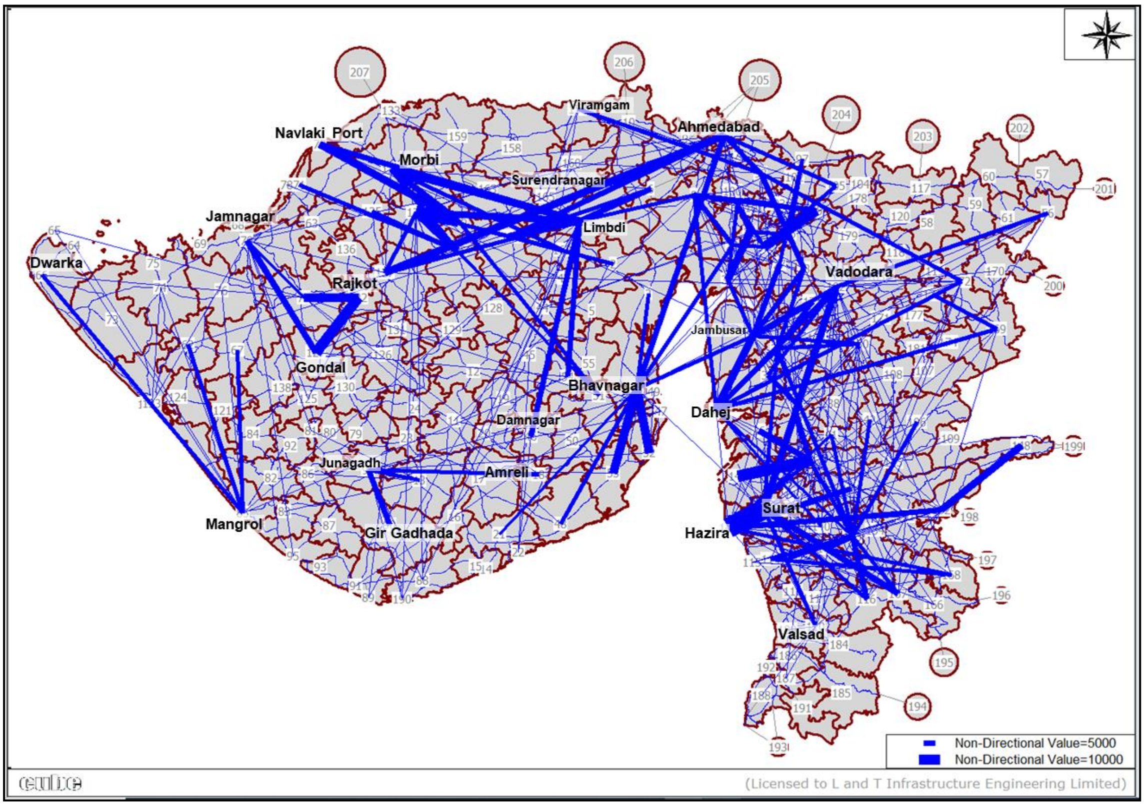


Figure 2.53: Desire line diagram for base year (2022)

(b) Description of various scenarios for forecasting the traffic

Considering the long horizon for traffic forecast and given the uncertainly in forecast the range of forecast are required so that appropriate decision can be taken on lane configuration for road development. In this regard, three scenarios (pessimistic, most likely and optimistic) have been worked out. The various underlying assumptions in various scenarios are presented below.

- **Optimistic scenario**

(1) All road network improvements (such as road widening and greenfield roads) are expected to happen as planned
(2) Travel demand is expected to grow proportionate to population and economy
(3) All the SEZ would be operational as planned
(4) 10.4 Lakh hectare additional land will be irrigated due to the Kalpasar project
(5) 1/3rd of the of goods generated from the irrigated crops will be transported
(6) 15 Lakh tourist per annum are expected in the year of project opening

- **Most likely scenario**

This scenario has following assumptions,
(1) Only 50% of projected SEZs would be operational;
(2) 10.4 Lakh hectare additional land will be irrigated due to the Kalpasar project;
(3) Only 1/5th of the of goods generated from the irrigated crops will be transported;
(4) Only 2/3rd of the expected tourist would arrive in the year of project opening;
(5) Same growth rates of optimistic scenario;
(6) All road network improvements are expected to happen in optimistic manner.

- **Pessimistic scenario**

Pessimistic scenario assumes that most of the developments will not be in the pace as expected. Following are the assumptions of pessimistic scenario,

(1) Only 25% of projected SEZs would be operational;
(2) Only 3/4th of the expected area would be irrigated;
(3) Only 1/5th of the of goods generated from the irrigated crops will be transported;
(4) Only 1/3rd of the expected tourist would arrive in the year of projecy opening;
(5) Reduced growth rates than that of optimistic scenario;
(6) All road network improvements are expected to happen in optimistic manner.

In General about 50% of goods generated are expected to be transported by rail.

Traffic demand forecast has been carried out at every decadal interval till 2101. It is assumed that 2032 is the opening year of the project. The base considered is 2022 and forecast has been made for every decade i.e. 2031,2041,2051,2061,2071,2081,2091 and 2101 and the same is presented in **Table 2.98.**

(c) Assessment of toll rates

- **NHAI toll policy (Jan 2011)**

The toll rates for the vehicles using National Highway Stretches, as per NHAI Notification Regd.No.D.L-33004799, Extraordinary - Part II - Section 3 - Subsection 1, dated December 5th 2008, which was amended on 12th Jan, 2011. As per NHAI policy there are toll rate comprises of two components:
(1) Base rate of toll; and
(2) Additional fee of structures (if structure cost exceeds 10 crore).

NHAI toll policy also allows concessions for local vehicles and vehicles making multiple trips.

- **Base rate of fee**

The rate of fee for the use of the section of national highway, permanent bridge, bypass or tunnel constructed through public funded project or private investment project shall be identical. The rate of fee for use of a section of national highway of four or more lanes shall, for the base year 2007-08, be the product of the length of such section multiplied by the following rates as presented in **Table 2.89.**

Table 2.89: Base toll rate (2008)

Type of Vehicle	Base Rate of Fee per Km (in Rupees)
Car, Jeep, Van or Light Motor Vehicles	0.65
LCV	1.05
Bus or Truck (2 Axles)	2.20
3-Axle Truck	2.40
Multi-Axle Truck (4 to 6 Axles)	3.45
Oversized Vehicles (7 or more Axles)	4.20

- **Additional toll fees for structure**

Additional Base Toll Rate in case of structure (i.e. Permanent bridges, tunnel, and bypass) cost exceeds Rs. 10 Crores is presented in **Table 2.90**. If cost of Bypass exceeds 10 Crores, then toll plaza for Bypass can charge 1.5 times the base toll rates.

Table 2.90: Base rate of fee (Rupees per vehicle trip) for permanent bridges, tunnel, and bypass (NHAI)

Base Rate of Fee for Structures (Rupees per vehicle per trip)						
Cost of Permanent Bridge, or Tunnel (Rupees in crore)	Car, Jeep, Van or Light Motor Vehicle	Light Commercial Vehicle, Light Goods Vehicle or Mini Bus	Truck or Bus	Three-Axle Commercial Vehicles	HCM, EME or MAV	Oversized vehicle
10 to 15	5	7.5	15	16.5	22	30
For every additional Rupees five crore or part thereof, exceeding Rupees fifteen crore and up to Rupees one hundred crore	1	1.5	3	3.3	4.5	6
For every additional Rupees five crore or part thereof, exceeding Rupees one hundred crore and upto Rupees two hundred crore	0.75	1.15	2.25	2.45	3.4	4.5
For every additional Rupees five crore or part thereof, exceeding Rupees two hundred crore	0.5	0.75	1.5	1.65	2.25	3

- **Concessions as per NHAI policy**

(1) Concessions for passenger vehicles
(2) Concessions for commercial vehicles

Toll for commercial vehicles registered within a district where toll plaza is located will be eligible for 50% of the discount. This discount is not applicable to vehicles given National Permit.

- **Government of Gujarat toll policy**

As per the Govt. of Gujarat Policy, Toll rates are decided based on toll rate viability, uniformity of rate in the region and restricting recovery to the tune of 50% of the perceived users' benefits. The perceived cost includes the vehicle operating cost, time saving cost and toll charges. Toll rates will be revised periodically for increase in tariff. Government may give some relaxation to local traffic using portion of the project facility.

- **Proposed toll rates for current project**

The Kalpasar project will result in significant distance and travel time-savings for users travelling between for Saurashtra and South Gujarat region. Kalpasar Project will result in a) Fuel cost savings (due to more than 100 km reduction in distance) b) Travel time savings c) Commodity Holding Cost savings of about 2 hours d) Existing tolls.

For the purpose of fixing the toll rates, perceived benefits arising from average 100 km distance savings and 2 hours travel time savings is considered, and further 50% of savings in perceived benefits due to use of Kalpasar project is considered as Toll rates as per the Government of Gujarat Policy and the same is presented in **Table 2.91.**

Around 92% of the truck operators interviewed in Saurashtra and 80% of the truck operators interviewed in South Gujarat reported their willingness to pay the proposed toll fee. Out of all the Car users surveyed at Vataman, Bagodara and Borsad Toll Plaza, about 89% of the users are willing to pay the proposed toll fee.

Table 2.91: Proposed toll rates (in Rs.) for Kalpasar

Type of Vehicle	Fuel Savings (in Rs)	Travel Time savings (Rs) (in Rs)	Existing Toll Savings (in Rs)	Total Savings (in Rs)	Proposed Toll Rate(in Rs)
Car	909	368	445	1,722	860
Bus	2,701	193	1,460	4,354	2,175
LCV	1,284	32	710	2,026	1,015
2-Axle Truck	2,138	233	1,460	3,831	1,915
3-Axle Truck	2,178	233	2,090	4,501	2,250
MAV	2,813	366	2,270	5,449	2,725

* Note-1: Proposed Toll Rate is kept at 50% perceived savings
* Note-2: Toll at **Karjan**, **Vasad**, **Borsad** and Proposed Toll at **Vataman** is considered as existing toll (The toll Rate at Vataman is considered same as that of Borsad)
* Note-3: Commodity holding Cost is calculated based on concept of commodity inventory cost as per SP30-2019 & Value of time (VOT) for Car and Bus is calculated based on as per SP30-2019.
* Note-4: Rounded off to nearest 5/- rupees.

(d) Traffic demand forecast

➢ **Road**

Traffic demand forecast has been carried out at every decadal interval till 2101. It is assumed that 2032 is the opening year of the project. The base considered is 2022 and forecast has been made for every decade i.e. 2031,2041,2051,2061,2071,2081,2091 and 2101.

- **Development of Horizon year Network**

Consultants have collected the information about future year network improvements from various authorities. The major network improvement proposals are listed in **Table 2.92** and the same shown in **Figure 2.54**.

The proposed new networks are added on to the existing road network. The proposed road on the dyke is coded into the future highway network.

Table 2.92: Future network improvement proposals

S. No	Road Improvement	Stretch	Length (Km)
1	New Roads	Delhi-Mumbai Expressway	401
2	New Roads	Ahmedabad-Dholera Expressway	84
3	New Roads	Necklace Road along the sead connecting Bhavnagar-Dahej	189
4	New Roads	Dahej to NH48 via Vagara	51
5	New Roads	Coastal road along Tarapur-Bhilad-Tithal-Ubrat-Khambhat	143
6	Road Widening	Widening of Coastal Road between-Bhavnagar-Somnath-Dwaraka	530
7	Road Widening	Mahuva to Amreli	88
8	Road Widening	Amreli to Bhavnagar	108
9	Road Widening	Dhandi to Kalamsar via Surat, Hansot and Jambusar	210
10	Road Widening	Tourist corridor connecting Saputara, Ukai, Devmogra, Zarvani and Statue of Unity	280

Figure 2.54: Future network improvement proposals

- **Development of matrix for horizon years**

Future traffic on Kalpasar Road comprises of:
(1) Normal traffic (diverted);
(2) Generated traffic; and
(3) Induced traffic.

- **Development of Matrices for Normal Traffic Matrix for Horizon years**

Mode wise Matrices for Normal traffic for the base year is derived from the **Primary Traffic Surveys** and the matrices have been strengthened based on link counts and socio-economic parameters. These matrices have been assigned on the existing network and validated. Traffic growth rates have been applied to the validated matrices to obtain the horizon year matrices. Traffic growth rates have been estimated based on the various socio-economic scenarios and the same is presented in **Section 2.3**.The mode wise growth rates that are used for arriving the horizon year matrices is presented in **Table 2.93**.

Table 2.93: Adopted mode-wise growth rates for normal traffic (Is it different from given in previous section)

Year	LCV	2 Axle Truck	3 Axle Truck	Multi-Axle Truck	Car	Bus
2011-2021 (Actual)**	6.00%	-2.00%	-2.00%	13.00%	8.00%	2.50%
2022-2030	4.25%	-1.40%	-0.90%	7.50%	7.50%	2.10%
2031-2040	3.50%	-1.30%	-0.70%	5.00%	7.00%	1.80%
2041-2050	3.00%	-1.20%	-0.60%	4.50%	6.00%	1.50%
2051-2060	2.00%	-0.90%	-0.40%	3.50%	5.00%	0.75%
2061-2070	1.50%	-0.45%	-0.30%	2.50%	3.00%	0.50%
2071-2080	1.00%	-0.20%	-0.10%	1.50%	1.50%	0.25%
2081-2090	0.50%	-0.10%	-0.10%	0.50%	1.00%	0.20%
2091-2100	0.25%	-0.10%	-0.10%	0.25%	0.50%	0.10%

** Growth rate for the Year 2011-2021 is derived by comparing the traffic volume from the survey conducted for current study and past study (2011).

- **Development of Matrices for Generated Traffic**

Generated traffic is an important component of future traffic as many developments have been proposed in the project influence area. In addition to the industrial developments, Kalpasar centric developments such as Tourism and Irrigation will contribute to generated traffic.

(i) Generated traffic from new industrial developments

Phasing of Major developments is considered based on Master Plan and suitable assumptions wherever information is not available. Net development area in hectare is multiplied with trip generates rates to obtain the total commercial trips generated from the development. Trip generation for commercial vehicles is considered as 1.7 trucks per hectare based on the primary and secondary information. All such trips are converted into Goods PCUs for the horizon years of 2025 to 2060 for span of every 5 years.

Passenger trips generated from the developments is obtained as following:

(1) Total area allocated to residential landuse is identified. Wherever data on area allocated for residential landuse is not available, 10% of the gross area is taken as area under residential landuse.

(2) Population of the residential area is estimated taking as 60 persons/hectare

(3) Modal split of passengers is taken as 40% by Car and 60% by Bus with occupancy of 2.5 and 40 respectively.

To estimate the passenger traffic, direct and indirect employment generated from each zone is calculated and passenger trips are estimated. All the estimated trips are converted into passenger PCUs with an assumption of external trips as 15%. Car and Bus are the modes that are expected to use the zone with an assumed mode share of 40% & 60% and occupancy of 2.5 and 40 respectively. The generated traffic component is used to estimate the diverted traffic component on the Kalpasar project.

Based on the trip generation/ attraction rates, consultants have estimated the number of trips that will be generated/ attracted to the proposed developments. From the zone-wise trip generations and attractions, consultants have estimated the mode wise OD matrices based on the travel pattern observed from the validated matrix.

The forecasted normal matrix is added with the matrix developed for future development to arrive at the total matrix.

(ii) Generated Traffic due to Tourism

Kalpasar project will create a fresh water reservoir of 2000 sq.km, which is huge considering anywhere in the World. It will create a large water frontage. It is expected hotels and other facilities and infrastructure necessary will be created around the frontage area formed by the lake. However, most tourists are expected to visit dyke view which can be seen from either side of the dyke. Tourism potential of Kalpasar is estimated to be 15 to 20 lakh per annum based on the review of similar projects. However, only a fraction of these tourists is likely to cross the road over dyke.

Assuming one fourth of the tourists cross the Kalpasar road over the dyke, the generated traffic due to tourism on Kalpasar project is estimated to be 1100 PCUs/day in the year of project opening (assuming 50% of passengers travel by car, 25% by bus and 25% by rail) to 6700 PCUs/day in the year 2101. Tourism traffic is highly seasonal with wide fluctuations expected over various months of the year. It is to be noted above estimated value is average value per day.

(iii) Generated Traffic due to Irrigation

From Kalpasar Project 10000 Mm3 water with 50% dependability will be available, out of this 6500 Mm3 to be earmarked for irrigation. Three garland canals at about EL 50 m, EL 70 m and EL 100 m are planned to irrigate about 10.40 lakh hectares of agricultural land of 6 districts and 39 Taluks of Saurashtra.

At present land under irrigation in Saurashtra district is around 15 lakh hectares (as per 2004 statistics).In this context adding 10.4 lakh hectares of land due to Kalpasar will have a profound impact on agricultural output.

An estimate has been made to assess the no. trucks likely to use Kalpasar due to additional land coming under irrigation. Following assumptions were made:
(1) Around 1/3 of the production is likely to be transported to South Gujarat from Saurashtra

(2) Yield from hectare of land is taken as per the the yield rate for various crops published by Directorate of Agriculture-Gujarat for the year 2019-20
(3) Two crops per annum is considered
(4) Around 60% land will be irrigated by 2051, 85% by 2071 and remaining by 2101. Therefore entire 10.4 hectares of land will be fully comes under irrigation by 2101.
(5) About 50% of produced crops will be transported by rail

Based on the above assumptions, Around 4000 additional truck PCUs per day is expected to be generated carrying food grains between Saurashtra to South Gujarat in the year of project opening and is expected to increase to 20,000 truck PCUs un the year of 2101.

- **Traffic Forecast for various Scenarios**

Traffic forecast has been carried out for three scenarios namely Optimistic, Pessimistic and Most likely scenarios.

Travel demand is estimated based on the assumptions stated in **section 2.3.4 (b)** for various scenarios and for various horizon years i.e., 2031 to 2101. The updated matrix is assigned on to the future highway network to assess the traffic on the proposed Kalpasar link. The scenario-wise link volumes on the road over the dyke are extracted from the model and the same is presented in **Table 2.94.**

Table 2.94: Traffic forecast for various scenarios

Year	Traffic Forecast (in PCUs)		
	Optimistic	Most Likely	Pessimistic
2022	22,375	22,375	22,375
2031	52,713	49,011	45,185
2041	81,251	74,826	71,674
2051	1,21,434	1,07,860	99,920
2061	1,64,676	1,51,083	1,36,171
2071	2,06,275	1,91,816	1,70,657
2081	2,32,746	2,18,864	1,87,895
2091	2,43,709	2,22,382	1,90,625
2101	2,53,147	2,24,167	1,94,132

The traffic flow diagrams for Most-Likely Scenario for various horizon years are presented in **Figure 2.55**.

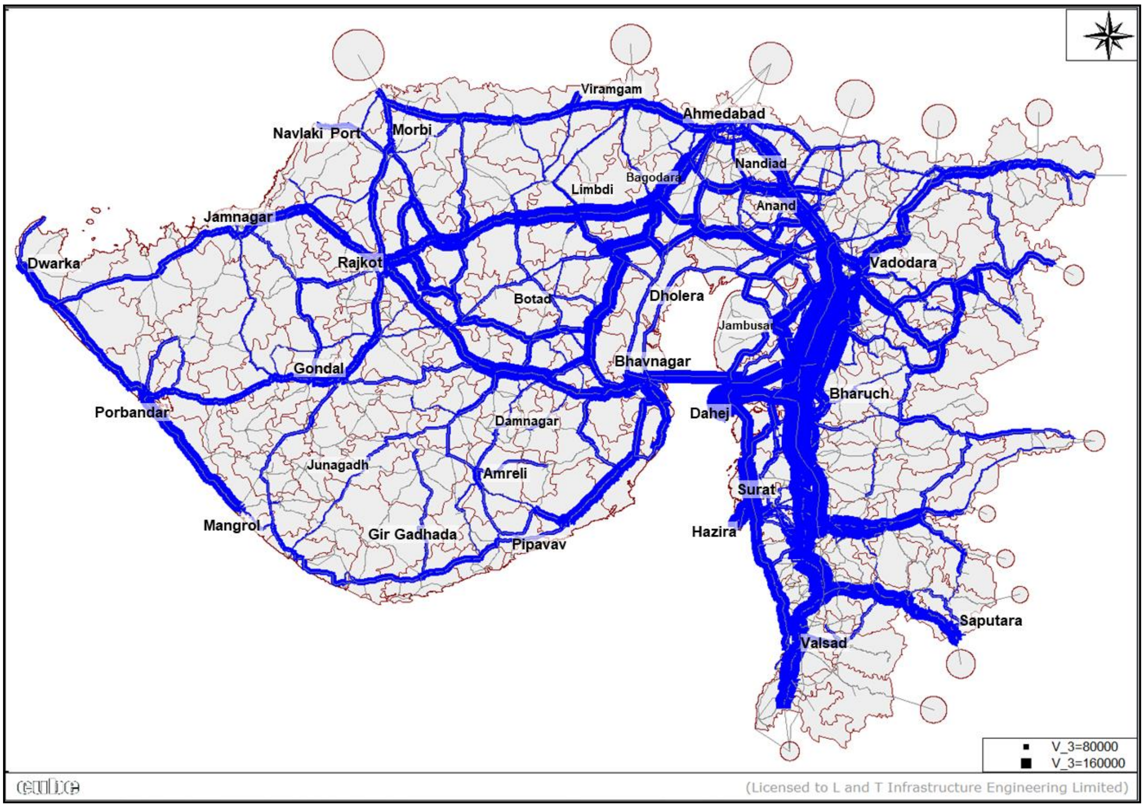


Figure 2.55: Traffic flow diagram for 2041 for most likely scenario

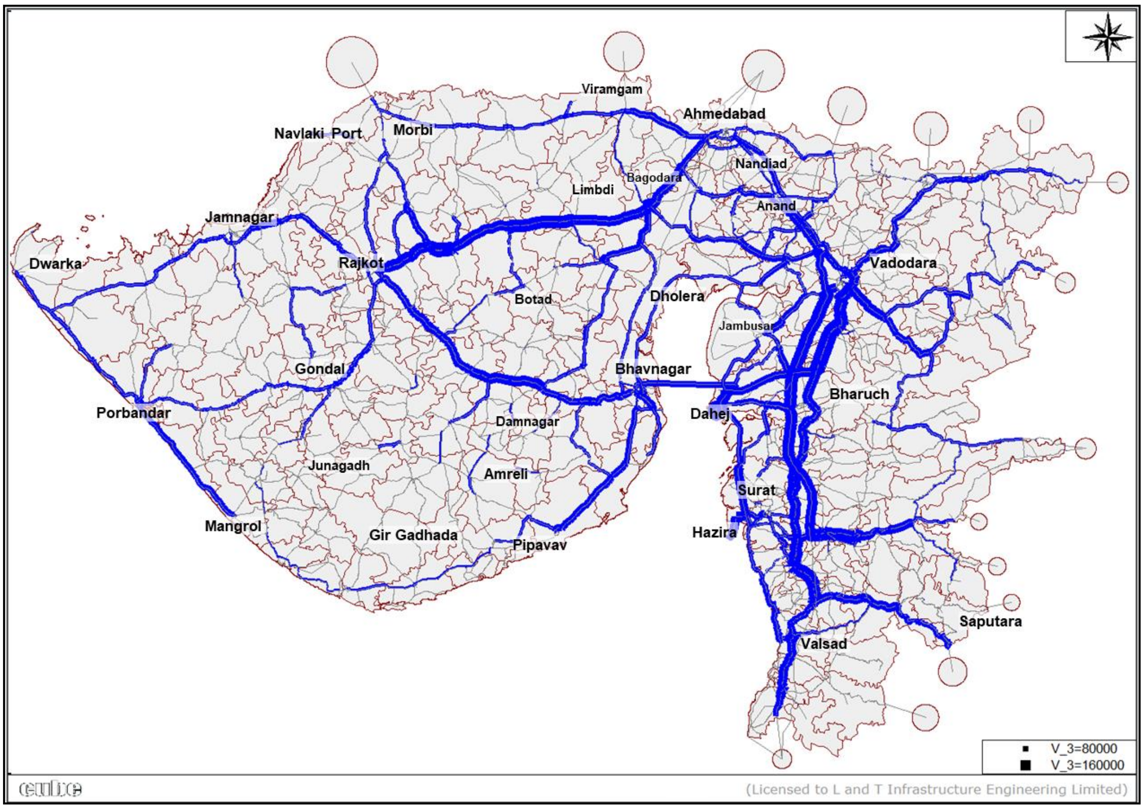


Figure 2.56: Traffic flow diagram for 2071 for pessimistic scenario

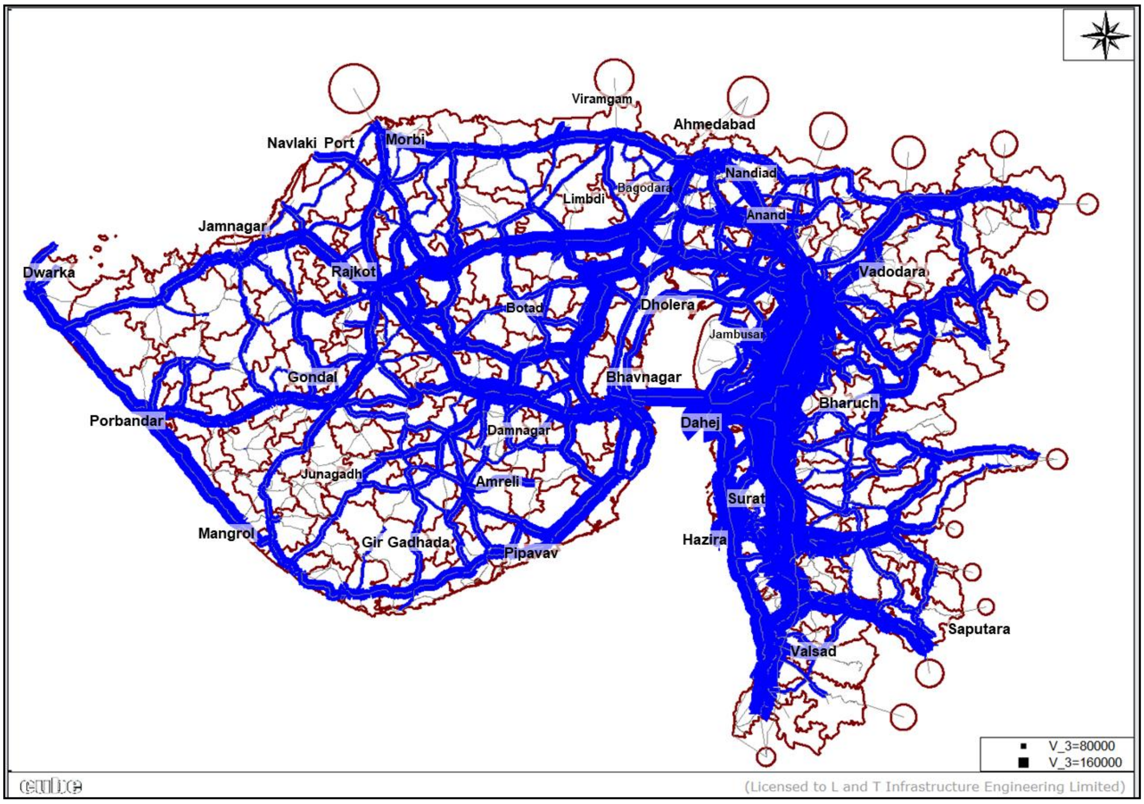


Figure 2.57: Traffic flow diagram for 2101 for optimistic scenario

- **Rail**

To meet the future passenger and freight demand between Saurashtra and South Gujarat, Rail link on the Kalpasar dyke is considered in addition to the multi-lane road. Prime facie, it is felt that Railway link is most essential to meet the long-term traffic demand as Railway provides huge capacity. Further, Railway system is sustainable mode of transport in terms of use of fuel and for a given width of Right of Way (ROW). Railway offers much higher capacity than roadway. Railway is also safe mode of transport and with Indian Railways emphasis on development of semi-high-speed railway network on major corridors. The rail will be faster mode in near future.

- **Existing railway demand**

In the absence of detailed Railway passenger O-D information, we have adopted two approaches to estimate the passenger demand on Kalpasar Rail link in the base year. The first approach is based on the current sectional passengers which is derived from the data obtained from Western Railways and multiplied with diversion potential based on the detailed O-D survey carried out for passenger vehicles (Car and Bus).

For estimation, 1700 is considered as average capacity of the passenger train with occupancy of 80%. The estimated passengers per day based on the first approach is 88,046. The details are presented in **Table 2.95** below.

Table 2.95: Passenger traffic demand for base Year on Kalpasar link (Approach 1)

Railway section	No of Trains in a day (both directions)	Diversion Potential	Total Passengers per day	Passengers on Kalpasar Link per day
Bharuch-Vadodara section	166	39%	2,25,760	88,046

In the second approach, we have identified the E-W trains currently plying per day (between South Gujarat, Madhya Pradesh, Eastern India to Saurashtra or Kutch region). Further, there will be transfer of passengers at Ahmedabad due to lack of direct connectivity of the trains for above regions. To estimate the transfer passengers all the trains terminating, originating at Ahmedabad station from South Gujarat, Madhya Pradesh, Saurashtra and Kutch region is assessed.

The proportion of transfers currently at Ahmedabad station is around as 5% of the originating or terminating passengers. The estimated passengers per day on Kalpasar link through second approach is 82,824 passengers. The details are presented below in **Table 2.96**.

Table 2.96: Passenger traffic demand for base year on Kalpasar link (Approach 2)

Railway section	No. of E-W Trains per day	E-W Passengers	Trains originating or terminating at Ahmedabad station	Transfer Passengers @ 5%	Total E-W Passengers
Bharuch-Vadodara section (Karjan Toll)	58	78,200	68	4,624	82,824

Both the above approaches provide base year passenger demand on Kalpasar Rail link between 82,825 to 88,046 per day with an average value of 85,435 per day.

(ii) Capacity requirements

- **Road**

Capacity of Rural Roads for various lane configurations based on IRC is considered. Since the IRC 64-1990 has not provided the capacity of multi-lane highways, design service volumes have been estimated based on IRC-SP:84-2014 and rounded off to the nearest values. As per Guidelines of IRC, LOS B shall be used for design of rural highways which corresponds to V/C ratio of 0.5. However, in the current project, capacity augmentation is considered if any project road section reaches the design service volume corresponding to LOS C. This is the normal practice for NHAI BOT projects. The per lane capacity works out to be around 1285 PCUs/hour/lane with peak hour share of traffic is 6%.

Table 2.97: Capacity of rural roads (in PCUs)

Lane Configuration	Capacity	Design Service Volume @ LOS C
4-lane	85,667	60,000
6-lane	1,28,500	90,000
8-lane	1,71,333	1,20,000
10-lane	2,14,167	1,50,000
12-lane	2,57,000	1,80,000
14-lane	2,99,833	2,10,000
16-lane	3,42,667	2,40,000

** Design service volumes have been rounded off; Source: IRC 64-1990, IRC-SP: 84-2014; Team analysis

The characteristics of traffic for various level of service (LOS) and the corresponding V/C ratios are presented below:

(1) LOS A: condition of free flow (V/C ratio upto 0.33)

(2) LOS B: reasonably free flow (V/C varies from 0.34 to 0.50)

(3) LOS C: represents stable range of flow but individual users will start getting affected with other vehicles in the traffic stream (V/C ratio varies from 0.51 to 0.70)

(4) LOS D: represent the limit of stable flow and with condition approaching close to unstable flow (V/C Ratio varies from 0.71 to 0.80)

(5) LOS E: represents operating conditions when traffic volumes are at or close to the capacity level (V/C ratio 0.81 to 1.00) which results in unstable flow

(6) LOS F: represents zone of forced or breakdown flow. This condition occurs when the amount of traffic approaching a point exceeds the amount which can pass it. Queues form behind such locations. Stop and Go situation will prevail (V/C ratio more than 1.00)

Traffic forecast has been carried out for three scenarios, i.e. optimistic, most likely and pessimistic. However, **Optimistic scenario** has been considered for the purpose of conceptual design in view of the uncertainty in long term forecast beyond 30 years.

The traffic forecast for Road over the Dyke and lane requirement is presented in **Table 2.98**.

Table 2.98: Traffic forecast and capacity requirements for various scenarios

Year	Traffic Forecast (in PCUs)			Lane Requirement		
	Optimistic	Most Likely	Pessimistic	Optimistic	Most Likely	Pessimistic
2022	22,375	22,375	22,375	2	2	2
2031	52,713	49,011	45,185	4	4	4
2041	81,251	74,826	71,674	6	4	4
2051	1,21,434	1,07,860	99,920	8	8	6
2061	1,64,676	1,51,083	1,36,171	10	10	10
2071	2,06,275	1,91,816	1,70,657	14	12	12
2081	2,32,746	2,18,864	1,87,895	16	14	12
2091	2,43,709	2,22,382	1,90,625	16	14	12
2101	2,53,147	2,24,167	1,94,132	16	14	12

Based on the traffic forecast (for optimistic scenario) for road, it can be noted 6-lane will be required till 2041, 8-lane by 2051. Therefore, ROW for maximum of 16-lane needs to be considered for Road and shall be developed in phased manner based on the traffic demand.

- **Rail**

Indian Railways determines the charted line capacity manually by master chart method. There are many factors affecting line capacity including mixed mode of traffic (freight & passenger), large number of trains, speed differential of rolling stock, terminal constraints, junction and cross movement of trains, weather conditions, maintenance blocks etc. Following capacity standards have been adopted for planning the railway network based on various established norms.

Table IV-99: Capacity standards for passenger and freight rail

S.No.	Configuration	Capacity (Trains/Day/Direction)
1	Single line (mixed operation)	25
2	Double line (mixed operation)	60
3	Double line (mixed operation) with Automatic TCAS + ABS + CTC signalling	90
4	Double line with Automatic TCAS + ABS + CTC signalling (for dedicated passenger operations)	200
5	Single line DFC (for dedicated freight operations)	40
6	Double line DFC (for dedicated freight operations)	140

Source: National Railway Plan-India, Draft Final Report (Dec, 2020)
** Capacity of Dedicated Freight Corridor (DFC) is taken from JICA Report on DFC
Note: 1. TCAS -Train Collision avoidance system
2. ABS – Automatic block signalling
3. CTC - Centralized traffic control (CTC) is a form of railway signalling that originated

Initially, double line for mixed operations (both passenger & freight trains) is considered. However, it is found that beyond 2045, double line will be saturated. The capacity utilization of double track for mixed operations is presented below in **Table 2.100**.

Table 2.100: Capacity utilization for single double track for mixed operations

Year	Passenger Trains per day	Freight Trains per day	Total Trains per day	Capacity of Double Track for mixed operations
2022	63	10	73	41%
2031	78	25	103	57%
2041	119	47	166	92%
2051	139	65	204	113%
2061	155	77	232	129%
2071	167	84	251	139%
2081	174	88	262	146%
2091	178	89	267	148%
2101	179	89	268	149%

In order to meet the demand beyond 2045, there is an option of third line or option of providing or two dedicated double line (separately for passenger and freight operations). Considering the long horizon, inefficiencies of mixed operations, dedicated lines for passenger and freight is suggested.

Further, Rail is most sustainable mode of operations and offers much more capacity than road. The capacity utilization of dedicated passenger and freight operations (2 double track lines) is presented below in **Table 2.101**.

The dedicated operations will allow higher speed of operations for passengers and more load carrying capacity and timely goods movements (as against the existing practice of prioritising the passenger operations, which is resulting in average speed of freight is only around 25 kmph) and will induce modal shift in favour of rail.

Table 2.101: Capacity utilization for dedicated passenger and freight lines

Year	Passenger Trains per day	Freight Trains per day	Capacity Requirement for Passenger dedicated passenger line	Capacity Requirement for dedicated freight line	Capacity Utilization for Passenger trains	Capacity Utilization for Freight trains
2022	63	10	Double track	Single track	16%	13%
2031	78	25	Double track	Single track	20%	31%
2041	119	47	Double track	Single track	30%	59%
2051	139	65	Double track	Single track	35%	81%
2061	155	77	Double track	Single track	39%	96%
2071	167	84	Double track	Double track	42%	30%
2081	174	88	Double track	Double track	44%	31%
2091	178	89	Double track	Double track	45%	32%
2101	179	89	Double track	Double track	45%	32%

Considering technological trends and future requirements dedicated double track is proposed for passenger trains (semi- high speed rail capable of reaching speeds upto 200 kmph) and dedicated double tracks are proposed for goods train (as per dedicated freight corridor (DFC) standards).

Due to huge capacity, railway lines can easily accommodate spill over demand from Road thus excess demand from road traffic (if any) can be shifted to railways through deployment of additional coaches, seamless integration for passengers and multi-modal logistics hubs for freight traffic as well as policy changes.

Therefore, considering Road & Rail as integrated solution and utilizing both road and rail capacities to the full extent, future traffic demand on Kalpasar link can be accommodated. In this regard, road based passengers can make use of semi-high-speed trains and trucks can use Ro-Ro facility (i.e. as practised in Konkan Railway) as shown in **Figure 2.58.** One train can carry 120 trucks if 60 wagons per train are considered.

Figure 2.58: Ro-Ro facility

(iii) Traffic dispersal plan

➢ **Road**

- **Bhavnagar Side**

The traffic from/to 16 lanes required to be dispersed smoothly to the existing road network on both the sides of the dyke. On Bhavnagar side, the access road to the dyke is starting from NH 751. Considering the traffic from south Gujarat to Rajkot and Jamnagar, it is proposed to extend the access road connectivity further west from NH 751 to NH 8E. Four locations are considered for major interchanges on Bhavnagar side for smooth dispersal of traffic. The proposed interchange locations are presented in **Table 2.102** and shown in **Figure 2.59.**

Table 2.102: Proposed interchange locations on Bhavnagar side

S.No	Interchange location	Chainage	Type of Interchange
1.	Near Songadh on NH 8E	00+000	Trumpet Interchange
2.	On SH 36 Crossing	09+800	Flyover with Slip roads
3.	On NH 751 Crossing	23+500	Cloverleaf interchange
4.	Near Lakdiya Pull	32+250	Flyover with slip roads

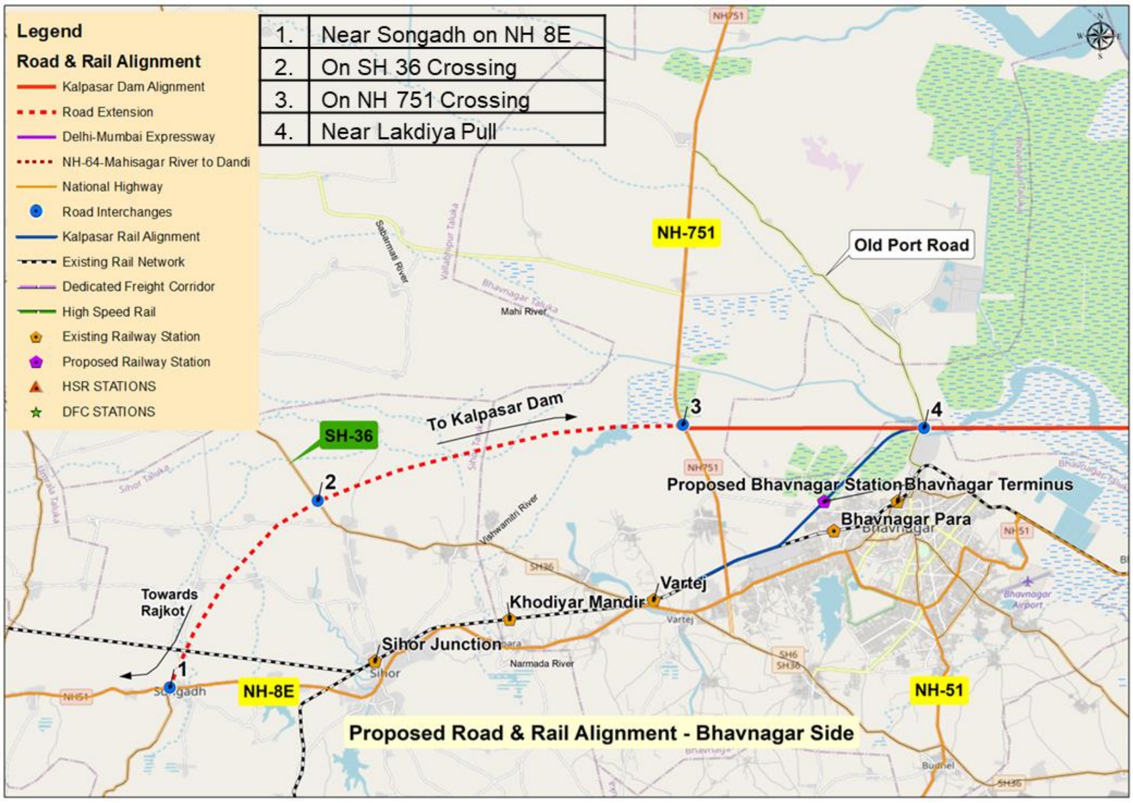


Figure 2.59: Proposed interchange locations on Bhavnagar side

The access road lane configuration is varied based on the traffic demand. The access road at the starting point (NH 8E) will have eight lane configurations. The proposed access road lane configurations for various sections are presented in **Table 2.103**.

Table 2.103: Access road lane configurations on Bhavnagar side

S.No	Section	Chainage		Lane Configuration	Traffic Volume in PCUs/Day (Year-2101)
		From	To		
1	From NH 8E to SH 36	00+000	09+800	Ten Lanes	1,60,280
2	From SH 36 to NH 751	09+800	23+500	Fourteen Lanes	2,00,644
3	From NH 751 to Lakdiyapull	23+500	32+250	Sixteen lanes	2,45,601
4	From Lakdiya Pull to Dyke	32+250	43+500	Sixteen lanes	2,53,802

- **Bharuch Side**

On Bharuch side, the access road is extended further from **'D'** point further to Bharuch – Dahej road (SH 6) for the smooth dispersal of traffic. Four interchange locations are proposed for the smooth dispersal of traffic. The proposed interchange locations are presented in **Table 2.104** and **Figure 2.60**.

Table 2.104: Proposed interchange locations on Bharuch side

S.No	Interchange location	Chainage	Type of Interchange
1.	Near Goladra on SH 6 (Dahej- Amod	83+660	Flyover with Slip roads

S.No	Interchange location	Chainage	Type of Interchange
	Road)		
2.	Pakhajan	93+800	Flyover with Slip roads
3.	Sadathala	98+730	Flyover with Slip roads
4.	On Bharuch – Dahej Road (SH-6)	104+500	Flyover with slip roads

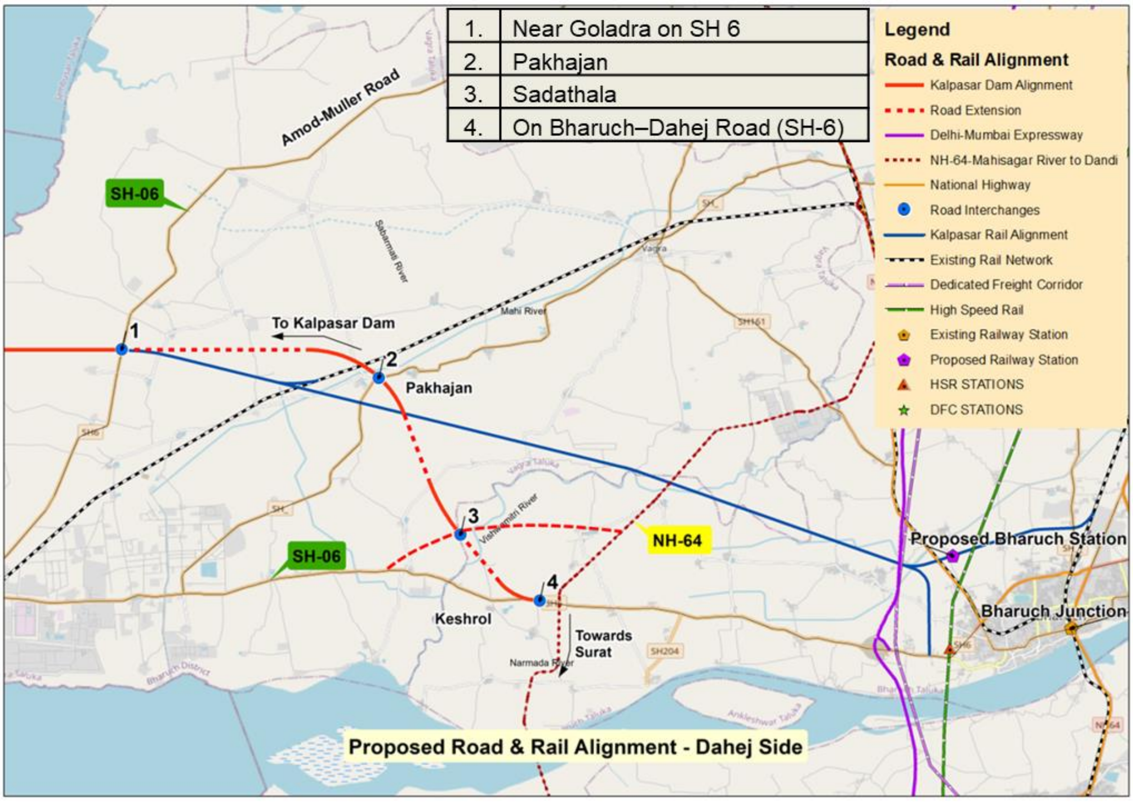


Figure 2.60: Proposed interchange locations on Bharuch side

The access road lane configuration is varied based on the traffic demand. The access road at the end point i.e. on Dahej- Bharuch road will have eight lanes. The proposed access road configurations at various road sections in presented in **Table 2.105**.

Table 2.105: Access road lane configurations on Bharuch side

S.No	Section	Chainage		Lane Configuration	Traffic Volume in PCUs/Day (Year-2101)
		From	To		
1	From Dyke to Dahej – Amod road (SH 6)	70+000	83+500	Sixteen lanes	2,53,802
2	From Dahej- Amod Road (SH 6) to Pakhajan	83+500	93+800	Twelve lanes	1,54,499
3	From Pakhajan to Sadathala	93+800	98+700	Ten Lanes	1,40,093
4	From Sadathala to Bharuch- Dahej road (SH 6)	98+700	104+500	Eight lanes	1,24,182

- **Rail**

Railway line over the Kalpasar link connects south Gujarat and Saurastra region. For effective dispersal of train passengers, the existing line is proposed to be connected with the proposed high speed rail station at Bharuch; similarly a new passenger terminal is proposed to be developed at Bhavnagar side.

To ensure continuous movement of trains from other districts of Gujarat and other states, a connecting link is proposed to connect the existing railway line for effective dispersal of train traffic.

New Railway terminal is proposed near Ramdev nagar at Bhavnagar side and at outskirts of Bharuch at Dahej side to ensure smooth dispersal of rail passengers.

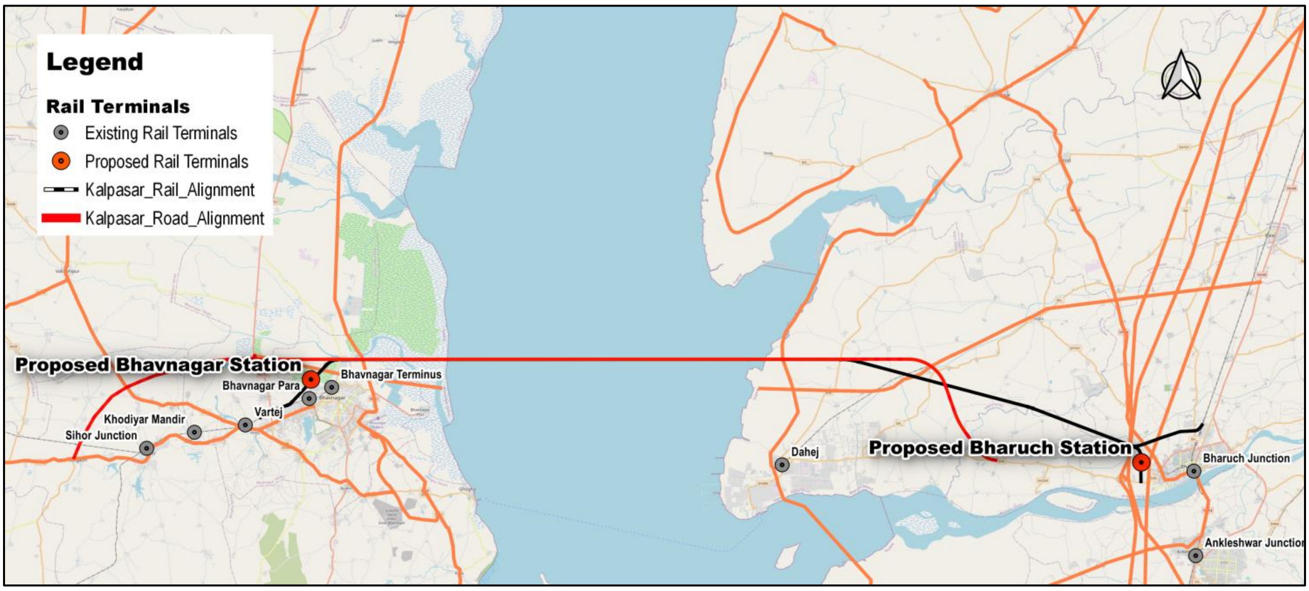


Figure 2.61: Proposed Rail Terminals

Table 2.106: Proposed Rail Terminal Location

Section of Road alignment	Chainage (in m)	Remarks
P	6+519	Proposed Bhavnagar Terminal
Q	96+511	Proposed Bharuch Terminal

2.3.5 Design basis

(a) Road design

IRC: SP: 87 "***Manual of Specifications & Standards for Six-laning of Highways through Public Private Partnership***" and other relevant IRC codes are considered as design basis.

- **Geometric design standards**

Design speed: Ruling design speed of 100 Kmph for main carriageway and 40 kmph for service road is followed for the entire project stretch.

Carriageway width: Carriageway width of 3.5 m is considered.

Cross slope: Camber shall be provided for each carriageway including paved shoulders in accordance with **IRC: 73**. The cross-fall for earthen shoulder shall be minimum 0.5% steeper than that of the carriageway. The camber details are shown in below.

Table 2.107: Camber Value

S. No	Description	Camber
1	Carriageway including Paved Shoulder	2.5%
2	Earthen Shoulder	3.0%

Sight distance: In the design, desirable Intermediate Sight distances (ISD) shall be ensured all along the project road. However, adoption of minimum stopping sight distance (SSD) shall be based on the site constraints.

Horizontal alignment design: The radius of horizontal curves will not be less than desirable minimum values as given in **IRC: SP: 87** for the specified design speed. Wherever possible higher radii shall be adopted, subject to the availability of ROW.

Vertical alignment design: The vertical alignment shall be designed as per **IRC: SP: 23.** The aspect of efficient drainage shall be taken into consideration while designing vertical profile and cross sections of the highway in accordance with **IRC: SP:42 and IRC: SP:50.** There shall be coordination between horizontal alignment and vertical profile of the project highway and as per guidelines in accordance with **IRC: SP:23**.The vertical alignment of the carriageway in widening bypass and realignment locations shall be designed as per **IRC: SP: 87**.

Super elevation: The desirable minimum radius is 60m for service road. The super elevation is provided up to a certain radius as presented in Table 15 of **IRC: 73** for the design speed of 40 Kmph. On super elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse cross fall of 0.5%.

Transition curves: IRC Geometric Design Standards for Rural Highways, **IRC: 73**, suggests that the length of the transition curve should be the larger of the two values arrived at based on the following criteria:
(1) Rate of change of centrifugal acceleration
(2) Rate of change of super elevation (not steeper than 1 in 150)

At-grade intersections: The intersection designs shall be done as per the guidelines given in Ministry of Surface Transport (MoRTH). Type Designs for Intersections on National Highways, 1992 and based on IRC: SP:41, 'Guidelines for the Design of At-grade Intersections in Rural and Urban Areas. The at-grade intersections shall be designed based on the following:
(1) Total traffic volume and Turning traffic volumes;
(2) Composition of traffic;
(3) Number of approach roads and their category;
(4) Width of approach roads;
(5) Angle of approach with main highway;
(6) Surface type;
(7) Site conditions / constraints; and

(8) Local importance and demand

Grade separated intersections and interchanges: The geometric design standards shall be as per **IRC:92** appropriate for the design speed adopted for the Project Highway. The design speed for ramps shall not be less than 40 km per hour. The desirable values of various parameters given in IRC:92 shall be adopted unless there are severe site constraints.

Surface drainage: A good drainage system is vital for the safety and longer life of any structure. Proposed development surface must be protected from any ingress of water. For this purpose, the following conditions have to be ensured a) saving the pavement structure from stagnation of water b) efficient dispersal and disposal of water c) quick disposal of sub-surface water away from the pavement d) interception of the surface runoff e) keeping the water flow duration on the paved surface to a minimum. Longitudinal gradient of minimum 0.3% is followed for better internal drainage of paved surface layers. Cross slope / transverse gradient of proposed development facilities is also necessary for quick surface runoff disposal from the surface.

Bus bay: The lay out for Bus Bays shall be in accordance with IRC: 80-1981.

Truck lay-bys: Truck lay bye shall be provided as per site requirements. The size of truck lay bye shall be constructed based on adequate number truck to park and space for facilities & future expansion. The truck lay-byes shall have the following facilities:
(1) Paved parking;
(2) Rest areas with toilets, drinking water;
(3) Telephone; and
(4) Lighting facilities

Rest areas: The rest areas shall be provided at beginning of approach road start location of either side as it is not feasible over the dyke portion due to space constraints as well as security reasons. The rest areas should have minimum facilities such as toilets, telephones, cafeteria, restaurant, parking for cars, buses and trucks, dormitory, rest rooms, shops for travel needs, fuel stations and garage, first aid etc. the following facilities capacity requirements needs to be provided in the rest areas confirming to IRC: SP: 87.

Roadside furniture: Roadside furniture shall be provided in accordance with Section 9 of IRC: SP: 87. Traffic signs include roadside signs, overhead signs and route marker signs and kerb mounted signs along the entire Project Highway and shall be designed as per IRC: 67.

Pavement markings on the project highway shall be in accordance with IRC: 35. These markings shall be applied to road centre, edge line, continuity line, stop line, give way lines, diagonal/chevron markings and zebra crossing and at parking areas. Km stones, 5th Km stone and Hectometre stones for the project shall be provided in accordance with IRC: 8 and IRC: 26. The foundation details, text size, height and locations shall be in accordance with the IRC codes stated above.

The safety barriers shall be provided at the outer edges of roadways wherever the embankment height is more than 3m, settlement locations and at major bridge approaches. If horizontal curve radius is less than 450m, the safety barriers shall be provided at median and outer edge of super elevated section. Safety barrier shall be provided between main carriageway and service road.

Highway lighting: The highway lightings shall be provided along project corridor as per the **IRC: SP: 87**. Unless stated otherwise in this Manual, the minimum level of illumination on the locations of the Project Highway where lighting is to be provided as per this section shall be 40 Lux. Overhead electrical power and telecommunication lines erected within the ROW shall be provided with adequate clearance so that safe use of the highway is not affected. Vertical and horizontal clearances for electrical installations shall conform to **IRC:32.**

Access control: Median opening interval and control of access shall be provided as per IRC 62-1976 Viz. Median opening shall be provided at 5km interval for U turns purpose in case of emergency. The emergency lane shall be provided at 5km interval for breakdown vehicle to park their repairing activities.

Rigid pavement design: The rigid pavement type is provided considering longer lifespan and low maintenance costs which is designed according to **IRC: 58-2015 "Guidelines for the Design of Plain Jointed Rigid Pavements".**

Intelligent transport system (ITS) have been considered as per relevant IRC codes (IRC: SP: 110-2017) as well as based on the best practices in recently implemented projects in India.

- **Codes, specifications and standards**

Standard specifications and codes of practice for road bridges of the IRC: wherever applicable are followed. The following codes in **Table 2.108** have been generally followed with their latest amendments.

Table 2.108: List of codes, specifications and standards

S. No.	Description	Design code/standard	
1	Geometric Designs & standards	(i)	IRC:38:1988 Guidelines for design of horizontal curves
		(ii)	IRC:SP-23:1993 – Vertical curves for Highways
		(iii)	IRC:86:2018 – Geometric Design standards for urban roads in plains
		(iv)	IRC:106:1990 – Guidelines on capacity of urban roads in plain areas
3	Design of Pavement	(i)	IRC:37:2018 – Guidelines for Design of Flexible Pavement
		(ii)	IRC:-5:2015 Guidelines for the Design of Plain Jointed Rigid Pavements for Highways

S. No.	Description	Design code/standard	
3	Junctions / Intersections / Interchanges	(i)	IRC:92:1985 - Guidelines for Design of Interchanges
		(ii)	IRC:93:1985 – Guidelines on Design & Installation of Road Traffic signals
		(iii)	IRC:SP-41:1994 – Design of At grade junctions
		(iv)	Type designs for intersections on NH by MORT&H
4	Kilometer stones, 200m stones and boundary pillar	(i)	IRC:8-1980 – Type Design for Highway kilometre stones
		(ii)	IRC:26:1967 -Type design for 200m stones
		(iii)	IRC:25:1967 -Type design for boundary stones
5	Traffic Signs	(i)	IRC:31:1969 – Route marker signs for state routes
		(ii)	IRC:67:2012 – Code of practice for road signs
6	Road Markings	(i)	IRC: 35:2015 – Code of practice for road markings.
7	Ancillary Works	(i)	IRC:80:1981 – Type design for pick up bus stops on Rural & Urban Highways
		(ii)	IRC: SP-12:2015 – Guidelines on provision of parking areas.
8	Drainage	(i)	IRC:SP:42:2014 – Guidelines on Road Drainage
		(ii)	IRC:SP-50:2013 – Guidelines on urban drainage
9	Safety Measures	(i)	IRC:103:2012 – Guidelines for pedestrian facilities
		(ii)	IRC:SP-44 – Highway Safety Code
		(iii)	IRC:SP-55:2014 – Guidelines on traffic Management in work zones

(b) Rail design

➢ Introduction of semi high-speed rail in India

Semi High-Speed Rail is proposed over the Kalpasar dyke for movement of passenger traffic. According to the Ministry of Railways, a route which has trains that run between 160 kmph to 200 kmph is considered as **semi high-speed rail**, while the routes which have trains running at speeds of less than 160 km/h are considered as conventional rail lines. According to UIC (International Union of Railways) definition, the commercial speed of over 200 km/h is the principal criterion for the definition of High-speed railways.

Vande Bharat train

Indian Railways have a track of over 8,000 km capable of running semi high-speed trains. Indian railways have introduced several semi-high speed rail services in India such as **Gatiman Express (2016), Tejas Express (2017), Vande Bharat Express (2019) and Tajas Rajdhani (2021)**. Currently, these trains run between 130 kmph to 160 kmph.

As the high-speed trains are very costly (about Rs. 120 to 200 crores/km) and takes several years to build, Indian Railways (IR) are giving lot of importance and priority to semi high speed trains, which can be run by upgrading the existing infrastructure with certain improvements including track, signalling, traction, coaches and electric locomotive. Thus, semi high-speed rail is cost effective and can be implemented quickly as compared to **high-speed rail**.

➢ Design standards for semi high-speed rail

Design parameters for track structures are presented in **Table 2.109.**

Table 2.109: Design parameters for track structure for semi high-speed rail

Track	Track structure for speeds upto 160 kmph	Track structure for speeds from 160 to 200 kmph
Rails	60 kg & 90 UTS	71 kg & 90 UTS
Sleepers	Mono block PRC sleeper	Mono block PRC sleepers
Sleeper density	1660 no. per km.	1660 nos. per km.
Fastenings	ERC clips mark III with rubber pad 6mm Same as col.2 thick & liner — steel or GFN	Same
Points and Crossings	Thick web, head hardened switches and cast manganese	Same

Track	Track structure for speeds upto 160 kmph	Track structure for speeds from 160 to 200 kmph
	crossings on PRC sleepers	
Ballast cushion	50/300 mm depth with 150 mm sub ballast	Hard stone ballast with 300 mm cushion over 150 mm sub-ballast
Formation	Stable with penetration of ballast	Well compacted and stable
Miscellaneous	Existing track may serve the purpose	Constraints to be removed

** Values in the Table are corresponding to an Annual GMT (Gross Million Tonne) of equal or more than 5.

In order to upgrade existing tracks to cater to the semi-high speed rail following elements to be renewed so that trains can run faster than 160 kmph.

Sharp curves: Sharp curves more than 1° will have to be earned to get speed > 160 kmph (1° curve corresponds to 1750m radius). This will require survey of each curve including fixed installations and thereafter re-alignment should be undertaken keeping all constraints in view.

Turnouts: Loose heel switches should be removed, and only fixed heel type switches should be continued to remain in the section where high speed trains are to be introduced. For speed higher than 160 kmph, turnouts on wooden sleepers should be replaced by turnouts on concrete sleepers.

Fencing: For speed higher than 160 kmph fencing of the entire section may become necessary. For speed upto 160 kmph, fencing can be need based in the vicinity of the habitation and in approach of major bridges, level crossings etc.

Formation: Weak formation creates maintenance problems during monsoon seasons and sometimes even after that. Therefore, rehabilitation of formation must be undertaken before introduction of high-speed rail; Properly designed blanket should be provided in areas having weak formation. This can be facilitated by use of aluminium alloy girders designed and developed by RDSO.

The elements that are required apart from fixed infrastructure for running the semi-high speed rail are summarised below:
(a) WAP5 and WAP4 locomotives and LHB coaches for the trains;
(b) Provision of fencing of track all through its length for prevention of trespassing and cattle runover;
(c) Provision of clamp type lock along with thick web switches in fencing direction on main line points;
(d) Provision of Train Protection Warning System (TPWS);
(e) Provision of second distant signal or automatic signaling to meet the requirement for breaking distance for higher speed trains. In case of the absence of automatic signaling, provision of Block Providing by Axle Counter (BPAC) is necessary;
(f) Provision of Swivelling type cantilever OHE where tension in the conductors is automatically regulated, with a presage of 50/100 mm;
(g) Use of Mobile Train Radio Communication System (GSM-R) for reliable train radio communication between driver & guard and nearest station and/or control office;
(h) Minimization of level crossings by provision of ROB/RUB; and

(i) IR Standard IV interlocking system.

Improvement of track geometry: Track geometry will require improvement so as to conform to higher standards.

➢ **Dedicated Freight Corridor (DFC)**

In order to augment the rail transport capacity to meet the growing requirement of movement of freight traffic, the Indian Railways has been developing dedicated freight corridors along the busy trunk routes. In this connection, Western Dedicated Freight corridor from Delhi to Mumbai and Eastern Dedicated Freight from Ludhiana (in Punjab) and Dankuni (near Kolkata) is under development. The Western DFC (1483 kms.) is being implemented from Jawaharlal Nehru Port (JNPT) in Mumbai to Tughlakabad and Dadri near Delhi and would cater largely to the container transport requirements between the existing and emerging ports in Maharashtra and Gujarat and the northern hinterland. The Eastern DFC is being implemented from Ludhiana in Punjab to Dankuni (1806 kms) near Kolkata and will largely serve coal and steel traffic.

Dedicated Freight Corridor (DFC)

The existing mixed operations resulted in priority to passenger trains and thus affecting the freight movement. This has negative effect on logistics cost and competitiveness by Rail. Further, transportation charges of freight by Rail are higher due to cross subsidisation of passenger trains. Therefore, DFC is planned to decongest already saturated road network & promote shifting of freight transport to more efficient rail transport.

The enhanced carrying capacity because of doubling of train length and punctuality of transit on DFCs should give railways a competitive edge over other transport modes, enabling it to claw back lost freight share and capture new time-sensitive cargo categories. Overall, the proliferation of DFCs is expected to change rail-freight logistics for the better in India, and help Indian Railways regain edge over rival modes.

With the Dedicated Freight Corridors, the Indian Railways aim to bring about a paradigm shift in freight operation with prime objective of reduction in unit cost of transportation with higher speed of freight trains, better turnaround of wagons and thereby much improved wagon productivity in terms of improved ton-km per wagon day, increased payload to tare ratio by introduction of higher axle load wagons on the rail network, improved locomotive utilization and improved specific fuel consumption. The ultimate objective is to reduce the Operation and Maintenance Cost (O&M Cost) significantly and in penultimate analysis; the benefit is passed on to the customer in the form of lower transport Logistics Cost.

Thus, the shift from Road to Rail is expected to offer significant reduction of Green House Gas (GHG) emissions in transport sector in India. It is expected that DFC will save more than 450 million ton of CO_2 in first 30 years of operation (Ernst & Young).

- **Design Standards for DFC**

Various design parameters of DFC and their specifications are presented in **Table 2.110**. Some of the Basic Parameters proposed to be followed by the DFCs are given in the **Table 2.110** which is taken from "**Standard Schedule of Dimensions for Eastern & Western Dedicated Freight Corridors of Indian Railways**" released in January 2013.

Table 2.110: Fundamental design parameters for DFC

Parameters	Specifications
Gauge	B.G 1676 mm
Axle Load	32.5 tonne loading standard for Bridges and Formation. Track structure shall be of 25 tonnes to start with.
Traction	Electric, 2x25 Kv, 50 Hz single phase AC
Maximum Permissible Speed	100 kmph, Average speed 65-70 Kmph.
Rolling Stock	Locomotives: 9000 HP Wagons: 25 ton axle load
Double stack trains	Double-stack container train operation on the Western Corridor
Track	60 kg/m, UIC/90 UTS rails, PSC sleepers, 1660 nos./km density.
Points and Crossings	60 kg rail, 1 in 12 thick web switches
Ballast	300/ 350 mm cushion
Ruling Gradient	1 in 200 (compensated)
Curves	Maximum degree of curvature of 2.5 degree (700m radius) to ensure sustained speed potential of 100kmph; curve compensation @ 0.04% per degree of curvature.
Formation	Formation width: Double-line – 13.5 m, Single Line – 7.6 m; Side slope of embankment to be maintained at 2:1 ; blanket thickness as per RDSO GE :0014 specification
Moving Dimensions	Vertical MMD of 7.1 m on Western Corridor and 5.1 m on Eastern Corridor
Track Centres	6.0 m on DFC and between existing IR tracks and DFC track, min.6.0, Recommended 7.925 m.
Bridges	Standard of loading of 32.5 tonne axle load; 12 tonne/m trailing load
Loop Length	Normal loop length 750m with facilities for running Long haul trains through nominated loops of 1500m length at Junction Stations.

Parameters	Specifications
Signalling	Double Line: Automatic Block, with Multiple Aspect Colour Light Signalling (MACLS) except Rewari-Dadri which will be with Absolute Block System. Single line: Absolute Block, with around 10 km station spacing and Multiple aspect colour-light signalling.
Station Spacing	40 km apart on double line and 10 km on single line
Junction Stations	Western DFC: 17 Junction Stations Eastern DFC: 27 Junction Stations
Road Crossing/ Level Crossing	As far as possible there shall be no level crossing; Complete length to be fenced on both sides

(c) Bridge design

➢ **Road**

This section summarises the general functional & design requirements, guidelines & design philosophy for the design of superstructure and substructure for road loading bridges. It is understood that beyond the Dyke portion, the connectivity stretch for Roadway would cross several existing waterways, roadway and railway line. Hence, structure type includes Roadway superstructure for Flood regulator, Major bridges, Minor bridges, Major RUBs, Minor RUBs, Pedestrian subways & Flyovers carrying vehicular loading.

- **Materials**

Concrete

All material properties shall be as per IRC: 112-2020 specifications including relevant amendments. The grades of concrete are based on 28 days characteristic compressive cube strength. For Reinforced and Pre-stressed concrete, the preferred nominal aggregate is 20mm. Modulus of elasticity of concrete for various grades shall be taken as per table 6.5 of IRC: 112-2020. The Poisson's ratio of un-cracked concrete is taken as 0.2 and that of cracked as zero as per Cl 6.4.2.5 (4) (ii) of IRC: 112-2020.

Reinforcements

All reinforcement shall be high yield strength deformed ductile steel bars (HYSD steel), Grade Fe500 conforming to IS: 1786-2000 and Table 18.1 of IRC: 112-2020 for all major structures. The characteristic strength (f_{yk}) of reinforcement shall be 500 MPa with modulus of elasticity 200 GPa.

Pre-stressing Steel

Pre-stressing steel shall be stress relieved Class II 7 ply strands of low relaxation type conforming to IS: 14268. It is proposed to use HDPE sheathing for this project. Dimensions of sheathing shall be as per manufacturer's recommendation.

Grout for Post-Tensioning Tendons

The grout is composition of cement, water, and appropriate super plasticizer. The materials shall conform to the requirements specified in IRC: 112-2020 Cl. 18.8.1.

Expansion Joints

The type of expansion joint provided shall be either single strip seal joint or modular joint depending upon the movement to be catered. The fabrication and installation of expansion joint shall be as per IRC SP: 69-2011.

Bearings

Bearings for the superstructure shall be capable of being inspected at regular intervals and being replaced during the lifetime of the structure without modification to the adjacent structure. Jacking points shall be located adjacent to all bearings to facilitate the replacement operation and shall be marked clearly for easy identification. The superstructure shall be checked for loading conditions. The bearings shall be conforming to IRC codes and MORTH specifications.

- **Design Loading**

General

The design loading for the bridge has been considered in accordance with IRC 6 - 2017 (Loads and Stresses – including Amendments) so as to sustain the most critical combinations of various loads, forces and stress.

Dead Load (G)

The unit weights will be considered as per clause 203 given in IRC 6-2017.

Pre-Stressing Force (PR)

As per clause 7.9.2 of IRC: 112- 2020 maximum jacking force, 90% of 0.1% proof stress i.e., 78.3% of the Ultimate tensile strength of strand shall be considered.

Superimposed Dead Load (SIDL)

Superimposed Dead Load is of two types i.e. Fixed SIDL which consists of load due to Crash Barrier, median, footpath with hand rails and Variable SIDL which consist of Wearing coat.

Wearing coat (Variable load)

As per Cl. 2702.1 of “MORTH Specifications for Road and Bridge Works”, Wearing coat of Type 1-50mm thick Bituminous Concrete or Type 3-50mm Stone Matrix Asphalt along on top of 4mm thick water proofing membrane is adopted for the project.

Crash barrier (Fixed dead load)

New Jersey type crash barriers as per details in IRC: 5-2015 shall be adopted.

Live load due to vehicle (Q)

The carriageway load combination shall be considered as per Table 6A of IRC: 6-2017. Footpath Live load (Q_{fp}).

Impact factor (Q_{im})

Impact factor shall be considered for the Longitudinal and Transverse Design of Superstructure as per clause 208 of IRC: 6-2017.

Reduction in longitudinal effect

Reduction in longitudinal effect is as per clause 205 of IRC: 6-2017 depending on the number of lanes.

Longitudinal forces

As per clause 211 of IRC: 6-2017, bridge structural elements shall be designed for longitudinal forces arising due to Braking Force and Frictional Resistance offered due to movement of free metal bearings or the deformation of the Elastomeric Bearings.

Braking force (F_b)

Braking forces is derived as per clause 211.2 of IRC:6-2017.

Frictional resistance (F_f)

Frictional resistance offered to the movement of bearings due to change in temperature shall be calculated as per clause 211.5 of IRC: 6-2017.

Distribution of longitudinal forces for elastomeric bearings

For a simply supported span sitting on identical elastomeric bearings at each end resting on unyielding supports. Force at each end is derived as per cl. 211.5.1.3 of IRC: 6-2017.

Wind load (W)

Wind Load depends on the geographical locations, terrain of surrounding area, the fetch of terrain upwind of the site locations, the local topography, the height of the bridge above the ground, horizontal dimensions and cross section of bridge or its element under consideration. As per Fig. 10 of IRC: 6-2017, the basic wind speed shall be considered as 50 m/s.

Wind forces on structure and vehicles shall be considered to act in the direction such that resultant stresses in the members are maximum and shall be computed as per Clause 209 of IRC: 6-2017.

Wind Load on the substructure shall be accounted in accordance with clause 209.4 of IRC: 6-2017.

Seismic force (Feq)

Seismic force calculation and design shall be as per IRC: SP: 114. The seismic zone shall be decided as per Fig. 4.1 of IRC: SP: 114-2018. The proposed project location falls under the seismic zone III.

Relaxation clauses

As per Section 2.3 of IRC: SP: 114-2018, the following relaxations from seismic analysis:
(1) Culverts and minor bridges up to 10m length in all seismic zones need not be designed for seismic effects;
(2) Bridges in seismic zones II and III satisfying both limits of total length not exceeding 60 m. and individual simply supported spans not exceeding 15m need not be designed for seismic effects; and
(3) The dynamic earth pressures on abutments during earthquakes shall not be considered in Zones II and III.

Thus, seismic analysis and design need not be considered for design of Culverts, Vehicular underpasses and Box type Bridges. Further, dynamic earth pressure need not br considered in the design.

Seismic combinations

As per Clause 4.2.2 of IRC: SP: 114, the following combinations shall be taken, where, r_1, r_2 and r_3 force resultant due to full design seismic force along x, z and vertical direction respectively.

- $\pm r_1 \pm 0.3 r_2 \pm 0.3 r_3$
- $\pm 0.3 r_1 \pm r_2 \pm 0.3 r_3$
- $\pm 0.3 r_1 \pm 0.3 r_2 \pm r_3$

- **General guidelines for foundation design**

As per Note no. vii under table 4.1 of IRC SP: 114-2018, Capacity Design should be carried out where plastic hinges are likely to form. If elastomeric bearings are designed to transfer the seismic loads, structure shall be designed for Response Reduction factor of 1 and hence capacity design is not required.

- **Temperature effects (Fte)**

Overall temperature

As per the maximum and minimum temperature obtained from Amendment No.6 on May 2021 /IRC: 6- 2017 Annexure F of IRC: 6-2017. The maximum temperature shall be considered as 47.3˚C and minimum temperature shall be considered as 0.6˚C (Bhavnagar). The temperature has influence on the movement of expansion joints as well as on bearings.

The temperature effect of rise and fall takes place over a season and hence the long-term value of Modulus of Elasticity shall be considered in the analysis, and it is estimated considering creep coefficient as per cl. 6.4.2.5 (4) and Table 6.9 of IRC: 112-2020.

Differential temperature

Temperature gradient within the superstructure shall be derived from two cases:
(1) Positive temperature difference due to solar radiation and other effects causes gain in heat through top surface of superstructure; and
(2) Negative temperature differences due to re-radiation and other effect causes loss of heat from top surface of bridge deck.

The temperature differences shall be assumed as shown in Fig. 15a, 15b & 15C of Amendment No 6 - IRC: 6-2017.

Creep and shrinkage (Fs)

Creep and Shrinkage strain shall be as calculated per Clause 6.4.2.6 and 6.4.2.7 of IRC: 112. This strain has influence on stresses for indeterminate structures or composite members, movement of expansion joints and bearing movement apart from loss of pre-stress force. Creep and shrinkage calculation shall be done considering relative humidity of 54% As per Table A-7-1 of Annexure A7 in IRC 112-2020.

Centrifugal forces (Fcf)

The Centrifugal forces will be considered as per the Cl: 212 of IRC: 6-2017.

Horizontal force due to water current (Fwc)

For piers which are parallel to direction of water current, the intensity of pressure shall be calculated from the following equation as per cl. 210.2 of IRC: 6-2017.

Buoyancy (Gb)

For piers and foundation under the influence the water flow, the effects of buoyancy as specified in Cl. 213 of IRC: 6 - 2017 shall be considered.

Earth pressure (Fep)

The effect of earth pressure shall be calculated in accordance with coulombs theory for earth retaining structures. Soil properties for earth pressure load shall be per the recommendations of geotechnical engineer. All abutments and return walls shall be designed for a live load surcharge equivalent to 1.2m earth fill and the centre of pressure exerted by the backfill shall be at a height of 0.42 times the height of wall above the base as per clause 214.1 of IRC: 6 2017. Soil property of back fill shall be as per appendix-6 of IRC: 78-2014.

Jacking up condition

The effects of jacking on the deck during bearing replacement shall be considered for design of superstructure. It is assumed that structure shall be lifted by 10 mm, lifting of superstructure has no effect on deck continuous superstructure and for structurally continuous structures; it shall be checked without live load on deck. During the replacement of bearing, no vehicular traffic shall be permitted.

Construction loads (Fer) for precast girder launching using L.G

Wherever launching girder (L.G) is used to erect the precast girders, construction loads coming from L.G shall be accounted in design based on erection sequence. The structures will be designed with due consideration to construction sequence and various stages application of various loads.

Collision load (Vc)

Vehicle collision load shall be considered as per clause 222 in IRC: 6-2017.

- **Load combinations**

It is proposed to adopt Limit State of Design as per IRC: 112-2020, therefore combination of loads shall be as per Annexure B of IRC: 6-2017. Loads shall be combined to check equilibrium and the structural strength under ultimate limit state. The equilibrium of the structure shall be checked against overturning, sliding and uplift. It shall be ensured that ratio of stabilizing to restoring forces is more than unity. The equilibrium and structural strength shall be checked under basic, accidental and seismic combinations of loads.

Load combination for checking the equilibrium

For checking the equilibrium of the structure, the partial safety factor for loads are taken from Table B.1 of IRC: 6-2017.

Load combination for checking the structural strength (ULS)

For checking the Structural strength of the structure, the partial safety factor for loads is taken from Table B.2 of IRC: 6-2017.

Load combinations for verification of serviceability limits state

The serviceability limit state check shall be carried out to keep the stress, deflections, crack width within the permissible as per the relevant code. As per IRC: 6-2017, the rare combination of loads shall be used for checking the stress limit with partial safety factor loads given in column No. 2 of Table B.3.

The frequent combinations shall be used for checking the deflection and crack width in prestress concrete structures, the partial safety factor for loads are given in column no.3 under Table B.3.

Quasi permanent Combination shall be used for checking the crack width in RCC structures, settlement, creep effects and to estimate the permanent stress in the structure, a partial safety factor for loads are shown in column 4 under table B.3.

Load combinations for base pressure/ Pile capacity in foundation

For checking the base pressure/pile capacity in foundations, load combinations are as per clause 706 of IRC: 78-2014.

Load combinations for design of foundation under ULS

The partial load factors for the structural design of foundations are taken from Table B.4 of IRC: 6-2017.

- **Design parameters**

Durability

Exposure condition

The exposure condition shall be decided as per Table A-7-1 of Annexure A 7 of IRC 112-2020.

Minimum concrete cover

Cover to the reinforcement shall be the minimum clear distance measured from the surface of the concrete to the closest reinforcing bars. Minimum concrete cover is decided based on durability provisions as per Cl. 14.3.2 of IRC: 112-2020.

Limit state of strength

Stability of overall structure shall be checked as per the load combinations.

Failure of members or whole structure by buckling of its element and failure of members at critically loaded areas under the action of axial force, bending moment, shear and torsion is checked for the load combinations.

- **Permissible stresses**

Permissible stresses in pre-stressed concrete members

For the superstructure proposed as Precast I Girder, the permissible stresses are taken from Clause 12.2.1 & 12.2.2 of IRC: 112-2020.

The maximum compressive stresses in concrete under rare combinations of loads for SLS condition shall be limited to 0.48 f_{ck} and 0.36 f_{ck} under quasi permanent loads. Tensile stresses are allowed per table 12.1 of IRC: 112-2020.

The stresses at the least compressive face under Rare Combination of Loads shall be limited to minimum residual compression of 0.5 MPa at joint locations in case of epoxy jointed precast segments as per Clause 3.2 of IRC: SP: 65-2018.

- **Permissible stresses in RCC members**

Permissible stresses in concrete

As per Clause 12.2.1 of IRC: 112-2011, maximum allowable compressive stress in concrete under rare combination of loads is $0.48f_{ck}$ and the same under quasi-permanent loads is $0.36\ f_{ck}$.

Permissible stresses in steel

As per Clause 12.2.2 of IRC: 112-2011, maximum allowable tensile stress in reinforcement shall be limited to $0.8\ f_{yk}$ under rare combination of loads with due consideration to long term creep of concrete.

Humidity parameters for creep & shrinkage assessment

The nearest place near to project area is Bhavnagar with maximum & minimum relative humidity of 64% & 44% respectively, as per Table A-7-1 of Annexure 7 of IRC 112 - 2020. Thus, the average relative humidity for the project location in a day is 54%. The same is adopted for assessing creep & shrinkage.

Fatigue design

As per Cl. 5.3.2.5 of IRC: 112-2020 Annexure 8 of Amendment-1, Fatigue verification is not necessary for the following:
(1) For RCC structures when the stress in the tensile reinforcement is less that 300Mpa under SLS Rare combination; and
(2) For prestressed concrete members under SLS Frequent combination only compressive stresses occur at the extreme concrete fibres.

The verifications of fatigue requirement can be performed according to any one of three methods of increasing refinement, as given in section A8.2 to A8.4 of Amendment-1-IRC112-2020. Stresses in reinforcing steel in prestressed concrete members under fatigue loading in method II & III shall be increased by factor as given in section A8.5 of Amendment No1 – IRC 112-2020.

As per amended clause 204.5.4 of IRC:6-2017, (vide Notification No. 24 Amendment No.5/IRC:6/August, 2019) Fatigue check is not required under Load Combination with SV loading.

IRC: 6-2017, Clause 204.6 defines the vehicle to be considered for fatigue analysis. Special reference to Amendment-1 of IRC 112-2020 on MAY 2021, for permissible stresses shall be made in case the above conditions are not satisfied.

Design stresses in structural steel

As per as per clause.503.4 of IRC: 24, design strength, Sd in plate girders shall be limited to Su/γm. Where Su = Ultimate Strength and γm = partial safety factor (refer Table 1 of IRC: 24).

Limit state of cracking

Crack width check shall be carried out as per clause 12.3.4. Crack width shall not exceed the admissible value for exposure condition defined in Table 12.1 of IRC: 112-2020.

Further minimum reinforcement for reinforced concrete members for crack control shall be provided as per clause 12.3.3 of IRC: 112-2020. In pre-stressed members if the concrete is in compression under rare combination, then only minimum reinforcement for early thermal and shrinkage cracking shall be provided as per Cl 16.5.4 of IRC: 112-2020.

Limit state of deflection

Deflection of structural members under the frequent load combination shall be checked. As per clause 12.4.1 (2) of IRC: 112-2011, deflection limits under live load shall be limited to span/800. When vehicles are on cantilever the permissible deflection is cantilever span/300. Deflection shall be checked against frequent combination only.

- **Design assumptions for superstructure, substructure & foundation design**

Pier cap

Pier cap shall be designed as corbels if shear span to effective depth ratio is less than 1. In other cases, it shall be designed as flexural member.

Pier & abutments

Pier analysis and design will be based on IRC-78:2014. Piers shall be designed to withstand the load and forces transferred from the superstructure and the load and forces of the pier itself.

Foundations

Wherever it is practical to excavate, shallow open foundation system founded on soil shall be used or else pile foundation shall be used with appropriate embedment into good stratum. In case of river bridges depth of foundation shall be decided after accounting the design scour depth. The embedment of the foundation into the soil depends upon the geotechnical requirements.

- **Design assumptions for open foundation**

Bearing pressure underneath open foundation shall be worked out based on Serviceability Limit State (SLS) load combination basic, accidental, seismic and it shall be ensured that maximum bearing pressure shall be less than allowable bearing pressure. Impact factor on live load shall not be taken into account for comparing the maximum bearing pressure vis-à-vis allowable bearing capacity. It is also not to be taken into account for structural design of open foundation.

Shallow open foundation on soil

Open foundation on soil shall be adopted, where required bearing pressure & settlement criteria are met. The sizes of open foundations shall be so proportioned such that resultant of all forces on the base of the foundation shall fall within the middle third. It means that all parts of the foundation shall remain under compression under all SLS load combinations.

Structural design of open foundation

Open foundation shall be checked as RCC member in SLS with stress check for rare load combinations & crack width check for quasi-permanent load combination. Structural design of open foundation shall be as per IRC: 112-2020.

Allowable bearing pressure

Allowable Safe Bearing capacity for open foundation shall be assessed by the geotechnical specialist. For SLS seismic and accidental load combination, allowable bearing pressure shall be enhanced by 25%.

Design assumptions for pile foundation

Piles and pile caps are checked as RCC member in SLS with stress check for rare load combinations and crack width check for quasi-permanent load combination. Impact factor on live load shall not be taken into account while comparing the actual pile load vis-à-vis pile capacity. It is also not required to be considered for structural design of pile.

The various specific assumptions made for the pile and pile cap design are as follows:
(1) Large diameter bored cast-in-situ vertical group of piles have been contemplated for the foundation of piers;
(2) The vertical load capacity of the pile in soil shall be based on static formula given in Appendix-5 of IRC: 78-2014 for basic load combination. The lateral load capacity of pile under basic combination in soil by limiting the lateral deflection to 1% of the diameter of the pile considering it as fixed headed pile. This deflection limitation will not be applicable in load combinations with seismic/accidental conditions for which the resulting structural capacity of the section would be the governing criterion. For pile carrying vertical load, the SLS check under basic, seismic and accidental combinations only will be considered and no reference will be made to ULS combinations. The permissible increase in vertical load capacity of pile for seismic and accidental combinations would be taken as 25%; and
(3) The maximum depth of scour for design of foundation shall be derived from Cl. 703 of IRC: 78-2014.

Initial load tests and Routine Test shall be performed on test piles as per test procedure in IS 2911 (part IV). The evaluation of capacity shall be as per provisions of clause 709.1.8 of IRC: 78-2014.

- **Rail**

This section highlights the general functional & design requirements, guidelines & design philosophy for the design of superstructure and substructure for rail loading bridges. It is understood that beyond the Dyke portion, the connectivity stretch for Rail line would cross several existing waterway, roadway and railway line. Hence, structure type includes Railway superstructure for Flood regulator, Major bridges, Minor bridges, Major RUBs, Minor RUBs, Pedestrian subways & Railway Flyovers carrying 32.5 tons axle load DFC loading.

- **Clearances**

Maximum moving dimensions (MMD) and minimum clearances for track structures

The Maximum Moving Dimensions (MMD) calculated based on the condition of wagon's static and dynamic movement for the freight along with minimum clearances required is reproduced below from Diagram No 2 in "*Standard Schedule of dimensions for Dedicated Freight Corridor for 1676mm gauge in Western corridor*".

Vertical clearances to be maintained for structure locations as per Sec: 8.6 of SSOD Of WDFC are shown below:
(1) Light overhead structure such as foot over bridges - 8430 mm;
(2) Heavy overhead structure such as Road Over Bridge or Flyover - 8050 mm; and
(3) Heavy overhead structure at turnout etc. - 8430 mm

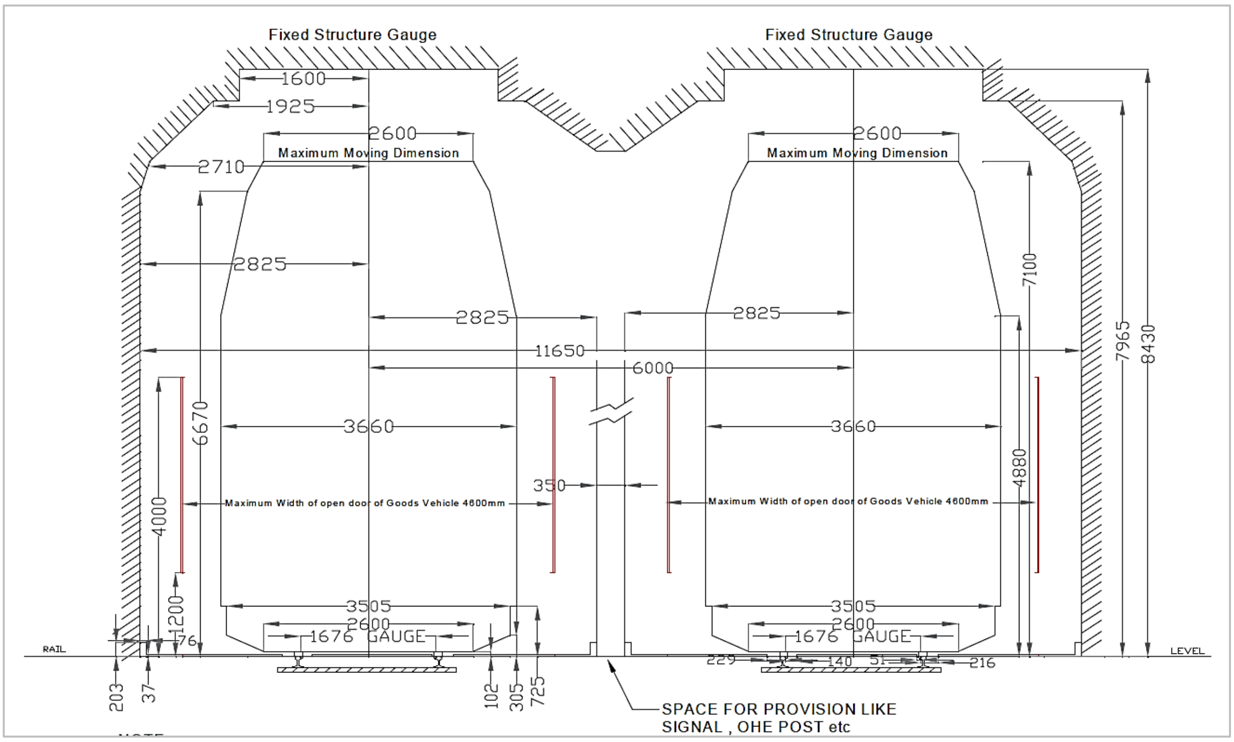


Figure 2.62: Maximum moving dimension - lateral and vertical clearances for double track for freight

When Freight tracks are crossing over passenger Lines, the vertical clearances to be observed (as per IR Schedule of Dimensions) shall be:
(1) Light overhead structure such as FOB - 6250 mm; and
(2) Heavy overhead structure such as Flyover or ROBs - 5870 mm

Clearance requirement of highway structures

The minimum vertical clearances for RUBs/ Underpasses for different highways/ roads shall be as under:
(1) National Highways – 5.5m
(2) State Highways – 5.0m
(3) Village Roads and for non-vehicular traffic - 3.5m
(4) Cattle crossing – 4.5m
(5) Pedestrian Crossing – 2.5m

For major bridges vertical clearances (from HFL to soffit of super structure) varying from 600mm to 1800mm depending on the quantum of discharge shall be as per C.l:4.8.1 of IRS substructure code.

For all minor bridges with box sections minimum free board shall be 1.0m (Cl:4.9 of IRS substructure code).

- **Proposed structural systems**

Classification of bridges

The bridges are defined and classified based on their span/location as per the provisions of Indian Railways Bridge Manual.

Typical deck cross-section

As per SSOD, Ballast retainers will be 2575mm from the centre line of track for straight alignment and for curves of radius 875m or more. This will be increased to 2725 for alignment on curves of radius less than 875m. 900mm width of footpath/ walkway is provided on one side of the track.

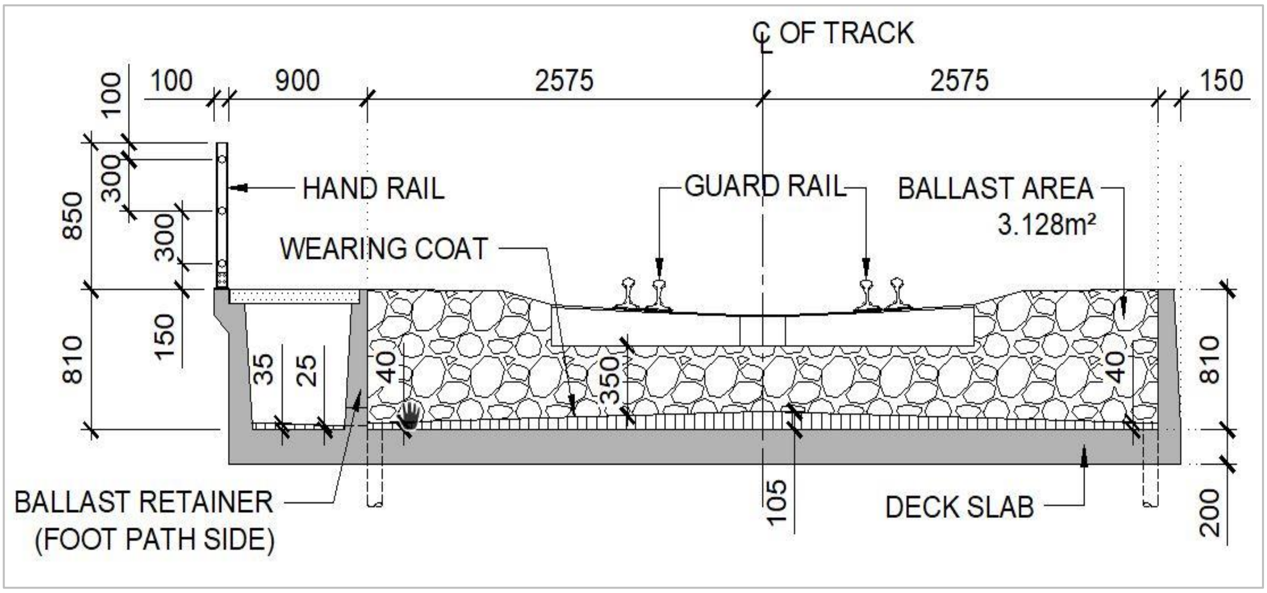


Figure 2.63: Deck section for single track

Bearings

Elastomeric bearing are proposed to be used for bridges with PSC I girder. If the elastomeric bearings could not be designed to transfer longitudinal forces, suitably designed Pin / Metallic Guided bearings will be proposed for this purpose. Design of elastomeric bearing shall be carried out as per UIC – 772 (R). Provisions of IRC 83 (Part: III) shall be applicable for design for Pin/Guided bearings. For items not covered in IRC 83, reference shall be made to BS 5400: Part 9.1 & 9.2. The pier cap will be designed with space for inspection and replacement of bearings.

- **Materials**

- **Concrete**

As per Clause 5.4.4 of IRS CBC, the minimum grade of concrete for bridges in pre-stressed concrete shall be decided based on the exposure condition.

Modulus of elasticity

The Modulus of Elasticity for the different grade of concrete shall be as per Clause 5.2.2 of IRS CBC.

For un-tensioned steel, modulus of elasticity adopted is 200 kN/mm². Long-term Young's modulus of concrete may be calculated through time dependent analysis of structures for the effects of creep and shrinkage. In the absence of the detailed study of time-dependent effects, long term Young's modulus may be assumed to be half of the instantaneous modulus.

Modular ratio

As per Clause 5.2.6 of IRS CBC, in elastic analysis the modular ratio for all concrete grades shall be taken as stated below:

(1) For Tensile reinforcement, m1= 280 / f_{ck}; and
(2) For Compression reinforcement, m2= 420 / f_{ck}

Co-efficient of thermal expansion
The coefficient of expansion shall be taken as per clause 2.6.2 of IRS Bridge Rules.

Density
Densities of various types of materials shall be as per clause 203 of IRC 6 and IS 875 – Part 1

Poisson ratio
Poisson's ratio for Uncracked concrete: 0.20 and zero for cracked concrete as per Cl. 6.4.2.5 – (S.No: 4 – (ii)) of IRC 112.

- **Steel**

Cast steel
The use of cast steel shall be limited to bearings and other similar parts. Steel for castings shall conform to Grade 280-520N of IS: 1030.

Pre-stressing steel
The pre-stressing steel shall conform to either of the following:
(1) Plain hard drawn steel wire conforming to IS: 1785 (Part I);
(2) High tensile steel bar conforming to IS: 2090; and
(3) Uncoated Stress Relieved Low Relaxation strands conforming to IS: 14268

Type of pre-stressing units
All pre-stressing steel units will be of 0.6"/0.5" strands type (Nominal dia =15.2/12.7mm, Area =140mm^2 / 98.7 mm^2 respectively) (As per Table: 2 of IS: 14268). Pre-stressing steel shall be conforming to IS: 14268, class II - Uncoated stress relieved Low relaxation seven ply-strands.

Breaking strength
The breaking strength of strand shall be considered as per Table: 1 of IS: 14268 as follows:
(1) Breaking strength of strand = 260.7 kN (for 15.2mm strand)
(2) Breaking strength of strand = 183.7 kN (for 12.7mm strand)

- **Properties of reinforcement / un-tensioned steel**

For plain and reinforced cement concrete (PCC and RCC) or pre-stressed concrete (PSC) works, the reinforcement / Un-tensioned steel as the case may be shall consist of the following grades of reinforcing bars as specified in Table below. For portion of structure required to be ductile detailed reinforcement should be with Fe415/Fe500D with percentage of elongation not less than 14.5%.

Table 2.111: Requirements of reinforcement/ un-tensioned steel

S. No	Grade Designation	Bar Type confirming to governing IS Specifications	Characteristic Strength (f_y) MPa	Elastic Modulus GPa
1	S 240	Grade 1 Mild Steel & Medium Tensile Steel bars conforming to IS: 432 Part I Mild Steel Bar	240	200
2	Fe 500	Cold twisted bars conforming to IS: 1786 High Yield Strength Deformed Bars (HYSD) / TMT bars	500	200
3	Fe 500 D	High Yield Strength Deformed Bars (HYSD) / TMT bars with percentage elongation not less than 14.5%	500	200

- **Design loadings**

Dead load

Dead load shall include permanent / self-weight of the structure under consideration. The unit weight of materials shall be used as defined in the earlier sections. In case of truss, the weight of truss members shall be increased suitably to account for the stiffeners, diaphragms, gussets, welds or nut and bolts/rivets etc.

Superimposed dead load

The superimposed dead load to be applied to the structures shall include, but not necessarily limited to the following loads: Running rails, Guard rails, Sleeper including rail fastenings, utilities, parapet & railing, Overhead electrification mast, wearing coat, footpath live load and Ballast.

Live Loads

The live loads considered for the structure is as follows:

(1) Static loading: The design loading shall be DFC Loading (32.5 ton axle load). The loading standards applied to the Rail track Structures and Rail track Formations shall generally be in accordance with Bridge Rules. The nominal loading for the design of members shall comprise of fully loaded locomotive(s) and wagons each having four, six and eight axles as shown in the Bridge Rules [DFC Loading (32.5t Axle Load)];

(2) Dynamic effect: The Static Loading given above shall be multiplied by an appropriate dynamic factor as detailed in Clause 2.4 of the IRS Bridge Rules;

(3) Longitudinal braking and traction loads: Longitudinal loads from braking and traction shall be in accordance with Clause 2.8 of [Longitudinal Forces] of the Bridge Rules. Five (5) different combinations of the coupled locomotive(s) and wagons as prepared for the DFC loading (32.5t Axle Load) or Longitudinal loads due to live load as per Appendix: XXVIII shall be considered;

(4) Forces due to Eccentricity and Curvature of tracks: As per clause 2.5.1 of IRS Bridge Rules, for ballasted deck bridges, even on straight alignment an eccentricity of centre line of track from design alignment up to 100 mm shall be considered for the purpose of designs. Difference in load sharing between inner and outer girder on the bridges in curves will be considered in the design as per IRS Bridges Rules and girders will be designed accordingly. Also in box type minor bridges, this effect will be considered;

(5) Longitudinal and Lateral Distribution of Railway Live loads: The live load will distribute through the sleeper uniformly on top of ballast over the contact area of sleeper

and the load under the sleeper shall be assumed to be dispersed by the fill including ballast at a slope not greater than 0.5H: 1V. When there is effective lateral transmission of shear force, the load may be further distributed in a direction at right to the span of structure will be:
i. ¼ span on each side of the loaded area in case of simply supported, fixed and continuous spans; and
ii. ¼ of loaded length on each side of the loaded area in the cantilever slabs.

Seismic load

Seismic loading and analysis shall be carried out as per RDSO guidelines of seismic design of railway bridges issued in January 2015, as given below:
(1) Box and pipe culverts need not be analyzed for seismic forces in all Zones;
(2) Bridges with overall length less than 60m or spans less than 15m are not required to be designed for seismic forces in Zone II & III; and
(3) For zone IV & V bridges with all spans to be designed for seismic forces.

Zone factor

For the purpose of determining the seismic forces the country is classified into four seismic zones. The Zone factor "Z" for varies Zones are tabulated below.

Table 2.112: Zone factor Z for horizontal motion

Seismic Zone	Zone Factor - Z
II	0.10
III	0.16
IV	0.24
V	0.36

The proposed project location falls in seismic zone III.

Important factor

The values of Importance factor "I" = 1.5 for Major bridges on group – A route comes under Category – 1.

For span type minor bridges Importance factor shall be 1.25. Span type Minor bridge is the one for which individual span is less than 12m or overall vent way less than 18m.

Seismic weight and live load

Seismic weight

The seismic weight of the superstructure shall be taken as its full dead load plus appropriate amount of live load. The seismic weight of the substructure and of the foundation shall be their respective full dead load. Buoyancy and uplift shall be ignored in the calculation of seismic weight.

Live load in seismic weight

No live load (train load) shall be considered while calculating horizontal seismic forces along the direction of traffic (Longitudinal direction).

The horizontal seismic forces in the direction perpendicular to traffic (transverse direction) shall be calculated using 50 percent live load (excluding impact effect).

The vertical seismic force shall be calculated using 50 percent live load (excluding impact effect).

Combination of seismic components

The seismic forces shall be assumed to come from any horizontal direction. For this purpose, two separate analysis shall be performed for design seismic force acting along two orthogonal horizontal directions. The design seismic force resultant (that is axial force, bending moments, shear forces, and torsion) at any cross section of a bridge component resulting from the analyses in the two orthogonal horizontal directions shall be combined according to the expression below:

i. $\pm EL_x \pm 0.3EL_y$
ii. $\pm 0.3EL_x \pm EL_y$

Where,

EL_x = Force resultant due to full design seismic force along x direction; and
EL_y = Force resultant due to full design seismic force along y direction.

When vertical seismic forces are also considered, the design seismic force resultants at any cross section of bridge component shall be combined as below:

i. $\pm EL_x \pm 0.3EL_y \pm 0.3EL_z$
ii. $\pm 0.3EL_x \pm EL_y \pm 0.3EL_z$
iii. $\pm 0.3EL_x \pm 0.3EL_y \pm EL_z$

Where EL_x and EL_y are as defined above and EL_z is the force resultant due to full design seismic force along the vertical direction.

As an alternative to the procedure given above, the forces due to the combined effect of two or three components can be obtained on the basic of square root of sum of square (SRSS), that is:

$$\sqrt{EL_x^2 + EL_y^2} \quad \text{or} \quad \sqrt{EL_x^2 + EL_y^2 + EL_z^2}$$

Wind load

The bridge structure shall be designed for wind loading in accordance with Clause 2.11 [Wind Pressure Effect] of the Bridge Rules. For purpose of design, the Map as given in IS: 875 (part 3) in conjunction with the table therein, may be used for determining the basic wind speed. Basic wind speed of 50m/s shall be considered. The wind pressure specified above shall apply to all loaded or unloaded bridges provided that a bridge shall not be considered to be carrying any live load when the wind pressure at deck level exceeds the limit 1.47 kN/m^2 (150 kg/m^2) for Broad Gauge bridges.

Design wind speed at any height, $Vz = k_1 \times k_2 \times k_3 \times v_b$

Where,

Vb = Basic Wind Speed (Depends on location)
K_1 = Probability factor
K_2 = Terrain, height and size factor

K_3 = Topography factor

The Design wind pressure can be calculated as, $Pz = 0.6 \times Vz^2$

The additional reaction due to wind load on live loads shall be considered for Box type structures. The foundation and sub structure shall be checked for wind load on corresponding members.

Temperature load

Effects on structure due to uniform rise and fall of temperature shall be considered as per IRS Bridge Rules Cl. 2.6. Elastic modulus shall be half of the value for calculation of effects due to uniform temperature.

Stress due to temperature gradient shall be considered as per the recommendations laid in IRC 6 (Fig.10 a).

Earth pressure

All earth retaining structures shall be designed for the active pressure due to earth fill behind the structure. The Load due to Earth Pressure is considered into 3 categories:
(1) Active Earth Pressure
(2) Dead Load and Live load surcharge
(3) Earth Pressure due to seismic

Active earth pressure: The active earth pressure due to earth fill shall be calculated as per cl.5.7 of IRS: Code of Practice for the design of substructure and foundation of bridges.

Dead load and live load surcharge:

Abutment: Earth pressure due to surcharge on account of live load and dead loads shall be considered as equivalent load placed at formation level and extending up to the bottom of the box. The surcharge due to live loads for DFC loading of 32.5t axle load, shall be considered as 163kN/m with a 3.0m width of uniform distribution at formation level , vide table no 3 of IRS substructure code.

Other loadings

Derailment loading: Derailment loading applied to the bridge structures shall be in accordance with Clause 2.14 [Derailment loads] of the bridge rules.

Derailment loads for DFC loading will be considered in the design as per Bridge Rules. Serviceability, Ultimate and stability checks will be carried out for derailment loads.

Derailment load for ballasted deck bridges for both serviceability and ultimate condition shall be checked as per Appendix-XXIX of IRS Bridge rules assuming bridge with guard rails. It is presumed that all the bridges will be provided with guard rail.

For purpose of checking the stability of structure, the live load 122 kN/m with a total length of 20m as per Appendix-XXIX of IRS Bridge Rules shall be assumed to be acting at inner face of the ballast retainer.

Construction loads: Live loads during construction stage shall include but limited to the weight of workers and all mobile equipment, such as vehicles, hoist, cranes, and structure components used during the process of erection/construction.

Accidental load (Collision load on piers): In case of RUB major and minor**,** Piers or other guide ways support elements that are situated on the edges should be designed to withstand the horizontal static forces, unless protected with suitable barriers. This condition occurs with the dead load of structures but does not need to be applied concurrently with other applied loads. IRC: 6 shall be referred for accidental load on piers spanning over road traffic.

LWR/ CWR forces: Forces due to LWR/CWR to be taken for structural design shall be in accordance with UIC 774-3R and IRS bridge rules.

Footpath / walkways on bridges: Consideration of the loads due to pedestrian traffic as indicated in Clause 2.3.2 [Footbridges and Footpath on Bridges] of the IRS Bridge Rules shall be taken into account. Footpath live load shall be adopted as 490 kg/m^2. The force on the parapet shall be as per clause 2.10 of IRS bridge rules.

- **Load combinations**

Concrete bridges:
The load combinations are adopted as per Clause 11.2 of IRS Concrete Bridge Code.

- **Design Philosophy**

The design of structural components is done by the following two concepts as IRS CBC:
(1) Serviceability limit state
(2) Ultimate limit state

- **Exposure condition**

The durability of concrete structure depends on its resistance to deterioration, and this is purely dependent on the environment in which it is placed. The general environment to which the concrete will be exposed during its life period is classified under different levels of severity by various codes. The exposure condition shall be identified as per clause 5.4 of IRS -Concrete Bridge Code.

- **Serviceability Limit State [SLS] condition**

In this the structural members are checked for stresses in materials i.e., concrete and reinforcement, crack width and deflection. The design method for superstructure for SLS condition is indicated in the subsequent sections. The substructure and foundation will be designed based on SLS condition as per cl 10.2 of IRS Concrete Bridge Code. The load factors to be operated for various load combinations on basic loads are tabulated in Table: 15 of the manual.

The following design parameters shall be considered for design.

Permissible stresses in structures

For RCC structures:
The compressive stress in concrete and tensile stress in reinforcement are calculated based on bending moment in SLS case.

i. Compressive stress in concrete

$$f_c = \frac{Mx_u}{I_{cr}}$$

ii. Tensile stress in reinforcement

$$f_t = \frac{m\,M(d - x_u)}{I_{cr}}$$

Where,

I_{cr} = Cracking moment of inertia
X_u = Depth of neutral axis
M = Modular ratio

Allowable stresses in superstructures for SLS check for different types of structures shall be as per Clause 10.2.2.1 of IRS Concrete Bridge code.

For PSC structures:
The compressive stress in concrete at transfer shall not exceed values mentioned in Table: 24 of IRS: CBC.

Crack Width
The crack width is calculated as per cl.15.9.8.2.1 of IRS CBC. Permissible crack width is as per table no. 10 of IRS CBC.

Clear Cover for Untensioned reinforcement
Clear cover shall not be less than the size of the bar or the maximum aggregate size plus 5mm. In case of a bundle of bars, it should be equal to or greater than the size of single bar of equivalent area plus 5 mm.

From durability consideration, minimum clear cover to any reinforcement shall be as per Table 20.

Clear cover shall not exceed 75mm in any type of structural element. The Minimum Clear cover to any reinforcement shall be as per Clause 15.9.2 of IRS CBC.

- **Ultimate Limit State [ULS] condition**

In this structural member are checked for the design method for superstructure for ULS condition. The substructure and foundation will be designed based on ULS condition as per cl 10.3 and cl 15.4 of IRS Concrete Bridge Code. The pier cross section will be designed based on cl 15.6 of the code. The design of slender piers will be based on cl 15.6.4 of the code. The load factors to be operated for various load combinations on basic loads are as per cl 11.2 of IRS Concrete Bridge Code.

- **References**

Relevant codes/ standards are as given below:
(1) Indian Railway Brides Rules, specifying the loads for Design of Superstructure and Substructure of Bridges (with up-to-date correction slip) including Chapter – VII for the rule for the opening of Railway;
(2) Loading Standards as given in Design Criteria (specified in Employer's Requirements – Part – 2, Volume -04 of bid document);
(3) Indian Railway Schedule of Dimensions for Board Gauge;

(4) DFC Draft Schedule of Dimensions;
(5) Indian Railway Code for Practice of Plan/Reinforced and Pre-stressed concrete for general / bridge construction (Concrete Bridge Code);
(6) IRS Specifications for Steel Bridges Code;
(7) Indian Railway Bridge Manual;
(8) Indian Railways Permanent Way Manual;
(9) Indian Railways Works Manual;
(10) IRS Standard Code of Practice for design of Sub-structure & Foundation;
(11) IRS: Manual on the design and construction of well and pile foundation;
(12) IITK-RDSO guidelines of seismic design of Railway Bridges;
(13) Indian Standard Specifications;
(14) IS: 875 (all 5 parts) – Design loads (other than earthquakes) for buildings and structures;
(15) IS: 456 - Plain and reinforced concrete;
(16) IS: 2911 (Part I to IV) - Code of practice for design and construction of pile Foundations;
(17) IS: 1893 Criteria for Earthquake Resistance Design of Structures;
(18) IS: 4326 Earthquake Resistance Design and Construction of Building – Code of Practice;
(19) IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces;
(20) IS: 875 (Part 3)– Code of Practice for Design Loads (Other than Earthquakes) for Buildings and Structures – Wind Loads (Second Revision);
(21) IS: 1786 - High Strength Deformed Steel Bars & Wires for Concrete Reinforcement (Third Revision);
(22) IS: 432 (Part-I & Part-I) – Mild Steel, Medium Tensile Steel Bars and Hard Drawn;
(23) IS: 280 Mild steel wires for general purposes;
(24) IS: 2502 Code of practice for bending and fixing of Bars for concrete reinforcement;
(25) IS: 1343 Pre-stressed concrete;
(26) IS: 14268 Pre-stressing Strands; and
(27) IS: 1493 Design of Bored and Cast in Situ Piles Founded in Rock. - Guide lines

2.3.6 Configuration

(a) Alignment

The proposed road and rail alignment over the dyke as well as access links on either end is presented in **Figure 2.64**.

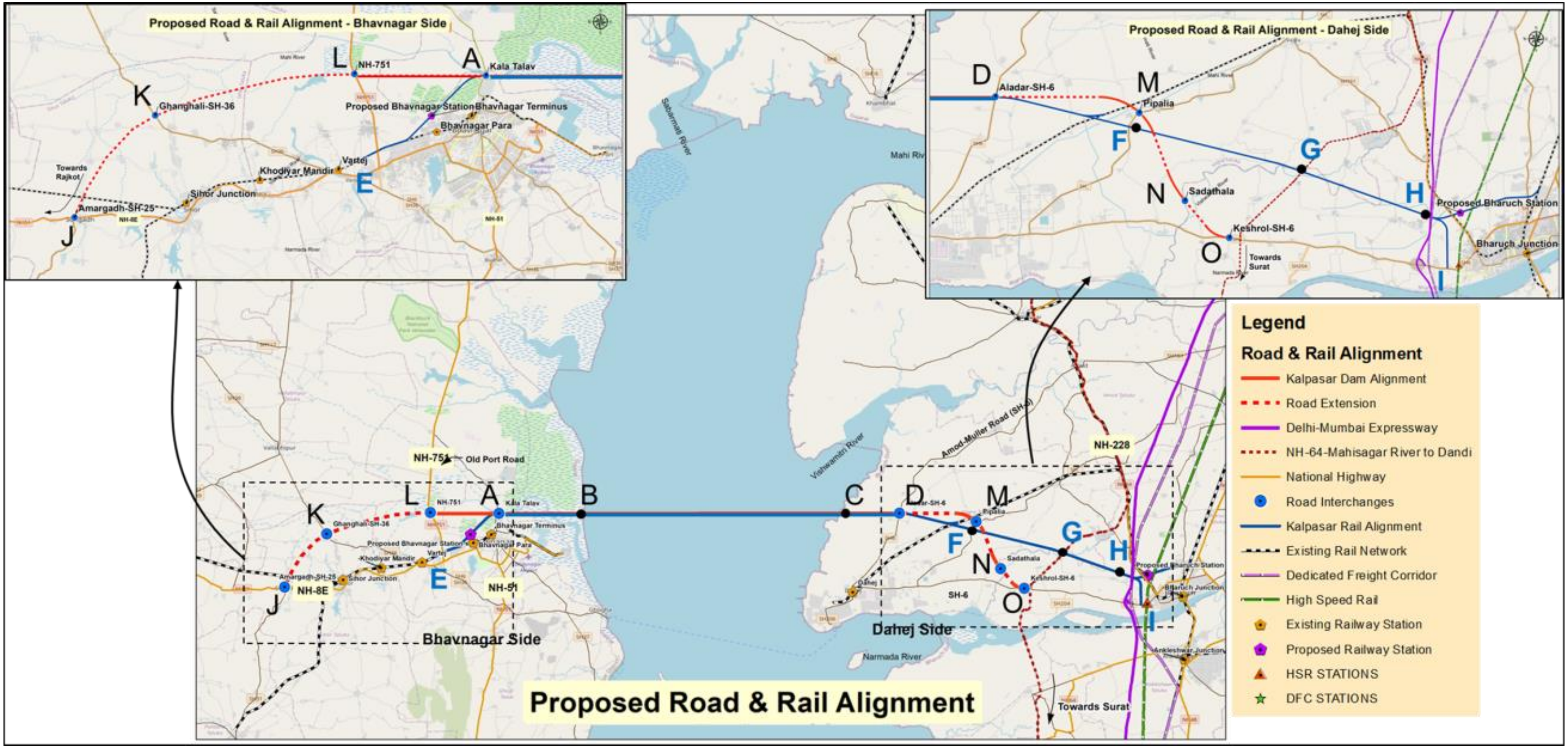


Figure 2.64: Proposed Road and Rail alignment including access links on either end

- **Road**

The detailed plan for the transport corridor has been prepared based on the capacity requirements to handle future traffic.

The description of road alignment is presented below. The major locations along the road alignment are marked in map is described below in **Table 2.113**.

Table 2.113: Road alignment chainage and location details

Section of Road alignment	Chainage (m)	Location
A	32+250	Kalatalav (Ladiyapul)
B	43+500	Gulf side of Bhavnagar
C	70+000	Gulf side of Dahej
D	83+660	Panjadara / Aladar on SH-6
J	0+000	Songadh on NH-8E
K	9+800	Ghanghali on SH-36
L	23+500	Nari on NH-751
M	93+800	Pipaliya / Pakhajan
N	98+730	Sadathala connecting NH-64 (under construction)
O	10+500	Keshrol on SH-6

The road alignment (on Bhavnagar side) connects NH-751 (point L). Further, for effective dispersal of the traffic, the alignment is extended to SH-36 at Ghangalia (point K) and Sonegadh on NH-8E (point J) as shown in **Figure 2.64**.

The road alignment (on Dahej side) connects Panjadara / Aladar on SH-6 (point D). Further, for effective dispersal of the traffic, the alignment is extended to Pipaliya / Pakhajan (point M), Sadathala connecting NH-64 (under construction) (Point N) and Keshrol on SH-6 (point O) as shown in **Figure 2.64**.

The total length of the road alignment including connectivity to various existing and proposed roads is 100 km. The break-up of distance between various points is summarised in **Table 2.114.**

Table 2.114: Length of road alignment (Section wise)

Section of Road alignment	Distance (in Km)	Remarks
A-B	11.25	Access road in intertidal zone
L-A	8.85	Access road
K-L	9.20	Access road
J-K	9.40	Access road
B-C	26.50	Dyke and flood regulator

Section of Road alignment	Distance (in Km)	Remarks
C-D	13.75	Access road in intertidal zone
D-M	10.10	Access road
M-N	5.60	Access road
N-O	5.80	Access road
Total length	100.5 km	

➤ **Rail**
The major locations along the rail alignment are shown in **Figure** 2.64 and tabulated in **Table 2.115**.

Table 2.115: Rail alignment chainage and location details

Section of Road alignment	Chainage (m)	Location
A	10+500	Kalatalav (Ladiyapul)
B	21+635	Gulf side of Bhavnagar
C	48+135	Gulf side of Dahej
D	62+000	Panjadara / Aladar on SH-6
E	0+000	Nari Railway Station
F	72+000	Pipaliya / Pakhajan
G	82+000	Cholad
H	92+000	Munubar
I	97+425	Bharuch
P	6+519	Proposed New Terminal at Bhavnagar
Q	96+511	Proposed New Terminal at Bharuch

- The rail alignment runs parallel to the road alignment at point A - Kalatalav (Ladiyapul), point B- Gulf side of Bhavnagar, point C- Gulf side of Dahej and point D- Panjadara / Aladar on SH-6.

- The rail alignment on Bhavnagar side deviates from road alignment at point A - Kalatalav (Ladiyapul) connecting Nari Railway Station (point E) from Kalatalav (Point-A) and merges with the existing rail alignment.

- The rail alignment on Dahej side deviates from road alignment at point D Panjadara / Aladar on SH-6 and passes through Pipaliya / Pakhajan (point F), Cholad (point G), Munubar (point H) and connects the existing railway line at Bharuch (point I).

- New Railway terminals are proposed near Ramdev nagar at Bhavnagar side and at outskirts of Bharuch at Dahej side. The total length of the rail alignment is 97.425 km.

The break of distance between various points is summarised in **Table 2.116.**

Table 2.116: Length of rail alignment (Section wise)

Section of Road alignment	Distance (in Km)	Remarks
A-B	11.25	Intertidal zone
B-C	26.50	Dyke and flood regulator
C-D	13.75	Intertidal zone
E-A	10.50	Proposed Bhavnagar Terminal
D-F	10.0	Access Rail Line
F-G	10.0	Access Rail Line
G-H	10.0	Access Rail Line
H-I	5.425	Proposed Bharuch Terminal
Total length	97.425 km	

(b) Cross section

The proposed cross section of the transport corridor for the optimistic scenario (Roadway comprising of 16 lanes (8 lanes in each direction) and Railway comprising of dedicated passenger & freight rail lines is presented in **Figure 2.65** as well as in **Annexure-2K and Annexure-2L.**

Some of the features of the cross-section are presented below:
(1) Lane width of 3.5 m;
(2) Median width of 6 m (as per 6-lane manual);
(3) Paved shoulder of 1.5 m and earthen shoulder of 1.0 m on either side of the carriageway;
(4) Multi-utility lane of 4 m is considered on either side of the carriageway. It will accommodate emergency parking, truck layby, utility, drop-off, landscaping and ITS components;
(5) Pedestrian drop off zone of 3 m is considered which is basically footpaths with other amenities such as seating arrangements etc.,
(6) On LHS side (reservoir side), a tree zone of 5 m has been proposed so that lighting will not affect the fish or other aquatic life during the night side;
(7) A setback distance of 3 m is considered between the Road and Rail corridors; and
(8) A total width of 40 m is considered for rail corridor as per the Railway norms in which 20 m. is allocated for passenger rail and 20 m for freight rail.

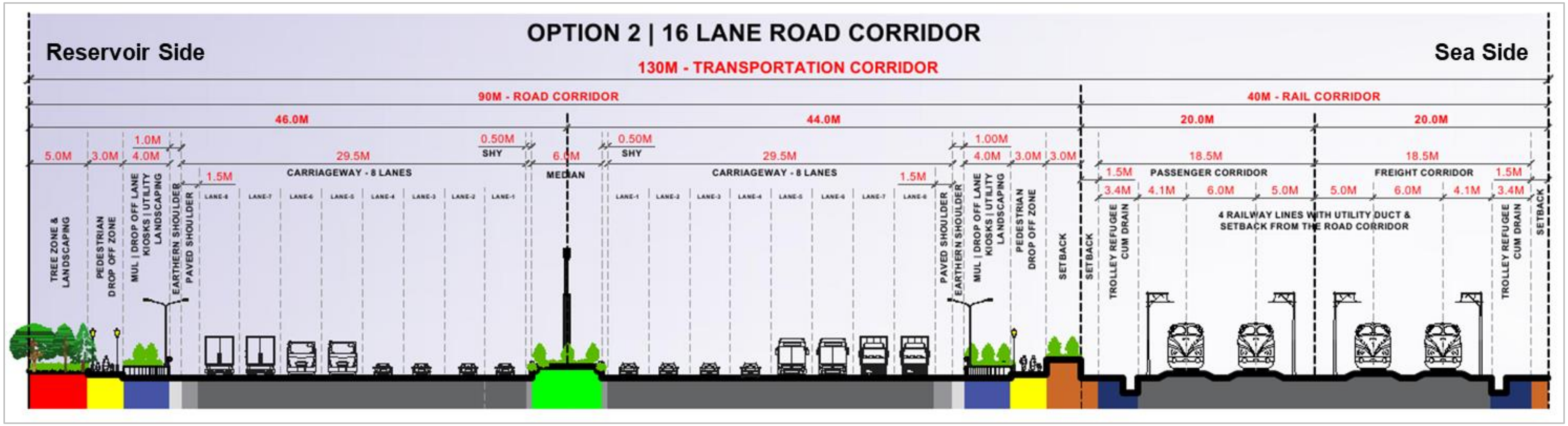


Figure 2.65: Proposed cross section of road & rail corridor (Option 1: 16 lane road corridor)

2.3.7 Design

(a) Design basics

➢ **Inputs for Detailed Project Report**

Consultants have collected various inputs required for design of road, rail and bridge components from NCCR and the same is presented below:

(1) Dyke alignment as well as alignment of access roads;
(2) Topographic data for dyke and approach road portion (60 m length);
(3) Cross-section of dyke and transportation corridor; and
(4) Geo-technical report

The alignment of dam and transport corridor including access roads as provided by NCCR is presented in **Figure 2.66**.

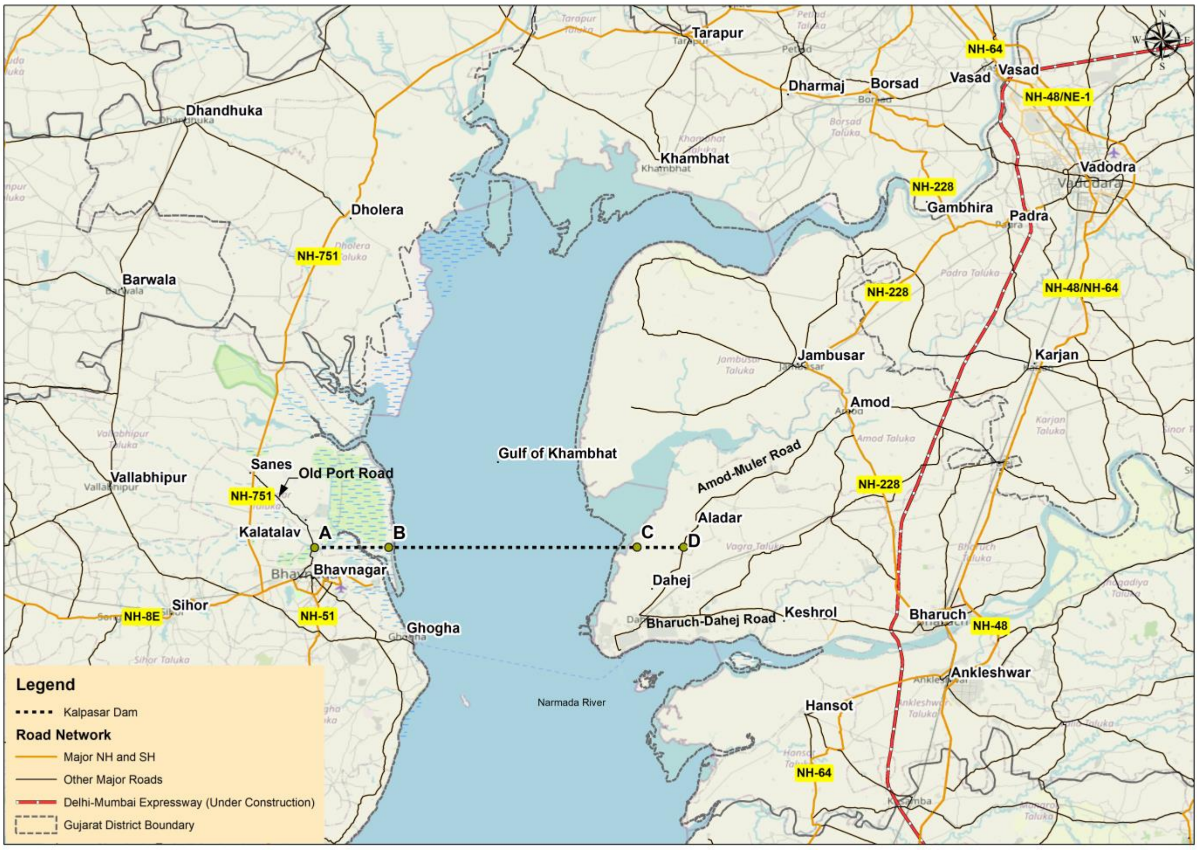


Figure 2.66: Alignment of Kalpasar dyke and access roads

Proposed dyke cross-section as provided by NCCR is presented in **Figure 2.67**.

The width of transport corridor proposed is 130 m to accommodate the road and rail alignment. NCCR has supplied the topographic survey data of dyke portion and till the nearest access roads (NH-751 on Bhavnagar side and SH-6 (Dahej - Aladar section) covering the A to D for about 60 km. Beyond 60 km, the access roads and interchange designs have been based on the google pro imageries.

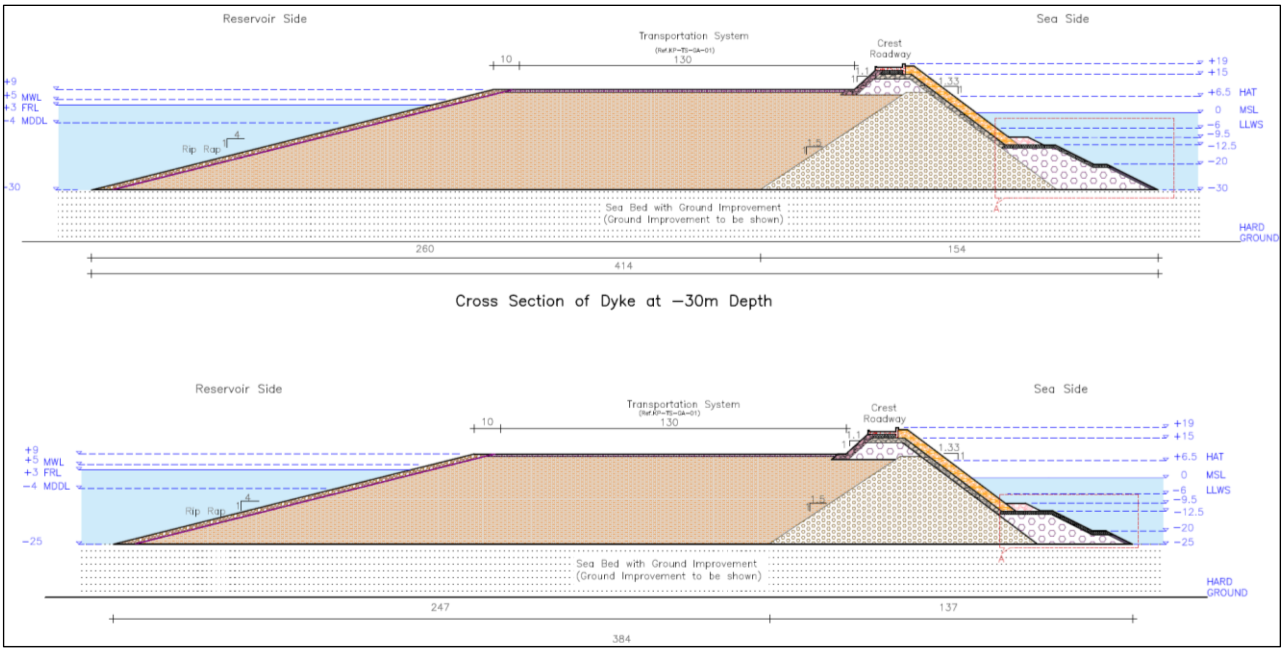


Figure 2.67: Cross-section of Kalpasar Dyke

Summary of Geotechnical report is presented in the following sections. The entire stretch is divided into 7 zones of which, one zone lies in the intertidal region of Bhavnagar, 4 zones lies in the Gulf region, 1 zone lies in the Flood regulator region and remaining 1 zone lies in the intertidal & tidal land region of Dahej.

Those 7 zones are as follows:
(1) Zone 1: Intertidal region in Bhavnagar;
(2) Zone 2: Channel A in Gulf region;
(3) Zone 3: Channel B in Gulf region;
(4) Zone 4: Channel C in Gulf region;
(5) Zone 5: Channel D in Gulf region;
(6) Zone 6: Flood regulator area; and
(7) Zone 7: Intertidal & tidal region at Dahej

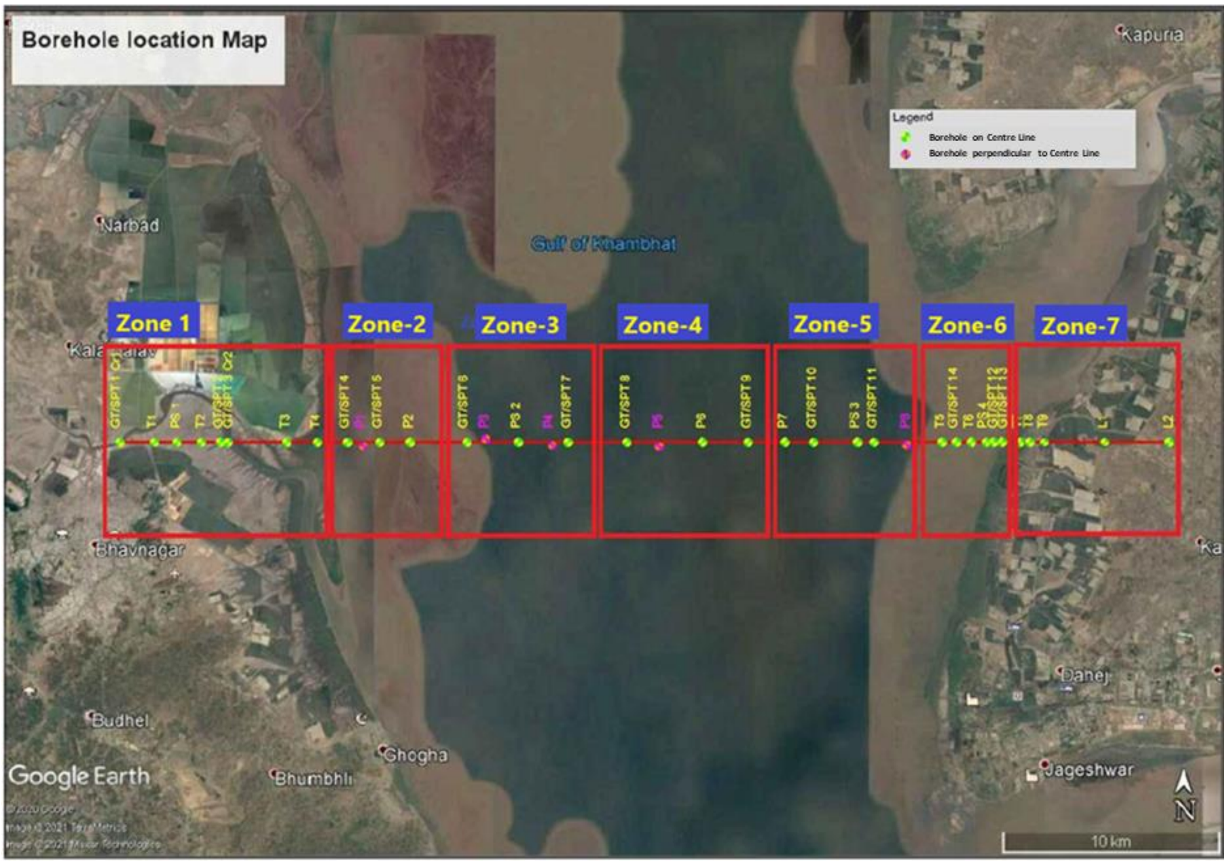


Figure 2.68: Zone bifurcation of Bore-log data

Following are the zone-wise observations on bore-log data. It can be observed that presence of soft clay and very loose to loose silty sand layers in top soil strata may cause excessive settlement. Suitable ground improvement techniques are required to be adopted to overcome settlement and to improve the bearing capacity.

Table 2.117: Zone wise soil condition observations

Zone	Observation
Zone 1	Soil conditions are predominantly clayey (mostly soft clay) in nature with presence of pockets of fine sand.
Zone 2 Zone 3 Zone 4 Zone 5	Soil conditions are predominantly sandy in nature with presence of pockets of silty clay at few depths. Dense to very dense sand layers found at greater depths.
Zone 6	Soil conditions in this zone are clayey (mostly soft clay) in nature with certain layers of silty sand.
Zone 7	Soil conditions are predominantly clayey in nature.

NCCR conducted bore log survey from 3 bore hole points and the easting and northing of bore log data points are shown in **Table 2.118**,

Table 2.118: Bore log data points

Borehole Number	Easting	Northing	Ground Level m w.r.t MSL
C1	248450.9977	2413474.5393	3.91
C2	248854.4190	2413460.9622	2.58

Borehole Number	Easting	Northing	Ground Level m w.r.t MSL
C3	249582.2418	2413450.4731	3.34

Figure 2.69 shows the bore log data collection sheet at points C1, C2 and C3 at maximum depth.

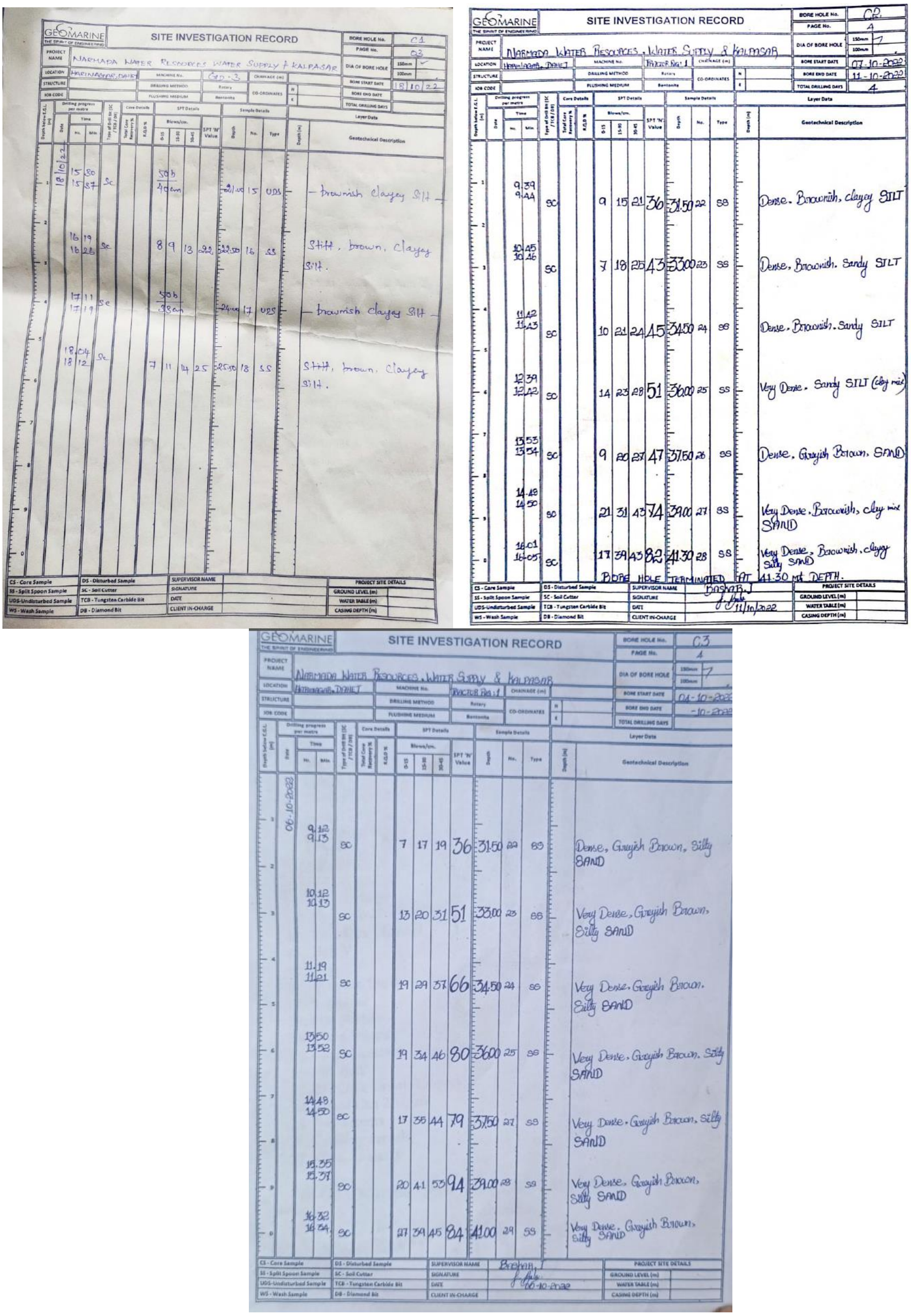


Figure 2.69: Bore log data

(b) Base line conditions and challenges

Canal diversion : It is proposed by Kalpasar Department, the water way on the Bhavnagar side will be diverted. In view of the above, no bridges are considered over the waterways in the inter-tidal zone.

Extension of access road till the major road: As per the initial concept from NCCR, the access is terminating on NH-751 (Ahmedabad-Bhavnagar Road of 4-lane configuration) on Bhavnagar side and on SH-6 (Dahej-Aladra section which is a 2-lane configuration) on Bharuch side. Terminating the Kalpasar road link on SH-6 (Dahej-Aladra section which is a 2-lane configuration) is not suggested as traffic needs to pass through Dahej industrial area. In view of above, it is proposed to extend the access road further joining the SH-6 (Dahej-Bharuch section) which is currently of 6-lane configuration. The access road requirements have been considered for horizon years is included in the current report.

Soil Improvements in inter tidal zone : It is observed that presence of soft clay and very loose to loose silty sand layers in top soil strata may cause excessive settlement. Suitable ground improvement techniques may be adopted to overcome settlement and to improve the bearing capacity.

Dispersal challenges : The capacity augmentation of existing regional network needs to be carried out considering the 16-lane traffic from Kalpasar in the phased manner. The proposed Kalpasar Road link needs to be connected at various locations including necklace road along the coast (proposed), NH-48, Delhi-Mumbai Expressway and upcoming regional roads. Dispersing huge traffic on the regional network will be a challenge as existing road networks are not planned to absorb the huge quantum of traffic. Thus, it is imperative that traffic needs to be dispersed at multiple locations rather couple of locations as there is a limitation of augmentation existing regional road network. With respect to railway traffic, upgradation of existing terminals and planning for new terminals is required. This issue is addressed in the current report.

Land acquisition: Though no land acquisition is required for access roads in the intertidal zones, Land acquisition may be required beyond the inter tidal zone for planning the road and rail links. It is especially required at the proposed interchanges which will connect with existing road network. Kalpasar transportation link will generate huge amount of traffic and therefore widening of all the existing regional network will be required. Similarly, LA may be required for proposed passenger and freight terminals for the railways. This shall be taken up during detailed design stage.

Existing crossings : Vehicle Under Pass (VUP), Pedestrian Under Pass (PUP) and Cattle Under Pass (CUP) are required to be considered for existing vehicle cross roads, pedestrian paths and cattle paths respectively. Similarly, ROB/RUBs will be required for crossing the existing and proposed railway lines and bridges are required to be considered for crossing the water ways. This issue has been addressed based on the available information.

Security hold area : As per the requirement from security perspective, there shall be provision of physical checking or screening of vehicles (in certain situations). This should ideally be carried out at the interchange locations. However, since it is very difficult to get the huge land parcel at interchange locations, it is suggested that security hold area can be planned in inter-tidal zone where sufficient land is available. In view of the above, suitable ramps can be planned so that vehicles can be diverted to security hold area and can merge with access roads once checking is completed. The concept plan for the same is presented in the report.

Planning for long horizon : Planning for long horizon is the major challenge as it is difficult to predict the future for a long horizon considering rapid transformation of socio-economic characteristics as well as evolution of future technologies. In view of the uncertainties, traffic is forecasted for three scenarios (pessimistic, most likely and optimistic).

(c) Design of Roadway

- **Plan and profile**

The plan and profile of Road corridor including the interchanges and traffic dispersal on either side of the dyke is presented in this section.

Road alignment accessing Kalpasar dyke starts at Sonpuri in Bhavnagar side and passes through Ghangali, Nari and Lakdiya Pull before connecting Kalpasar dyke, similarly the road alignment at Dahej side starts at Keshrol and passes through Sadathala, Pakhajan, Goladra before connecting the Kalpasar Dyke. The plan and profile of the proposed road alignment is presented with drawing numbers **RD-PP-01 to RD-PP-21 and the cross-section of the proposed road alignment is presented with drawing numbers RD-TCS-001 to RD-TCS-005** in **Annexure – 2K**

- **Road Bridge Structures**

Structural elements related to road such as bridge at flood regulator, interchanges and bridges in approaches are summarised in **Table 2.119**, **Table 2.120** and **Table 2.121** respectively.

Table 2.119: Bridge at Flood regulator

S. No.	Bridge classification	Chainage reference (Km)	Span Arrangement (EJ to EJ) (m)	Deck width (m)	Location reference	Remarks
1	Viaduct	Flood Regulator location	100 x 22m	2 x 43.5	Dahej side	The total No. of span is based on the proposal of 100 Nos. of gates to be provided at Flood Regulator

Table 2.120: Road interchanges

S. No.	Bridge classification	Chainage reference (Km)	Span Arrangement (EJ to EJ) (m)	Deck width (m)	Location reference	Remarks
1	Interchange	0+000	5 x 21m	1 x	Bhavnagar	Connectivity

	ramp			20.5	side	with NH-751 (existing 4 lane)
2	Cloverleaf Interchange ramp	23+500	4 x 21m (for 4 ramps each)	1 x 16.5	Bhavnagar side	Connectivity with NH-6 (existing 4 lane)

Table 2.121: Road Bridges Structures in Approaches

S. No.	Bridge classification	Chainage reference (Km)	Tentative clear span (m)	Deck width (m)	Location reference	Remarks
1	Road Flyover	0+000	40	2 x 20.5	Bhavnagar side	Road crossing, with three-legged interchange
2	Road Flyover	0+800	20	2 x 20.5	Bhavnagar side	Road crossing
3	ROB	1+610	20	2 x 20.5	Bhavnagar side	Single railway line crossing, details of future additional tracks unknown
4	Major Bridge	3+030	60	2 x 20.5	Bhavnagar side	waterway crossing
5	Road Flyover	3+850	40	2 x 20.5	Bhavnagar side	Road crossing
6	Road Flyover	5+100	25	2 x 20.5	Bhavnagar side	Road crossing
7	Road Flyover	8+620	25	2 x 20.5	Bhavnagar side	Road crossing
8	VUP	9+800	15	2 x 27.5	Bhavnagar side	Road crossing
9	Major Bridge	10+000	25	2 x 27.5	Bhavnagar side	waterway crossing
10	VUP	11+100	15	2 x 27.5	Bhavnagar side	Road crossing
11	Major Bridge	15+940	60	2 x 27.5	Bhavnagar side	waterway Crossing
12	Road Flyover	23+500	45	2 x 31	Bhavnagar side	NH-751 Crossing with clover leaf interchange
13	Road Flyover	32+250	30	2 x 31	Bhavnagar side	Span is tentative, decided based on existing

S. No.	Bridge classification	Chainage reference (Km)	Tentative clear span (m)	Deck width (m)	Location reference	Remarks
						two-lane road (ROW details are not available)
14	Road Flyover	83+660	20	2 x 24	Dahej side	Do
15	Road Flyover	85+210	20	2 x 24	Dahej side	Do
16	Major Bridge	87+500	16	2 x 24	Dahej side	Drain/pipe crossing
17	Road Flyover	88+660	16	2 x 24	Dahej side	Road crossing
18	Major Bridge	89+410	30	2 x 24	Dahej side	Drain/pipe crossing
19	Major Bridge	90+460	20	2 x 24	Dahej side	Drain/pipe crossing
20	Major Bridge	92+000	50	2 x 24	Dahej side	Waterway crossing
21	Flyover	92+600	25	2 x 24	Dahej side	Road crossing
22	ROB	93+000	20	2 x 24	Dahej side	Single railway line crossing, details of future additional tracks unknown
23	VUP	93+400	15	2 x 20.5	Dahej side	Road crossing
24	Major Bridge	93+460	40	2 x 20.5	Dahej side	Drain + road crossing
25	VUP	93+800	35	2 x 20.5	Dahej side	Road crossing
26	ROB	95+600	60	2 x 20.5	Dahej side	Road bridge crossing the proposed railway alignment with 4 tracks
27	Major Bridge	96+300	30	2 x 20.5	Dahej side	Road crossing
28	Road Flyover	98+730	30	2 x 17	Dahej side	Road crossing
29	Major Bridge	102+250	40	2 x 17	Dahej side	Waterway crossing

S. No.	Bridge classification	Chainage reference (Km)	Tentative clear span (m)	Deck width (m)	Location reference	Remarks
30	Major Bridge	102+650	20	2 x 17	Dahej side	Waterway crossing
31	Minor Bridge	103+350	12	2 x 17	Dahej side	Drain crossing
32	Flyover	104+500	30	2 x 17	Dahej side	Road crossing, end point integration with NH 6

- **Pavement design**

Rigid pavement is considered for Road taking into considering high intensity of the rainfall in the region, minimal maintenance requirements and durability.

- **Transportation facilities**

Following project facilities are required and the same have been provided.
(1) Truck lay bye;
(2) Bus bays;
(3) Way side amenities such as hotels, truck repair facilities etc.); and
(4) Security hold area for checking the vehicles

(d) Design of railway

The plan and profile of Rail corridor including the approach railway line on either side of the dyke as well as integration with existing regional rail network is presented in this section.

- **Plan and profile**

Rail alignment on Dahej side starts at Bharuch and connects Kalpasar dyke at Panjadara, similarly in Bhavnagar side the rail alignment starts at Nari railway station and connects Kalpasar dyke at Lakdiya Pull.

New Railway terminals are proposed near Ramdev Nagar at Bhavnagar side and at outskirts of Bharuch at Dahej side.

Table 2.122: Proposed rail terminal locations

S. No	Station Name	Chainage(km)	Remarks
1	New Bhavnagar	7.030	Passenger Terminal
2	New Bhavnagar	7.050	Freight Terminal
3	New Bharuch	95.800	Passenger Terminal
4	New Bharuch	96.100	Freight Terminal

The plan and profile of the proposed rail alignment is presented in Annexure-2L with drawing numbers RL-PP-001 to 024 and railway cross-sections are presented in drawings RL-TCS-001 and 002**.**

- **Railway Bridge Structures**

Bridge structures identified for rail loadings are listed in **Table 2.123 & Table 2.124.**

Table 2.123: Bridge at Flood regulator

S.no.	Bridge classification	Chainage reference (Km)	Span Arrangement (EJ to EJ) (m)	Deck width (m)	Location reference	Remarks
1	Viaduct	Flood regulator location	100 x 22m	4 x 6.2	Dahej side	The total No. of span is based on the proposal of 100 Nos. of gates to be provided at Flood regulator

Table 2.124: Rail Loading Bridge Structures in approaches

S. No.	Bridge classification	Chainage reference (Km)	Tentative clear span (m)	Deck width (m)	Location reference	Remarks
1	RUB Major	5+300	20	4 x 6.2m	Bhavnagar side	Road crossing
2	RUB Major	10+550	40	4 x 6.2m	Bhavnagar side	NH crossing
3	RUB Major	61+950	20	4 x 6.2m	Dahej side	Road crossing
4	RUB Major	63+450	20	4 x 6.2m	Dahej side	Road crossing
5	Major Bridge	65+670	15	4 x 6.2m	Dahej side	Drain crossing
6	Major Bridge	67+300	16	4 x 6.2m	Dahej side	Drain/pipe crossing
7	Major Bridge	68+050	20	4 x 6.2m	Dahej side	Drain/pipe crossing
8	Major Bridge	68+100	40	4 x 6.2m	Dahej side	Drain crossing
9	RFO	68+950	30	4 x 6.2m	Dahej side	Single railway line crossing, details of future additional tracks unknown
10	Major Bridge	69+700	30	4 x 6.2m	Dahej side	Waterway crossing
11	RUB Major	71+350	25	4 x 6.2m	Dahej side	Road crossing
12	Major Bridge	73+250	25	4 x 6.2m	Dahej side	Drain crossing

S. No.	Bridge classification	Chainage reference (Km)	Tentative clear span (m)	Deck width (m)	Location reference	Remarks
13	Major Bridge	77+400	25	4 x 6.2m	Dahej side	Waterway crossing
14	RUB Major	77+850	25	4 x 6.2m	Dahej side	Road crossing
15	Major Bridge	81+150	60	4 x 6.2m	Dahej side	Waterway crossing (high skew)
16	RUB Major	81+500	60	4 x 6.2m	Dahej side	Road crossing (high skew)
17	Major Bridge	84+800	60	4 x 6.2m	Dahej side	Canal crossing
18	RUB Major	86+450	15	4 x 6.2m	Dahej side	Road crossing
19	Major Bridge	90+450	35	3 x 6.2m	Dahej side	Canal crossing
20	RUB Major	90+550	15	3 x 6.2m	Dahej side	Road crossing
21	RUB Major	93+000	2 x 60	3 x 6.2m	Dahej side	Vadodara Mumbai expressway
22	RFO	93+250	60	3 x 6.2m	Dahej side	DFCC 15ABC Railway line crossing
23	Major Bridge	93+650	15	3 x 6.2m	Dahej side	Drain crossing

- **For single track Branch line from Ch: 87+500 of Main line**

Rail loading bridge structures for the single track branch line connecting the Kalpasar link with the existing Delhi-Mumbai mail railway line is shown in Table 2.125.

Table 2.125: Rail Loading Bridge Structures in approaches

S. No.	Bridge classification	Chainage reference (Km)	Tentative clear span (m)	Deck width (m)	Location reference	Remarks
1	Major Bridge	1+800	15	1 x 6.2m	Dahej side	Pipe crossing
2	RUB Major	3+550	20	1 x 6.2m	Dahej side	Road crossing
3	RUB Major	5+600	25	1 x 6.2m	Dahej side	NH Crossing
4	RFO	5+620	20	1 x 6.2m	Dahej side	Railway crossing
5	RUB Major	5+900	2 x 60	1 x 6.2m	Dahej side	Vadodara Mumbai expressway
6	RFO	6+200	60	1 x 6.2m	Dahej side	DFCC 15ABC Railway line crossing
7	RFO	7+000	25	1 x 6.2m	Dahej side	High Speed Railway line crossing

➢ Formation Design

In a general way, collectively refers to the layers comprising blanket, prepared subgrade/Subgrade.

Boundary (interface) between ballast and top of blanket or prepared subgrade/Subgrade (where blanket layer is not provided) is called formation top.

Pressure on Formation and sub-soil:

As good design practice, typical values for the maximum pressure on formation at bottom of ballast should not exceed 0.3MN/m2 or3 kg/cm2, and the pressure on sub-soil should not exceed 0.1MN/m2 or1 kg/cm2 generally.

Top Width of Formation:

It should be adequate to accommodate tracks laid with concrete sleepers and standard ballast section (minimum 35cm depth) and have minimum cess width of 90cm on either side.

Additional Width of formation will have to be provided to cater for increase in extra widening of ballast shoulder and extra clearances required on curves. It shall be regulated/provided in accordance with extant instructions as per the Indian Railway Schedule of Dimensions (IRSOD) &Indian Railway Permanent Way manual (IRPWM).

Cross Slope of Formation:

The top of formation should have a cross slope of 1 in 30 from center of the formation towards both sides for single line/multiple lines in new construction. In case of doubling or multiple line construction works in existing lines, the cross slope of 1 in 30 should continue from the edge of the existing formation towards cess/drain side (single slope) to avoid any stagnation of water between two tracks. However, if the cross slope of existing embankment is steeper than 1 in 30 due to any reason, the configuration of 1 in 30 cross slope shall be maintained in the new line while ensuring proper drainage conditions at the same time to avoid any stagnation of water in between tracks, by adopting appropriate measures as per site conditions.

Erosion Control System:

The design should provide for a suitable and cost-effective erosion control system considering soil matrix, topography, and hydrological conditions.

Borrow Pits:

It will be necessary to keep borrow pits sufficiently away from the toe of the embankments as far as possible at the extreme of Railway land but normally not less than 3m plus the height of the embankment to prevent base failures due to lateral escapement of the soil. Existing borrow pits, close to the toe of bank may be filled or their depth should be taken into account in analyzing slope stability of the bank.

Methods of Formation Rehabilitation:

All formation rehabilitation schemes need to be framed by Railways. Help of an expert may also be taken if required. It is the responsibility of executive authority to ensure that formation rehabilitation work is carried out in accordance with rehabilitation scheme and adequate control is exercised in execution. However, RDSO may also be approached to provide consultancy on weak formation, if required.

In general, following points may be kept in view while planning for rehabilitation:
(A) In developing rehabilitation schemes, stretches having similar soil characteristics and Embankment performance should also be included simultaneously;
(B) Cause(s) of instability of formation should be analyzed and accordingly rehabilitation measures formulated. There may be requirement to re-profiling of slope along with laying the blanket and other measures;
(C) Geo synthetics may also be used along with laying of blanket for formation rehabilitation as an alternative, in consultation with RDSO as required; and
(D) The method of laying of blanket should be appropriate depending on site conditions/requirements.

(e) Structural design

- **Structural design for road bridge superstructure at Flood Regulator**

Structural arrangement of Roadway bridge at Flood regulator is a PSC I-Girder superstructure supported over the wall piers of Flood regulator. 100 Nos. of 22m (EJ to EJ) span is provided for each carriageway. Details of Superstructure along with Cross section & plan are shown in **Figure 2.70** and **Figure 2.71** respectively.

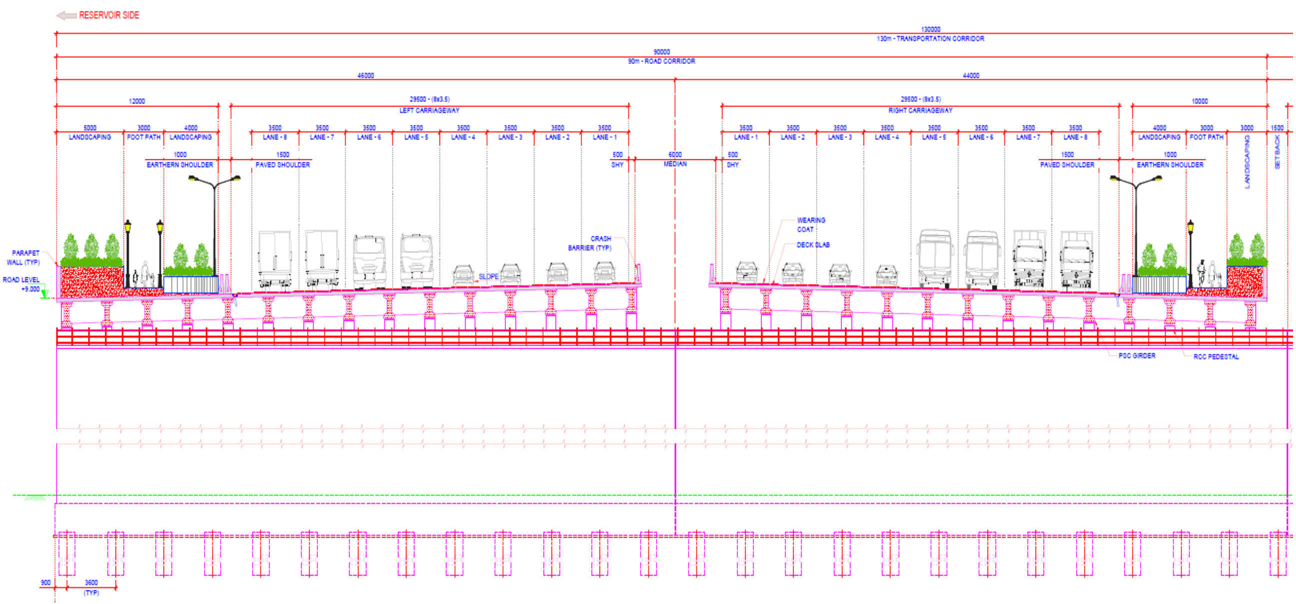


Figure 2.70: Cross section of road bridge **s**uperstructure at Flood regulator

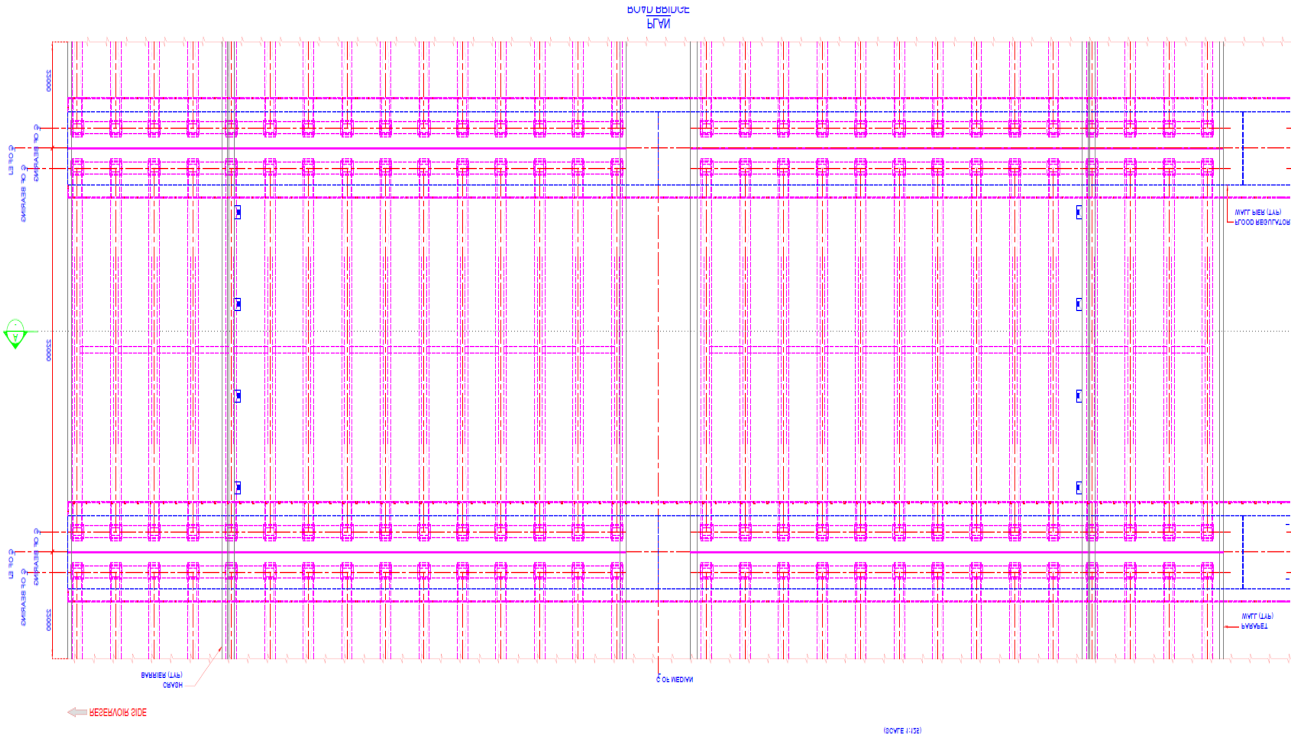


Figure 2.71: Plan of road bridge superstructure at Flood regulator

Individual superstructure is provided for each carriageway. Provision for footpath, MUL and landscaping is also provided in the superstructure. Specifications are as follows:
(1) Left & Right carriageways are provided for roadway traffic. Individual superstructure is provided for each carriageway. Provision for footpath, MUL and landscaping is also provided in the superstructure;
(2) Left carriageway deck slab is supported by 15 No. of PSC Post tensioned I-Girders & Right carriageway deck slab is supported by 14 No. of PSC Post tensioned I-Girders
(3) The Post tensioned I-Girders are precast elements;
(4) Deck slabs & Diaphragm are Cast In-situ elements;
(5) End diaphragms are provided at the two support locations of each span;
(6) Individual span length is 21m (EJ to EJ) considering clear opening between the flood regulator wall as 18m and width of flood regulator wall as 3m;
(7) The Girders are supported by Elastomeric bearings for transferring vertical loads;
(8) The bearings are provided over the pedestal. The pedestal rests over the flood regulator wall piers;
(9) The above structural arrangement has the advantage of casting multiple girders at a time in fabrication yard, carrying out post tensioning and then transporting to site and erecting it. The shuttering for cast In-situ deck slab cab be supported from the erected Girders itself;
(10) Road level considered is +9m, Pier top level is +7m.
(11) The construction depth considered for Superstructure is around 2m, in which PSC I Girder is of 1.4m depth and Deck slab of 0.2m depth.
(12) The PSC I-Girder superstructure is supported on wall piers which is supported over pile foundation;
(13) Width of wall pier considered is 4m. Bed level considered is -7m. Pile cap top level considered is -7.5m. Clear span of 18m is maintained between the adjacent wall piers of flood regulator; and
(14) Piles of 1.2m diameter is considered;

(15) The Design requirements, guidelines & design philosophy is as per the provisions mentioned in design basis section.

Detailed drawings, BOQ & costing details are provided in subsequent sections. The Design requirements, guidelines & design philosophy are explained in design basis section.

- **Details of PSC I-Girder:**

Plan and cross section of the prestressed concrete I-girder for roadway is shown in **Figure 2.72** & **Figure 2.73** respectively.

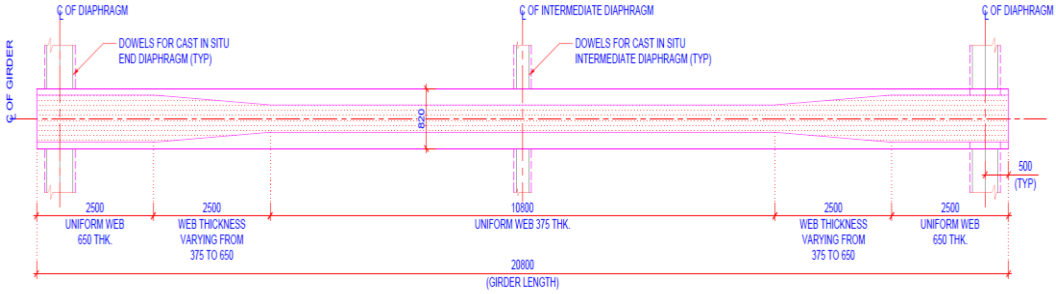


Figure 2.72: Plan of PSC I-Girder

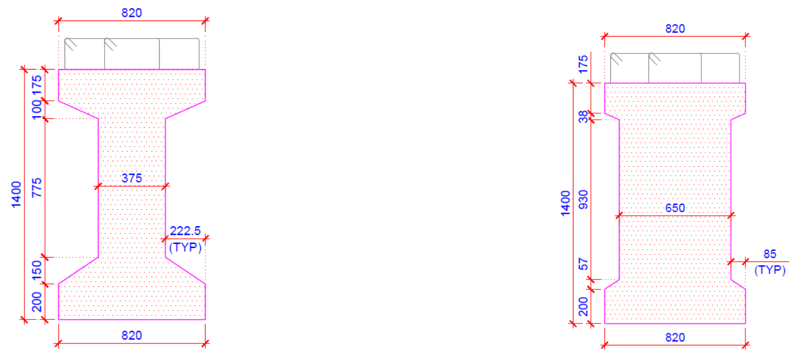


Figure 2.73: Cross section of PSC I-Girder (at Midspan & at Support)

- **Details of Crest Road Superstructure:**

PSC I-Girder superstructure arrangement is proposed for Crest road over the breakwater with deck width of 11.5m and span of 22m (EJ to EJ). The details of the same are presented below:

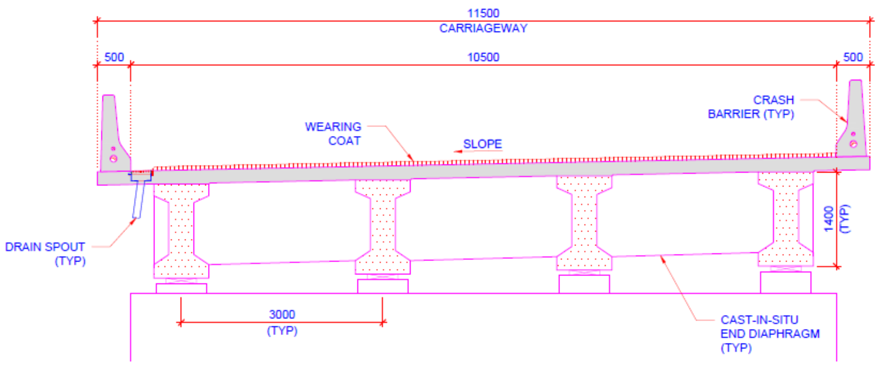


Figure 2.74: Cross section of Crest Road bridge superstructure

- **Details of Substructure supporting roadway superstructure:**

Wall piers of 4m width are proposed to support the Left & Right Main carriageway superstructure. Pile foundation is proposed.

Pier top level = +7m
Bed level = -7m
Pile cap top level = -7.5m

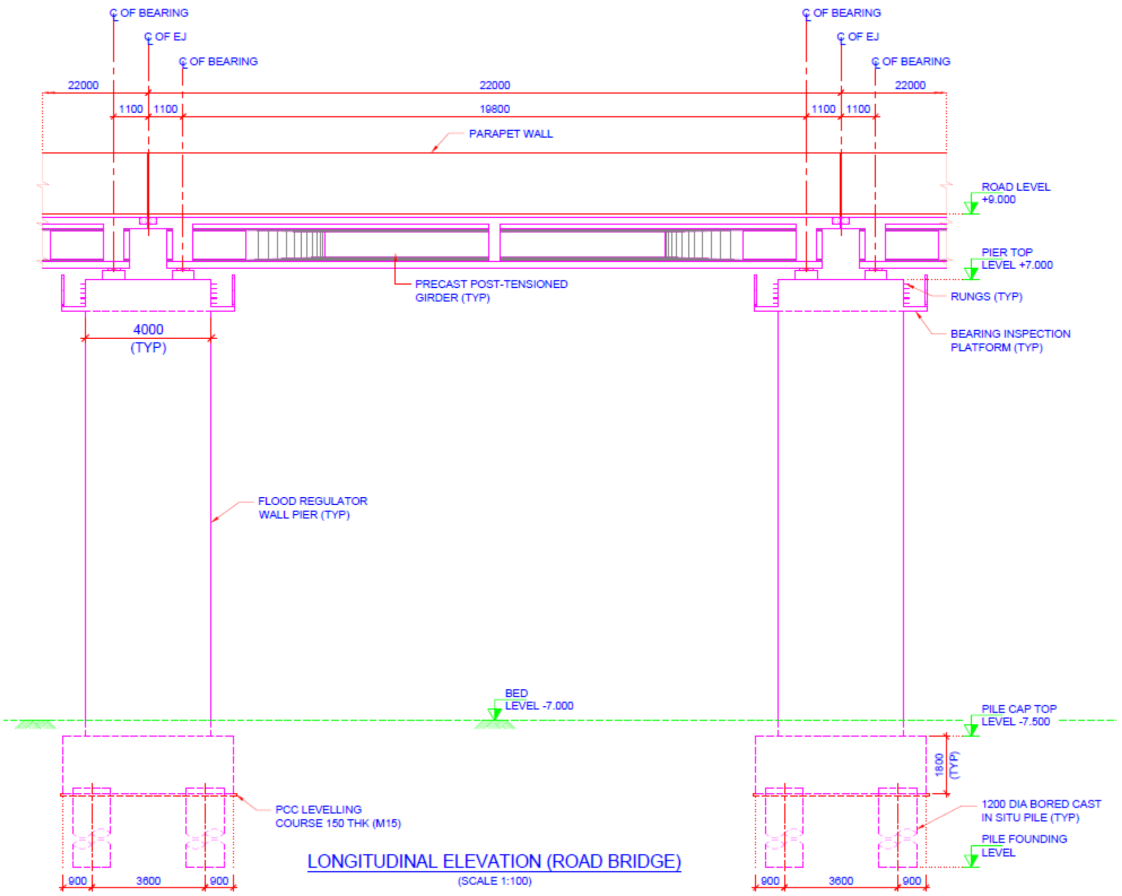


Figure 2.75: Elevation of wall pier supporting roadway superstructure

- **Structural arrangement for rail bridge superstructure in Flood Regulator**

Structural arrangement of Railway bridge at Flood regulator is a PSC I-Girder superstructure supported over the wall piers of Flood regulator. 100 Nos. of 22m (EJ to EJ) span is provided for each track. Details of Superstructure along with cross section & plan are shown in **Figure 2.76** and **Figure 2.77** respectively.

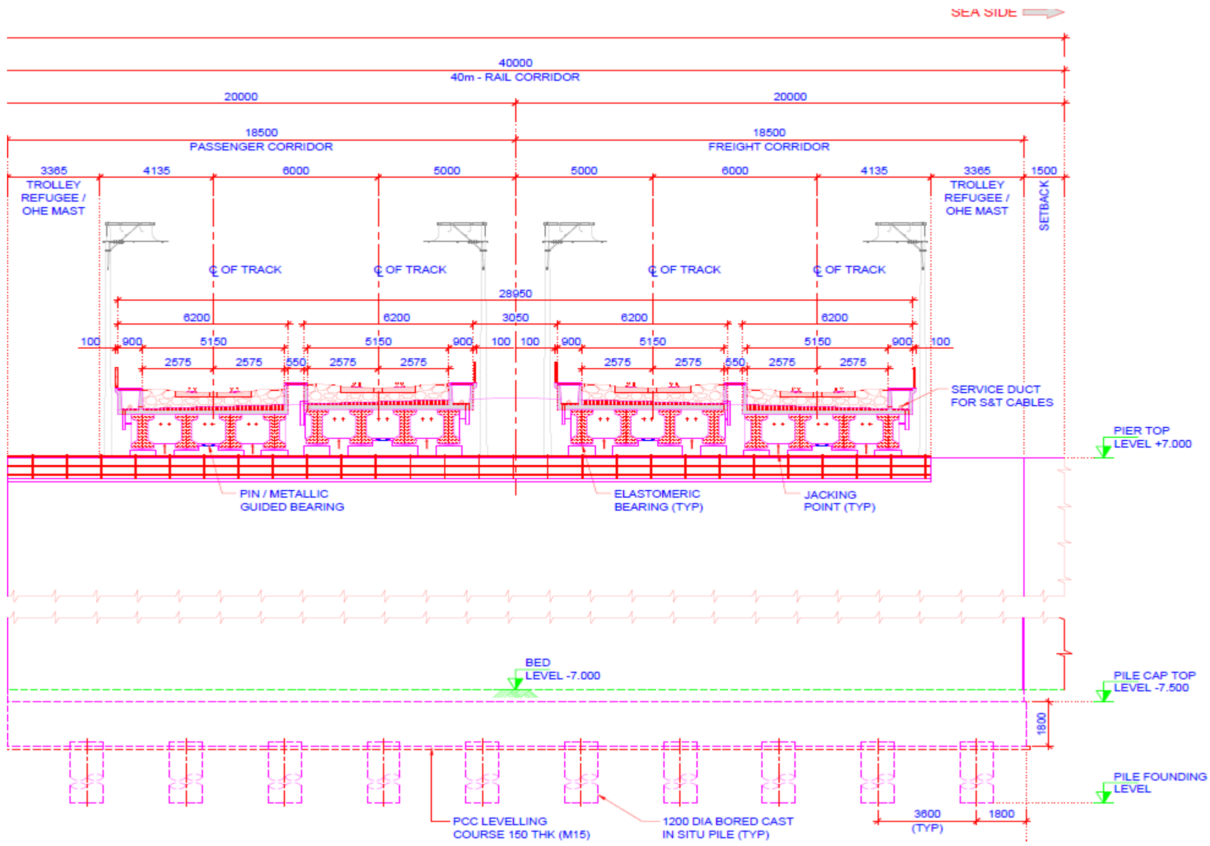


Figure 2.76: Typical Cross section of Rail bridge at Flood regulator

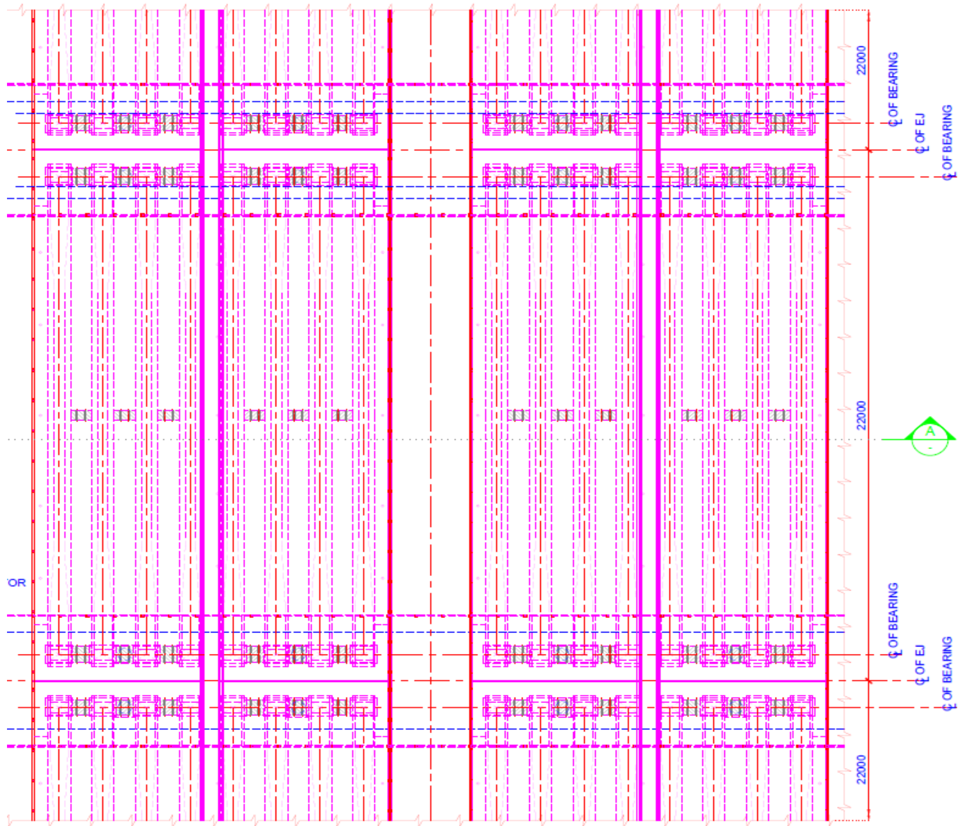


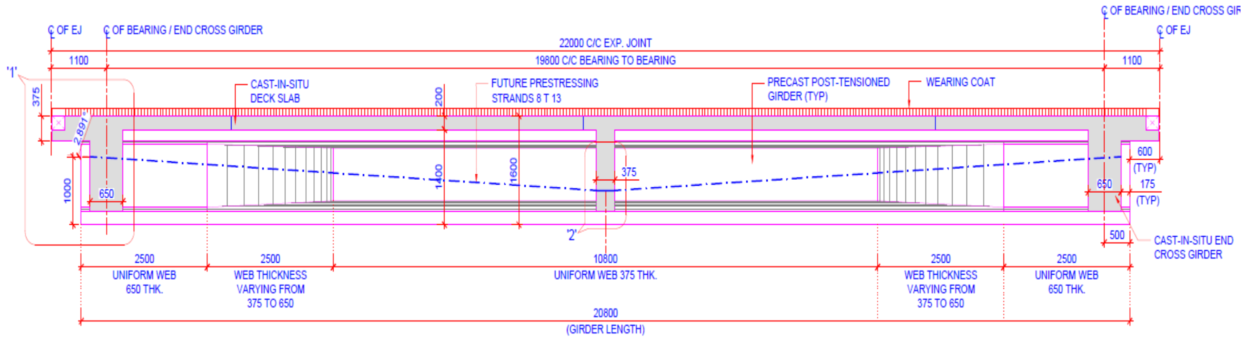
Figure 2.77: Typical Plan of Rail bridge at Flood regulator

Specifications of Railway Super-structure are as follows:
(1) A total of 4 Tracks are proposed for railway line;
(2) Each track is provided with an individual superstructure with deck slab of 6.2m width;
(3) Each deck slab is supported by 4 No. of PSC Post tensioned I-Girders;
(4) The Post tensioned I-Girders are precast elements;
(5) Deck slabs & Diaphragm are Cast In-situ elements;
(6) End diaphragms are provided at the two support locations of each span;
(7) Individual span length is 22m (EJ to EJ) considering clear opening between the flood regulator wall as 18m and width of flood regulator wall as 4m;
(8) The Girders are supported by Elastomeric bearings for transferring vertical loads and Diaphragms are supported by Pin/Guided bearings to provide longitudinal & transverse restraints;
(9) The bearings are provided over the pedestal. The pedestal rests over the flood regulator wall piers;
(10) The above structural arrangement has the advantage of casting multiple girders at a time in fabrication yard, carrying out post tensioning and then transporting to site and erecting it. The shuttering for cast In-situ deck slab cab be supported from the erected Girders itself;
(11) Formation level considered is +9m, Pier top level considered is +7m;
(12) The construction depth considered for Superstructure is around 2m, in which PSC I Girder is of 1.4m depth and Deck slab of 0.2m depth. ;
(13) The PSC I-Girder superstructure is supported on wall piers which is supported over pile foundation;
(14) Width of wall pier considered is 4m. Bed level considered is -7m. Pile cap top level considered is -7.5m. Clear span of 18m is maintained between the adjacent wall piers of flood regulator;
(15) Piles of 1.2m diameter is considered;
(16) The Design requirements, guidelines & design philosophy is as per the provisions mentioned in design basis section; and
(17) Detailed drawings, BOQ & costing details are provided in subsequent sections

The Design requirements, guidelines & design philosophy is explained in design basis section

- **Details of PSC I-Girder:**

Plan and cross section of the prestressed concrete I-girder for railway structure is shown in Figure 2.78



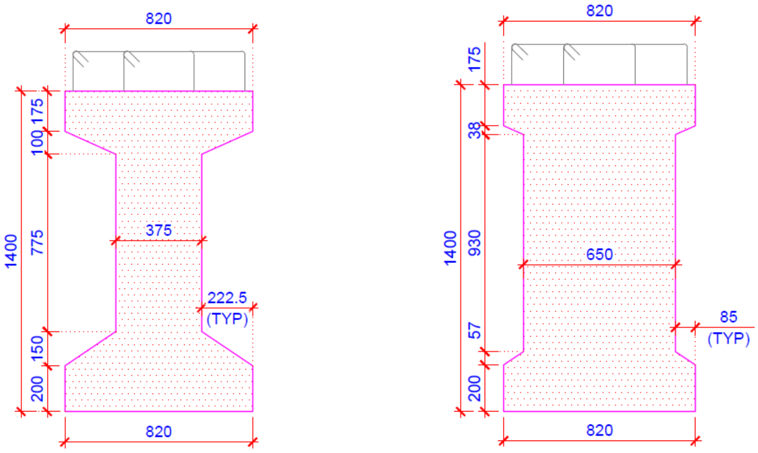


Figure 2.78: Cross section of PSC I-Girder (at Midspan & at Support)

- **Details of Substructure supporting railway superstructure:**

Wall piers of 4m width are proposed to support the railway superstructure. Pile foundation is proposed.

Pier top level = +7m
Bed level = -7m
Pile cap top level = -7.5m

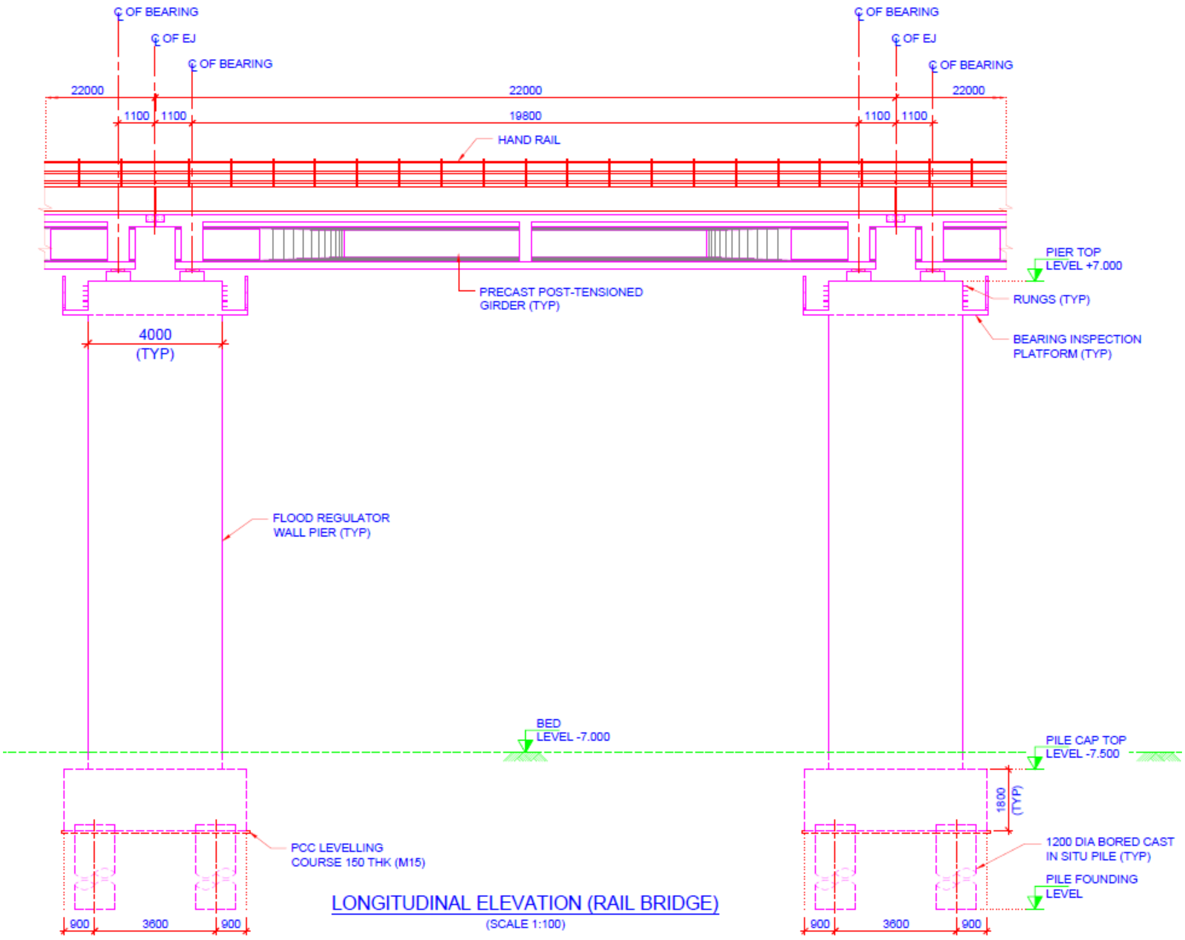


Figure 2.79: Elevation of wall pier supporting railway superstructure

2.3.8 Instrumentation

(a) ITS components

Intelligent Transportation Systems (ITS) is essential tool in managing real-time traffic management and incident management on Kalpasar road link where large traffic volume is required to be handled. There should be institutional arrangement for management of traffic as ITS is only a tool. The broad institutional arrangement is discussed in the following section. The proposed ITS system for Kalpasar road link is presented in below.

ITS facility and equipment is an indispensable component for any major highway project. Accordingly, the ITS shall be installed on viaducts and the Bridge portions on Kalpasar transport corridor from commencement of operation. The typical ITS system for Highways is presented in **Figure 2.80**.

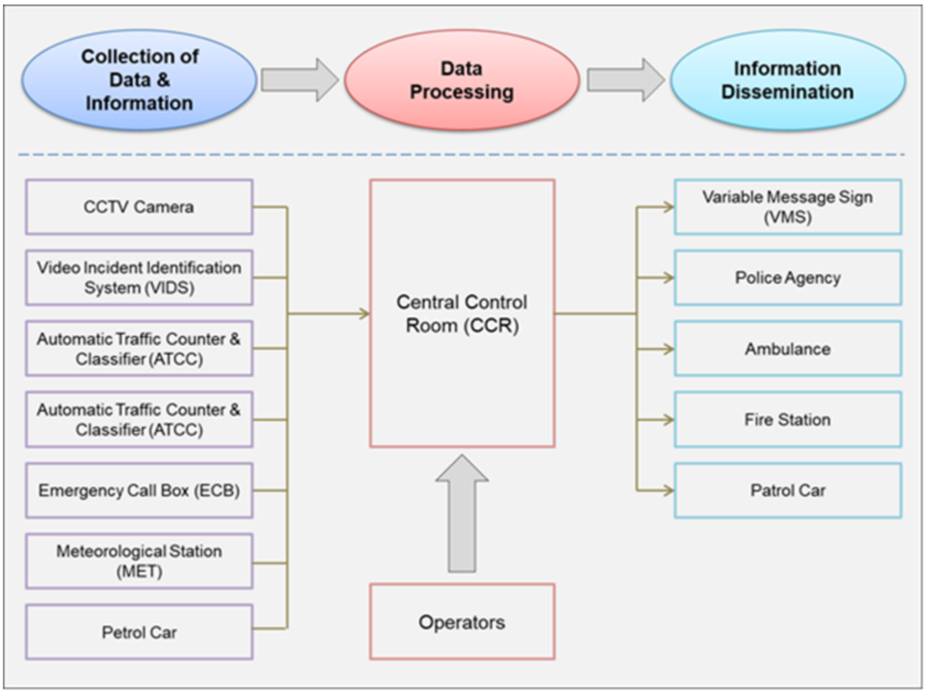


Figure 2.80: Typical ITS system for highways

ITS applications work on principle of information collection, processing and dissemination. The data is collected from instruments such as CCTV, ECB. MET and ATCC. The collected data is transmitted sent to central control room through optical cable which are laid along the transportation corridor. Further processed data is sent back to site to VMS to the road users as well as relevant agencies such as Highway operator (or toll operator such NHAI or state PWD), Traffic Police, Patrol Vehicles, Government and Private Hospitals etc., Highway operator shall maintain Patrol vehicle, Ambulance, towing vehicles, cranes and establish the first aid centres at suitable locations. Along the transport corridor, no hospitals are available, thus there is a need to establish the hospital with trauma care on either end of the project.

Patrol vehicles shall have features such as high-tech mobile surveillance, speed guns, cameras and e-challan machines and vehicle tracking system.

Traffic management usually consists of the following works:

(1) Provision of traffic information to the road users;
(2) Monitoring/surveillance of the traffic conditions;
(3) Regulation or control of traffic in case of emergency, accident and traffic congestion;
(4) Rescue of, or assistance to, broken-down vehicles; and
(5) Clearance of the accident site.

Highway users will be provided with following information:
(1) Accident which has not been cleared;
(2) Vehicle(s) stopping on the carriageway including shoulder;
(3) Any hazardous obstacle on the carriageway;
(4) Closure of the toll road;
(5) Maintenance works and other events occurring on the carriageway, shoulder or adjacent area of the toll road with or without traffic regulation; and
(6) Hazardous weather condition, such as heavy rain

In addition to the above, ambulance service shall be provided. Traffic control is carried out by Traffic Police to enforce the legislations relevant to the road traffic. The activities that fall under the traffic control include the followings:
(1) Regulation of speeds;
(2) Regulation of overtaking;
(3) Regulation of stopping/parking; and
(4) Checking licences, No pollution certificate etc.

The function of various components of ITS is presented in **Table 2.126** and described in subsequent sections.

Table 2.126: ITS components

Component	Function
CCTV	Monitoring of traffic condition, traffic congestion and accidents etc. Operation such as zoom, turning by remote control from the traffic control centre
ATCC (Automatic Traffic Counter-cum-Classifier)	Measurement of traffic volume Classification of vehicle type
Video Incident detection System (VIDS)	Speed of vehicle Incidents such as stoppage of vehicles, illegal parking, accidents, queue formation etc., and should generate automatic alerts
Weigh-in-motion (WIM) based over-weight detection and capture of vehicle information using ANPR	Enforcement of over-loading Judgment of vehicle type
MET (Meteorological Observation System)	Monitoring of weather condition of Kalpasar Dyke Precipitation, fog, wind direction, wind velocity
ECB (Emergency Call Box)	System to enable reporting of incidents to the traffic control centre at the time of first aid in a disaster, trouble, and accidents, etc

VMS (Variable Message Sign)	Dissemination of information such as road condition and weather condition
Patrol Car (Traffic Police and Highway Operator)	Rescue operation for accident/ broken-down vehicle Warning to drivers on hazardous road condition Actions to remove obstacles Repair works of defects of road facilities

- **Closed Circuit Television (CCTV)**

It is a system where all the elements like video camera, display monitors, recording devices are directly connected. It is used for traffic monitoring by detecting congestion and notice accidents. CCTV uses wired or wireless transmission to send the signals or broadcast to the monitor or recording device. It can transmit video, audio or both. Advanced CCTV cameras also have night vision capabilities to record low light images. The CCTV signals are not publicly distributed but are monitored for security purposes.


Closed-Circuit Television (CCTV)

- **Emergency Call Box System** (ECB)

Emergency Call Box System is an end-to-end solution for road-side assistance in case of emergency events. It is a robust communication system that comprises of telephone boxes installed at the highway and connected to a control centre for swift emergency response.

Emergency Call Box (ECB)

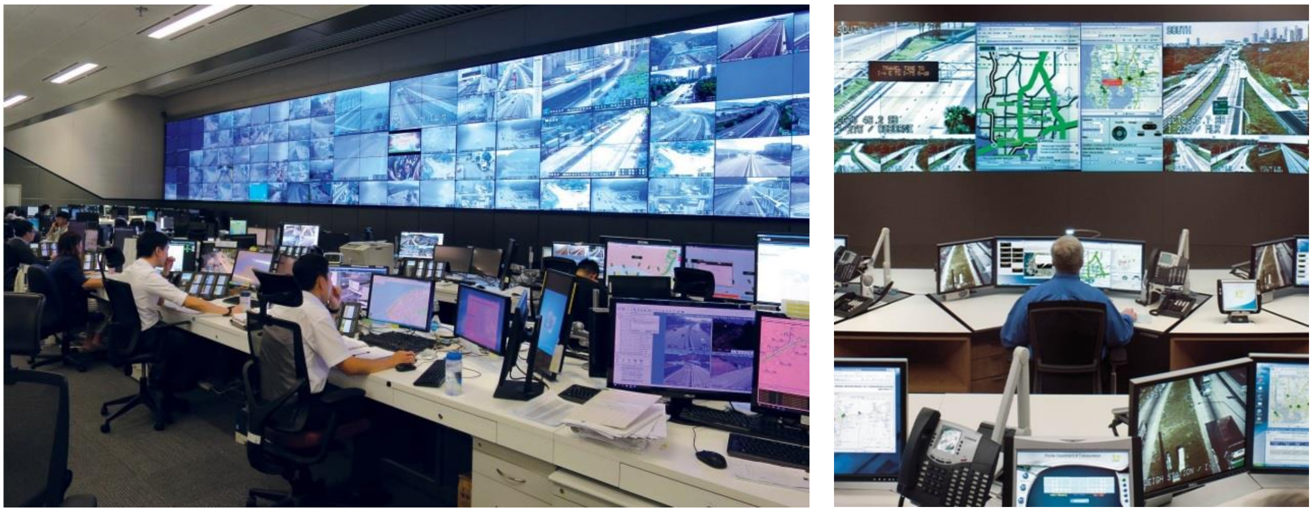
- **Meteorological System (MET)**

Each MET station includes instruments, data collection, and communication equipment required to gather, store, and report data. This data provides status on weather factors affecting power production capability.

Meteorological System (MET)

- **Central Control Room**

Central Control Room will have servers, workstations, secondary storage devices, application software, relevant database, printers, network system, internet services, UPS, and along with trained manpower with IT personals as well personnel from traffic police and highway operator. This will help close co-ordination of traffic police and highway operator.



Central Control Room

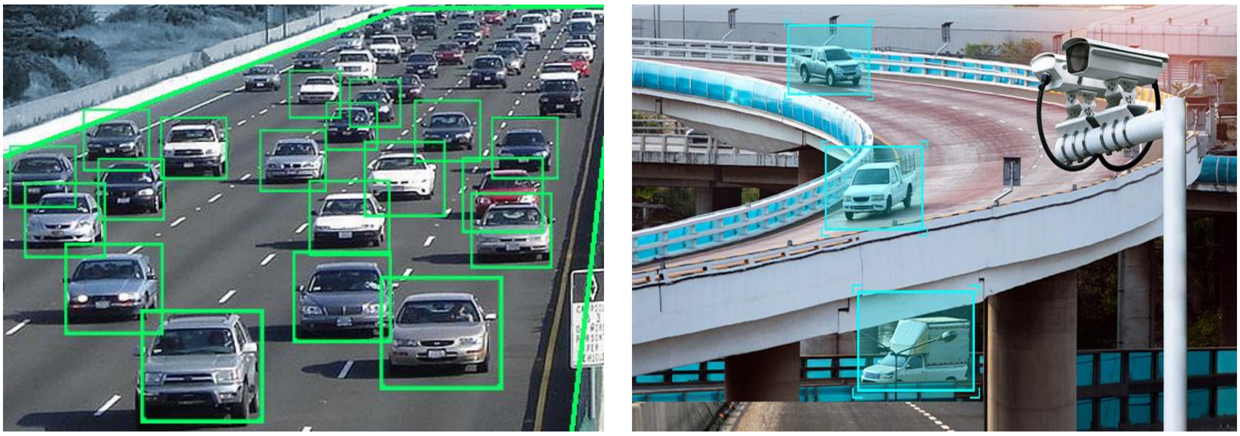
- **Variable Message Service (VMS)**

VMS is installed to disseminate different types of messages at different location in real time. The system should be capable of displaying messages that are sent through control room automatically in real time or as selected by operator of control room. The VMS display may be mounted on sign bridges, cantilevers, or poles. The VMS should be as per guidelines of IRC SP 2009, IRC 67, and IRC 93.

Variable Message Sign (VMS)

➢ **Automatic Traffic Counter and Classifier (ATCC)**

ATCC monitors the real-time traffic flow of a road section; keeps count of vehicles, and classify them according to their pre-defined classes. . To maximize the capacity of city roads as well as highways, continuous vehicle monitoring, counting, and classification efforts need to be carried out to understand seasonal, day-of-the-week, and time-of-the-day traffic volume patterns.



Automatic Traffic Counter and Classifier (ATCC)

➢ **Video Incident Detection System (VDIS)**

An efficient traffic management system depends on how fast incidents are detected, verified, and resolved. Video Incident Detection Systems (VIDS) consists of a network of cameras that automatically detect events and ensure appropriate responses.

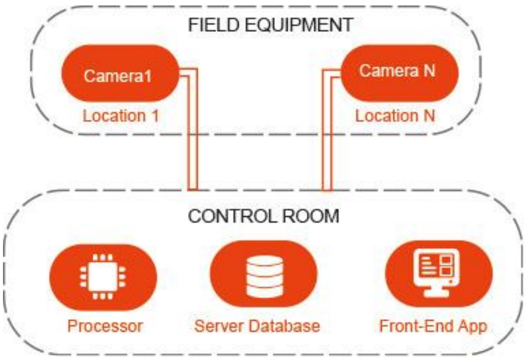
It provides accurate and reliable vehicle tracking with automatic incident detection for highways and expressways. The system helps providing safety on highways and generates e-Challans for violators on roads.

To make our roads safer and ensuring a smooth traffic flow, our VIDS can detect:
(1) Stalled/stopped vehicles;
(2) Vehicles coming from the opposite direction;
(3) Pedestrian crossing;

(4) Over speeding and under speeding;
(5) Crowd gathering;
(6) Weather status like normal conditions, smoke or fog;
(7) Acceleration/deacceleration; and
(8) Traffic status like congestion, dense, delay, stop and go, normal, etc.

The key **features** of the system are as follows:
(1) Monitor traffic density and alert road users;
(2) Automatic detection of traffic flow, congestion, and density;
(3) Easy integration with systems for automatic challan generation (for most violations); and
(4) Alert concerned authorities (police, ambulance, road clearing services, etc.) for immediate actions.

The VIDS cameras mounted on highway structures monitors the respective stretch. Dedicated algorithms monitoring the video signals turn the traffic data into actionable business intelligence. This traffic data is transmitted continuously to the technical control room, unusual activity detected by the system is validated and confirmed, to take required action depending upon the incident type.



- **Over Speed Detection System**
  VIDS can used to detect the over speeding vehicles.

- **Weigh-in-motion (WIM) System**
  For preventing damage to the roads it is important to ensure that the vehicles are not overloaded. The Indian Road Congress gives load and axle load limits for each vehicle. In high and fast traffic areas like the expressways, it is not a very feasible option to use the static weigh bridges (being widely used till now), as using the static weigh bridges means stopping the vehicles for weight measurement thus hampering the free flow of traffic.

The system can be pit type systems based on load cells. Load cells are fitted on a deck structure and embedded into a concrete pit of the road.

A control circuitry installed near the weigh scales stores and analyses the data obtained from the deck. One of the systems currently available in the market can measure the weight of vehicles in motion at a speed of 6-15 kmph, ±3% of gross weight for non-trade applications. This weight information is then used for penalizing overloaded vehicles.

The quantity of various ITS components for Kalpasar road corridor of about 100Km are presented in **Table 2.127**.

Table 2.127: Deployment plan for roadside facilities

S No	System	Equipment	Interval (Km)	Location	Quantity
1	Data Collection	CCTV (On Road)	0.2	Both Direction of Road	1,005
2		Automatic Incident Detection System (VIDS)	0.33	Both Direction of Road	610
3		Emergency Call Box (ECB)	2	Both Direction of Road	102
4		Meteorological Station (MET)	7	Both Direction of Road	9
5		Automatic Traffic Counter cum Classifier (ATCC)		At Entry Points	7
6		Automatic Speed Detection System	2	Both Direction of Road	409
7		Automatic Number Plate Detection (ANPR)	2	Both Direction of Road	409
8		Weight In Motion Detection System		At Entry Points	16
9		Height Detection System		At Entry Points	16
10	Processing and Monitoring	Central Control Room		At One End	1
14	Data Dissemination	Variable Message Sign (VMS)	10	At entry point and over the Dyke	22
16	Transmission	Optical Fibre Cable	4 Cables	Whole Length (m)	4,01,200
17		Power Cable	4 Cables	Whole Length (m)	4,01,200

(b) Toll systems

Currently, tolling on national highways based on FASTag supplied and deployed by the Indian Highways Management Company Ltd. (IHMCL). FASTag was introduced in 2016 and made compulsory in February 2021 reaching 30 M users in March 2021. Around, 97% of vehicles in India pay toll using FASTag. FASTag, however, has one major limitation. It is not 100 % seamless. For the RFID tag to be scanned and electronic payment to be made, vehicles still need to stop at toll gates, even though for seconds.

In order to improve the toll collection process, Government of India plans to introduce the **GNSS technology based tolling system** or **Automatic Number Plate Reader (ANPR) cameras**. This is expected to improve the toll collection and improve the traffic management. The description of these systems is presented in the following section.

➢ **GNSS Technology based Tolling System**

Under the global positioning technology-based electronic toll collection, virtual gantries (a virtual road charging point equivalent to a traditional road charging toll gantry) monitor the entry and exit of vehicles on the tolled section. There is no toll collection booth or physical gantries mounted with high resolution cameras to scan the vehicles passing underneath them, registering their tags and registration numbers. Instead, vehicles will be equipped with an on-board global positioning device. Users' bank account and vehicle details, including registration number and type of vehicle, will be seeded into the device. While using the toll road network, the on-board unit autonomously determines the position of the vehicle by using a Global Navigation Satellite System (GNSS). GNSS essentially refers to a satellite or a constellation of satellites that provides positioning navigation and timing (PNT) services. Once the toll section is identified, the on-board global positioning device begins a fully automated tolling process. The vehicle movement data is transmitted by the vehicle mounted unit to the back office of the service provider. The back office, in turn, determines the toll charges to be deducted based on parameters, including the distance of the tolled section used and the type of the vehicle, among others. For rolling out satellite-based tolling, India will soon start the process of geo fencing of the entire National Highway network in the country.

In Europe, is GNSS-based toll collection systems is successfully implemented such as the Stockholm congestion tax, the Austrian truck toll, the German Toll Collect, the toll system in Slovakia or the French Eco-tax. Each European GNSS-based tolling system has a compliance (payment) rate above 98% or 99%. The illustration of GNSS based toll collection for trucks (in Germany) are shown **Figure 2.81**.

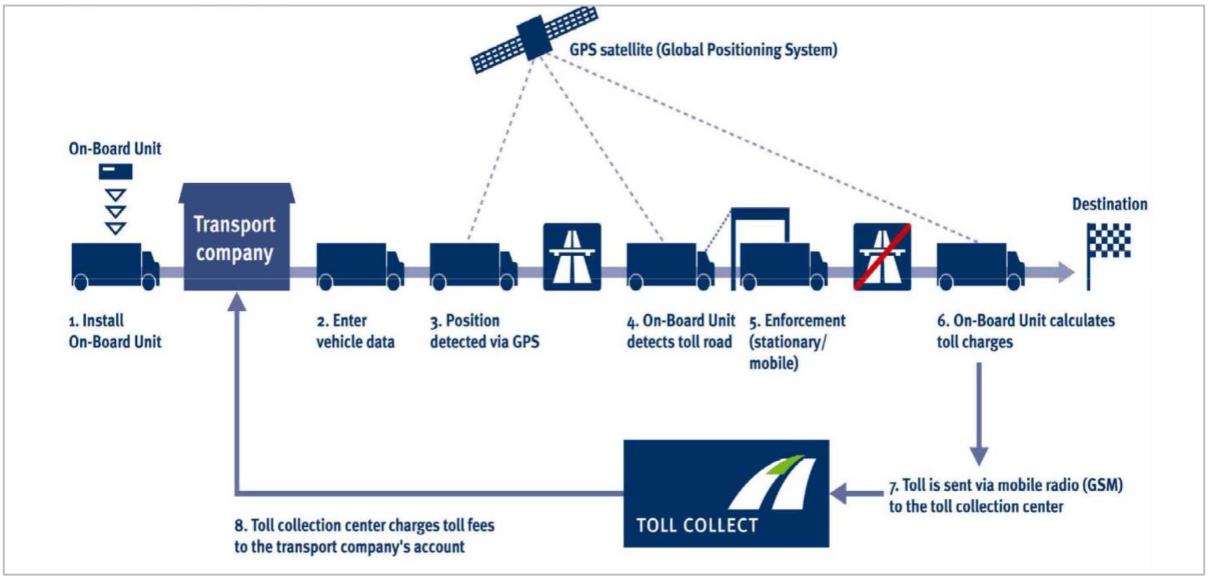


Figure 2.81: GNSS based toll collection (in Germany)

GNSS-based tolling can have many advantages compared to electronic toll collection systems currently in place in India. It will save time for passengers and cargo consignments as neither will they have to wait in long queues, nor will they have to stop at every toll booth. They can make payments at once through online platforms GNSS-based systems make a greater variety of charging schemes technically feasible; systems can be more easily expanded and scaled-up with low investment and the OBUs installed on vehicles for the use of GNSS can be used for additional value-added services to the end-users. However, such systems also bear their own challenges related to accuracy, privacy, and standardisation. In

India, while all new commercial vehicles are coming with vehicle tracking systems, the Government will need to come up with some plan to install GNSS technology in old vehicles which will have a widespread effect.

GNSS technology based tolling system is suggested for Kalpasar Project due to many advantages such as no need of physical toll plaza, unhindered movement of traffic and ease of tolling etc.

- **Automatic Number Plate Reader (ANPR) Cameras**

Recently, union ministry of road transport and highways has planned to remove all the toll plazas on the national highways and introduce Automatic Number Plate Reader (ANPR) cameras to reduce congestion at the toll plazas.

Automatic Number Plate Reader (ANPR) cameras will read vehicle number plates and automatically deduct toll from the linked bank accounts of vehicle owners. Entry and exit of toll roads will have cameras capable of reading number plates. At present not all number plates in India can be read, and only those that have come after 2019 will be registered by the cameras. The government, in 2019, had come up with a rule mandating passenger vehicle to have company-fitted number plates, and only these number plates can be read by cameras.

Issues with Automatic Number Plate Reader (ANPR): The success of ANPR cameras will depend on creating an ecosystem that is in sync with the requirements of the camera. The biggest issue during the trials is when things other than the nine-digit registration number are written on number plates, such as 'Govt of India/Delhi'. There is a difficulty in reading number plates on trucks, as most of the time they are hidden or soiled.

To conclude, physical toll plazas will be defunct in future. Either, GNSS technology based tolling system or automatic number plate reader (ANPR) cameras will be used for toll collection and therefore, physical toll plazas are not considered in the report.

(c) Security systems

As per the requirement from security perspective, there shall be provision of physical checking or screening of vehicles (in certain situations). The plan of the proposed security area is presented in **Figure 2.82**.

This should ideally be carried out at the interchange locations. However, since it is very difficult to get the huge land parcel, it is suggested that security hold area can be planned in inter-tidal zone where sufficient land is available. In view of the above, suitable ramps can be planned so that vehicles can be diverted to security hold area and can merge with access roads once checking is completed.

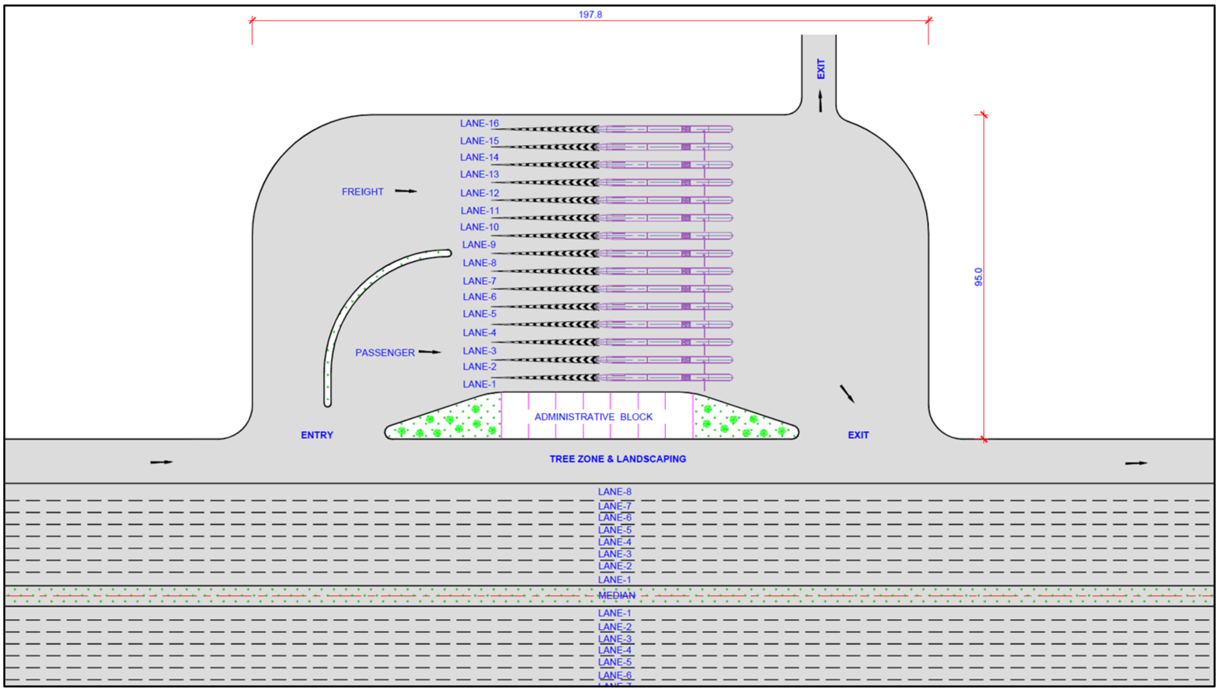


Figure 2.82: Plan of proposed security area in Kalpasar

2.3.9 Construction

(a) Kalpasar project materials

Detailed description and specification of various construction materials of road and rail is given in sub-section 2.3.14 (a).

(b) Formations

Formation comprises of Blanket and, Prepared subgrade/Subgrade. Depending upon techno-economic considerations, it can be Single layer or Two-layer construction as shown in Fig-3.1 & 3.2 below. For construction of a new line, it is important to ensure that the track bed layers (Blanket/Prepared subgrade/Subgrade) have the appropriate mechanical characteristics and are of adequate thickness.

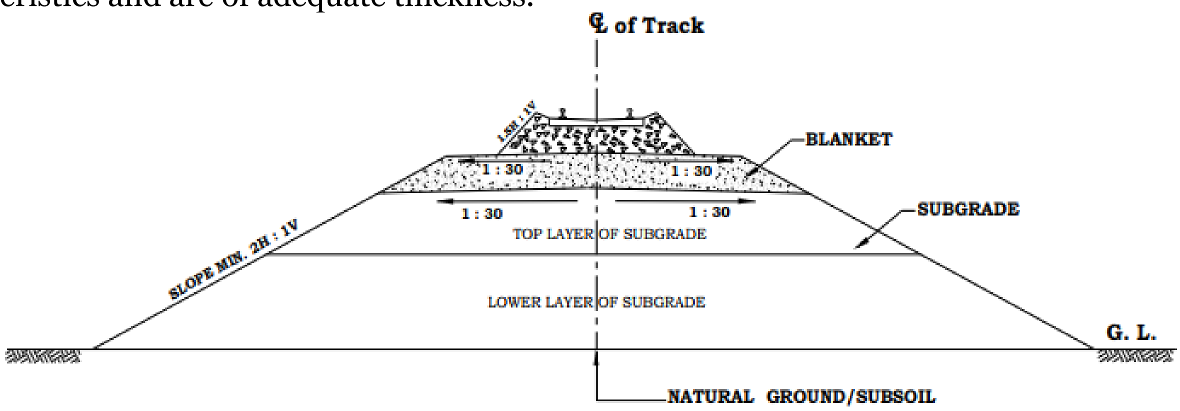


Figure 2.83: Single layer formation

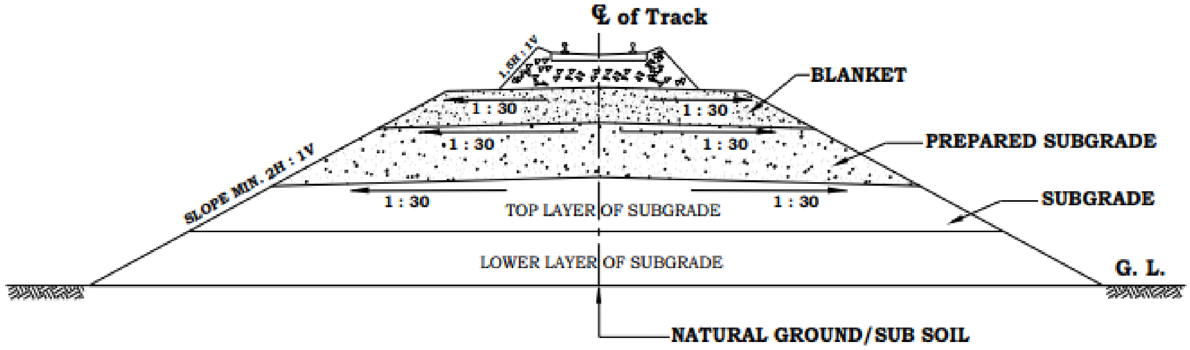


Figure 2.84: Double layer formation

Specifications and Thickness of Formation Layers:

(A) The Railway Formation may be constructed with a Single Layer System or Two Layer System based on the availability of local soils/materials and economic considerations. The thickness of the prepared sub-grade and blanket layer has been rationalized based on UIC-719 calculation for ballast cushion of 350mm. The specifications and thickness of Blanket layer, Prepared subgrade, Subgrade;

(B) (Top Layer & Lower layer) and Sub-Soil are tabulated for Single layer system and Two-layer system for 25T and 32.5T Axle load as below:-

Table 2.128: For 25T Axle Load

S. No.	**Soil type Category in Sub-grade**	**Prepared Sub-grade**		**Recommended Blanket Thickness (mm)**	**Remarks**
		Soil Type	Thickness (mm)		
1.	SQ1	SQ1*	--	550	Single layer
2.	SQ1	SQ2	500	400	Two layer
3.	SQ1	SQ3	500	300	Two layer
4.	SQ2	SQ2*	--	400	Single layer
5.	SQ2	SQ3	350	300	Two layer
6.	SQ3	SQ3*	--	300	Single layer

Table-3.2: For 32.5 T Axle Load

S. No.	**Soil type Category in Sub-grade**	**Prepared Sub-grade**		**Recommended Blanket Thickness (mm)**	**Remarks**
		Soil Type	Thickness (mm)		
1.	SQ1	SQ1*	--	700	Single layer
2.	SQ1	SQ2	500	550	Two layer
3.	SQ1	SQ3	500	450	Two layer
4.	SQ2	SQ2*	--	550	Single layer
5.	SQ2	SQ3	350	450	Two layer
6.	SQ3	SQ3*	--	450	Single layer

(C) Formation for 25T axle load

Table 3.3: Specification and Thickness of Formation Layers for 25T axle load: Single layer system

Layers	Specification	Thickness
Blanket	i) CU> 7 and CC between 1 and 3. ii) Fines (passing 75 microns) : 3% to 10% iii) Minimum soakedCBRvalue ≥25, (Soil compacted at 100% of MDD * in Lab) iv) Los Angeles Abrasion value < 40% v) Field Compaction: Min. 100% of MDD * in field trial vi) Minimum Ev2 **= 100 MPa vii) Size gradation – within a specified range or should lie more or less within enveloping curves viii) Filter criteria (***Optional) should be satisfied with sub-grade layer as given below: Criteria-1: D15 (blanket) < 5x D85 (sub-grade) Criteria-2: D15 (blanket) > 4 to 5x D15 (sub-Grade) Criteria-3: D50 (blanket) < 25x D50 (sub-grade)	**30 cm** over SQ3 sub-grade **40 cm** over SQ2 sub-grade **55 cm** over SQ1 sub-grade
Sub-grade Top Layer	SQ1/SQ2/SQ3 soil SQ1 soils (To be used only with dispensation of PCE/ CAO) i)For SQ2/SQ3 soil, CBR ≥6 (soil compacted at ii)98% of MDD *) iii)For SQ1 soil, CBR ≥4 (soil compacted at iv)98% of MDD *) v)Field Compaction:Min. 98% of MDD * vi)Minimum Ev2 = 45 MPa (for SQ1) vii)60 MPa (for SQ2/SQ3)	100 cm
Lower layer (fill)	SQ1/SQ2/SQ3 soil (+) i) CBR≥ 3 (soil compacted at 97% of MDD *) ii) Field Compaction: Min. 97% of MDD *	As per Embankment height
Ground soil/sub-strata	i) Undrained Cohesion of soil (cu) >25 KPa (only for soils having particles finer than 75 micron exceeding 12%) ii) Ev2 (determined from PLT) ≥ 20 MPa N (determined from SPT) ≥ 5 Ground Improvement is required if any of the above parameters are not complied with	--

Table 3.4:Specification and Thickness of Formation Layers for 25T axle load: Two layer system

Layers	**Specification**	**Thickness**
Blanket	i)CU> 7 and CC between 1 and 3. ii)Fines (passing 75 microns) : 3% to 10% iii)Los Angeles Abrasion value < 40% iv)Minimum soakedCBRvalue≥ 25, (Soil compacted at 100% of MDD * in Lab) v)Field compaction: 100% of MDD* in field trial vi)Minimum Ev2 **= 100 MPa vii)Size gradation – within a specified range or should lie more or less within enveloping curves viii)Filter criteria (***Optional) should be satisfied with prepared sub-grade layer as given below: Criteria-1: D15 (blanket)<5x D85 (prepared sub-grade) Criteria-2: D15 (blanket) > 4 to 5x D15 (prepared sub-grade) Criteria-3: D50 (blanket) < 25x D50 (prepared sub-grade)	**30 cm** over SQ3 Prepared Sub-grade **40 cm** over SQ2 Prepared Sub-grade
Prepared Subgrade	SQ2/SQ3 i)CBR >8 (soil compacted up to 98% of MDD) ii)Plasticity index <12 iii)Field Compaction: Min. 98% of MDD * Minimum Ev2 = 60 MPa	**50 cm** over SQ1 fill **35 cm** over SQ2 fill
Subgrade Top Layer	SQ1/SQ2/SQ3 (SQ1 soils (To be used only with dispensation of PCE/ CAO) i) CBR ≥ 5 (soil compacted at 97% of MDD *) for SQ2/SQ3 soils ii)For SQ1 soil, CBR ≥ 4 (soil compacted at 97% of MDD *) iii)Field Compaction:Min. 97% of MDD *	50 cm

Layers	Specification	Thickness
Lower layer (fill)	iv)Minimum Ev2 =30 MPa (for SQ1) 45 MPa (for SQ2/SQ3) SQ1/SQ2/SQ3 soil (+) i) CBR≥ 3(soil compacted at 97% of MDD *) ii) Field Compaction: Min. 97% of MDD *	As per Embankment height
Ground Soil/Sub-soil Strata	i)Undrained Cohesion of soil (cu) ᪲ 25 K3D (RQO\ IRU soils having particles finer than 75 micron exceeding 12%) ii)Ev2 (determined from PLT) ≥ 20 MPa iii)N (determined from SPT) ≥ 5 Ground Improvement is required if any of the above parameters are not complied with	--

(D) Formation for 32.5T Axle load

Table 3.5:Specification and Thickness of Formation Layers for 32.5T axle load: Single layer system

Layers	Specification	Thickness
Blanket	i)CU> 7 and CC between 1 and 3 ii)Fines (passing 75 microns) : 3% to 10% iii)Size gradation within a specific range or should lie within enveloping curves iv)Los Angeles abrasion value < 40% v)Minimum CBR value >25 vi)Field Compaction: Min. 100% of MDD * in field trial	**45 cm** over SQ3 sub- grade **55 cm** over SQ2 sub- grade **70 cm** over SQ1 sub- grade

Layers	**Specification**	**Thickness**
Subgrade Top Layer Lower layer (fill)	SQ1/SQ2/SQ3 soil (SQ1 soils (To be used only with dispensation of PCE/ CAO) i)CBR > 6 for SQ2/SQ3 soil compacted AT 98% of MDD ii)CBR > 6 for SQ1 soil compacted AT 98% of MDD iii)Field Compaction: Min. 98% of MDD* iv)Minimum Ev2 ** = 45 MPa (for SQ1 soil) v)60 MPa (for SQ2/SQ3) SQ1/SQ2/SQ3 soil (+) i) CBR > 3 (soil compacted at 97% of MDD) ii) Field Compaction: min 97% of MDD*	100 cm As per Embankment height
Ground Soil/Sub-soil	i) Undrained Cohesion of soil (cu) >25 KPa (only for soils having particles finer than 75 micron exceeding 12%) ii) Ev2 (determined from PLT) ≥ 20 MPa iii) N (determined from SPT) ≥ 5 Ground Improvement is required if any of the above parameters are not complied with	--

Table 3.6:Specification and Thickness of Formation Layers for 32.5T axle load: Two layer system

Layers	**Specification**	**Thickness**
Blanket	i)CU> 7 and CC between 1 and 3. ii)Finnes (passing 75 microns) :3% to 10% iii)Size gradation – within the specified range as given in Table 3.7or should lie within enveloping curves as given in Fig. 3.8 iv)Los Angeles Abrasion value< 40% v)Minimum soaked CBR value ≥ 25 (Soil Compacted at 100% of MDD* in Lab.) vi)Field Compaction: 100% of MDD* in field trial vii)Minimum EV2 ** = 120MPa	**45cm** over SQ3 prepared subgrade **55cm** over SQ2 prepared subgrade

Layers	Specification	Thickness
	Filter Criteria (***Optional) should be satisfied with subgrade layer, as given below: Criteria–1: D15 (blanket) < D85 (prepared sub-grade) Criteria–2: D15(blanket) >4 to 5x D15 (prepared sub-grade) Criteria–3: D50(blanket) <25x D50 (prepared sub-grade)	
Prepared Subgrade	SQ2/SQ3 CBR >8 (soil compacted up to 98% of MDD) Plasticity index <12 Field Compaction: Min. 98% of MDD * Minimum Ev2 = 60 MPa	**50 cm** over SQ1 fill **35 cm** over SQ2 fill
Subgrade Top layer	SQ1/SQ2/SQ3 Soil (SQ1 soils (To be used only with dispensation of PCE/ CAO) i)CBR > 5 for SQ2/SQ3 soil compacted AT 97% of MDD ii)CBR >46 for SQ1 soil compacted AT 97% of MDD iii) Field Compaction: Min. 97% of MDD* iv) Minimum Ev2** = 30 MPa (for SQ1 soil) 45 MPa (for SQ2/SQ3) SQ1/SQ2/SQ3 Soil (+)	50 cm
Lower layer (fill)	i)CBR > 3 (soil compacted at 97% of MDD) ii)Field Compaction: min 97% of MDD*	As per Embankment height
Ground Soil/Sub-soil Strata	i) Undrained Cohesion of soil (cu) >25 KPa (only for soils having particles finer than 75 micron exceeding 12%) ii) Ev2 (determined from PLT) ≥ 20 MPa iii) N (determined from SPT) ≥ 5 Ground Improvement is required if any of the above parameters are not complied with	--

Height of Embankment and Formation Layer thickness:

The minimum height of the embankment above ground level or highest flood level (HFL) whichever is higher should not be less than one meter to ensure proper drainage and avoid trespassing.

Total required thickness of formation layers for blanket, prepared sub-grade &Subgrade-Top Layer, should be provided/ensured uniformly in embankment/cutting for effective stress dispersal.

The specification of soil strata below the ground level (GL) must be ascertained from the results of soil exploration.

For effective stress dispersal, required total uniform thickness of formation layer (Blanket, Prepared sub-grade &Subgrade/Top Layer) shall be ensured in cuttings as well as in embankments, even where embankment height is less than about 1.5m or total uniform required thickness.

It is further explained below:

For Embankment: Where the height of embankment is less than required total uniform thickness): If the specification of sub-soil meets the required specification of blanket/prepared subgrade/subgrade-top layer, up to required total depth of uniform thickness below ground level, then there will be no need of excavation, else the excavations will be done below ground level as per the requirement, to satisfy the provision of total uniform thickness for effective stress dispersal.

For Cutting: If the specification of sub-soil does not meet the required specification of blanket/prepared subgrade/subgrade-top layer i.e. total required uniform thickness, below the proposed level of excavation in cuttings, the excavation level for cuttings shall be enhanced to the level so as to satisfy the total required uniform thickness requirement.

(c) Road and Bridges (Approaches, and flood regulator)

- **Construction Sequence of Roads**

Emabankment/ Subgrade Construction

The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material as approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment. The following types of material shall be considered unsuitable for embankment:
a) Materials from swamps, marshes and bogs;
b) Peat, log, stump and perishable material; any soil that classifies as OL, OI, OH or Pt in accordance with IS: 1498;
c) Materials susceptible to spontaneous combustion;
d) Materials in a frozen condition;
e) Clay having liquid limit exceeding 50 and plasticity index exceeding 25; and
f) Materials with salts resulting in leaching in the embankment.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when placed in the embankment and 50 mm when placed in the sub-grade. However, the Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size in such cases, however, shall not be more than two-thirds of the compacted layer thickness.

The material to be used in subgrade shall conform to the design CBR value at the specified dry density and moisture content of the test specimen. In case the available materials fails to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 of MORT&H specifications or by any stabilization method approved by the Engineer or by the IRC Accreditation Committee shall be followed.

Granular Sub-Base

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

The material to be used for the work shall be natural sand, crushed gravel, rushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. Gradings III and IV shall preferably be used in lower sub-base. Grading V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm. Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 of MORT&H specifications as applicable shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water, if necessary and rolled with two passes of 80–100 kN smooth wheeled roller.

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS: 2720 (Part 8). The mix shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation, or other means as approved by the Engineer.

Wet Mix Macadam Sub-Base/Base

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-grade/sub-base/ base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer. The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be up to 200 mm with the approval of the Engineer.

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set.

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement like pug mill or pan type mixer of concrete batching plant. The plant shall have following features:
i) For feeding aggregates– three/ four bin feeders with variable speed motor;
ii) Vibrating screen for removal of oversize aggregates;
iii) Conveyor Belt;
iv) Controlled system for addition of water;
v) Forced/positive mixing arrangement like pug-mill or pan type mixer;
vi) Centralized control panel for sequential operation of various devices and precise process control; and
vii) Safety devices.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22.4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. In no case shall there be dumped in heaps directly on the area where these are not to be laid nor shall their hauling over a partly completed stretch be permitted. The mix may be spread by a paver finisher.

The paver finisher shall be self-propelled of adequate capacity with following features:
i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed;
ii) Hydraulically operated telescopic screed for paving width up to to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer; and
iii) Automatic levelling control system with electronic sensing device to maintain.

Prime Coat over Granular Base

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix. The work shall be carried out on a previously prepared granular/ stabilized surface.

The primer shall be cationic bitumen emulsion SS1 grade conforming to IS: 8887 or medium curing cutback bitumen conforming to IS: 217 or as specified in the Contract.

The correct quantity of primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10 mm.

Primer shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 100C. Cutback bitumen as primer shall not be applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

The primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose material and other foreign material shall be removed completely. If soil/ moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

After preparation of the road surface as per Clause 502.4.2, the primer shall be sprayed uniformly at the specified rate. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiles to evaporate before any subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

Tack Coat

The work shall consist of the application of a single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or as instructed by the Engineer.

The binder used for tack coat shall be either Cationic bitumen emulsion (RS 1) complying with IS:8887 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC:70 as per IS:217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be as specified in the Contract or as directed by the Engineer.

Bituminous material shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

The tack coat shall be applied by a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying shall not be permitted except in small areas, inaccessible to the distributor, or narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and any extraneous material, and be otherwise prepared in accordance with the requirements of Clauses 501.8. The granular or stabilized surfaces shall be primed as per Clause 502. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high pressure air jet, or by other means as directed by the Engineer.

No dilution or heating at site of RS1 bitumen emulsion shall be permitted. Paving bitumen if used for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2 poise. The normal range of spraying temperature for a bituminous emulsion shall be 20°C to 70°C and for cutback, 50°C to 80°C. The method of application of tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed or forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

The tack coat shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

Dense Bituminous Macadam

The specification describes the design and construction procedure for Dense Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS:73, modified bitumen complying with Clause 501.2.1 in MORT&H technical specifications or as otherwise specified in the Contract.

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates has poor affinity for bitumen, the Contractor shall produce test results that with the use of anti-stripping agents, the stripping value is improved to satisfy the specification requirements. The Engineer may approve such a source and as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, at the cost of the Contractor.

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses.

The bitumen content required shall be determined following the Marshall mix design procedure contained in Asphalt Institute Manual MS–2. The Fines to Bitumen (F/B) ratio by weight of total mix shall range from 0.6 to 1.2. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2. Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS-2 and ASTM D 5581 shall be used.

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the following details:
i) Source and location of all materials;
ii) Proportions of all materials expressed as follows:
a) Binder type, and percentage by weight of total mix;
b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
iii) A single definite percentage passing each sieve for the mixed aggregate;
iv) The individual grading of the individual aggregate fraction, and the proportion of each in the combined grading;
v) The results of mix design such as maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test;
vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch;
vii) Test results of physical characteristics of aggregates to be used; and
viii) Mixing temperature and compacting temperature.

In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

The general provisions of Clauses 501.6 and 501.7 in MORT&H technical specifications shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing. It shall be ensured that the traffic is not allowed without the approval of the Engineer in writing, on the surface until the dense bituminous layer has cooled to the ambient temperature.

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tonnes or by the square metre at a specified thickness as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

Bituminous Concrete

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

Dry Lean Cement Concrete Sub-Base

The work shall consist of construction of (zero slump) dry lean concrete sub-base for cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer. The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the drawings.

The Contractor shall indicate to the Engineer the source of all materials with relevant test data to be used in the dry lean concrete work sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work in trial length. If the Contractor later proposes to obtain the materials from a different source during the execution of main work, he shall notify the Engineer with relevant test data for his approval at least 45 days before such materials are to be used.

If the subgrade soil contains soluble sulphates in a concentration more than 0.5 percent, sulphate resistant cement conforming to IS: 6909 shall be used. Cement to be used may preferably be obtained in bulk form. It shall be stored in accordance with stipulations contained in Clause 1014 and shall be subjected to acceptance test prior to its immediate use.

Fly-ash upto 20 percent by weight of cementitious material (cement+flyash) may be used along with 43/53 grade cement may be used to replace OPC cement grade 43 up to 30 percent by weight of cement. Fly-ash shall conform to IS:3812 (Part 1) and its use shall be permitted only after ensuring that facilities exist for uniform blending through a proper mechanical facility with automated process control like batch mix plant conforming to IS:4925 and IS:4926.

The mix shall be proportioned with a maximum aggregate cementitious material ratio of 15:1. The water content shall be adjusted to the optimum as per Clause 601.3.2 in MORT&H technical specifications for facilitating compaction by rolling. The strength and density requirements of concrete shall be determined in accordance with Clauses 601.7 and 601.8 in MORT&H technical specifications by making trial mixes. Care should be taken to prevent one size of aggregate falling into the other size of the hopper of the feeding bin while loading the individual size of aggregates into the bins.

The optimum water content shall be determined and demonstrated by rolling during trial length construction and the optimum moisture content and degree of compaction shall be got approved from Engineer. While laying in the main work, the lean concrete shall have a moisture content between the optimum and optimum +2 percent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

The cement content in the dry lean concrete shall be such that the strength specified in Clause 601.3.4 is achieved. The minimum cement content shall be 150 kg/cu.m of concrete. In case flyash is blended at site as part replacement of cement, the quantity of flyash shall not be more than 20 percent by weight of cementitious material and the content of OPC shall not be less than 120 kg/cu.m.

The average compressive strength of each consecutive group of 5 cubes made in accordance with Clause 903.5.1.1 shall not be less than 10 MPa at 7 days. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5 MPa at 7 days. The design mix complying with the above Clauses shall be got approved from the Engineer and demonstrated in the trial length construction.

The Dry Lean Concrete shall be laid on the prepared granular drainage layer. The pace and programme of the Dry Lean Concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The Dry Lean Concrete sub-base shall be overlaid with concrete pavement only after 7 days of sub-base construction.

Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tipping trucks with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner.

Lean concrete shall be placed by a paver with electronic sensor on the drainage layer or as specified in the Contract. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub-base. One day before placing of the dry lean cement concrete subbase, the surface of the granular sub-base/drainage layer shall be given a fine spray of water and rolled with a smooth wheeled roller.

The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is well closed. The minimum dry density obtained shall not be less than 98 percent of that achieved during the trial length construction in accordance.

No heavy commercial vehicles like trucks and buses shall be permitted on the dry lean concrete sub-base. Construction vehicles at slow speed may be permitted after 7 days of its construction with the prior approval of the Engineer.

Cement Concrete Pavement

The work shall consist of construction of un-reinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer.

The Contractor shall indicate to the Engineer the source of all materials to be used in the concrete work with relevant test data sufficiently in advance, and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work in trial length. If the Contractor subsequently proposes to obtain materials from a different source during the execution of main work, he shall notify the Engineer, with relevant test data, for his approval, at least 45 days before such materials are to be used.

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but preference shall be to use at least the 43 grade or higher. Cement to be used may preferably be obtained in bulk form. If cement in paper bags is proposed to be used, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them off suitably.

Site mixing of fly ash shall be permitted only after ensuring availability of the equipments at site for uniform blending through a specific mechanised facility with automated process control like batch mix plants conforming to IS:4925 and IS:4926. Site mixing will not be allowed otherwise. The Portland Pozzolana Cement produced in factory as per IS: 1489-Part I shall not have fly-ash content more than 20 percent by weight of cementitious material. Certificate from the manufacturer to this effect shall be produced before use.

Admixtures conforming to IS:9103 and IS:6925 shall be permitted to improve workability of the concrete and/or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used must be furnished to the Engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures should be proved both on the laboratory concrete trial mixes and in the trial length paving. If air entraining admixture is used, the total quantity of air shall be 5±1.5 percent for 31.5 mm maximum nominal size aggregate.

Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 31.5 mm for pavement concrete. The fine aggregates shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS:383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37).

Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS:456.

After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer vide Clause 602.3.4. The mix design shall be submitted at least 30 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IRC:44 or IS:10262.

When Ordinary Portland Cement (OPC) is used the quantity of cement shall not be less than 360 kg/cu.m. In case fly ash grade I (as per IS:3812) is blended at site as part replacement of cement, the quantity of fly ash shall be upto 20 percent by weight of cementitious material and the quantity of OPC in such a blend shall not be less than 310 kg/cu.m. The minimum of OPC content, in case ground granulated blast furnace slag cement blended, shall also not be less than 310 kg/m3. If this minimum cement content is not sufficient to produce concrete of the specified strength.

The characteristic flexural strength of concrete shall not be less than 4.5 MPa unless specified otherwise. Target mean flexural strength for mix design shall be more than 4.5 MPa + 1.65s, where s is standard deviation of flexural strength derived by conducting test on minimum 30 beams. The ratio between the 7 and 28 day strength shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at least six batches of trial mix. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio "R' shall be determined. The ratio 'R' shall be expressed to three decimal places.

The workability of the concrete at the point of placing shall be adequate for the concrete to be fully compacted and finished without undue flow. The optimum workability for the mix to suit the paving plant being used shall be determined by the Contractor and approved by the Engineer. The Contractor shall carry out laboratory trials of design mix with the materials from the approved sources to be used as per IRC:44. Trial mixes shall be made in presence of the Engineer or his representative and the design mix shall be subject to the approval of the Engineer.

The proportions determined as a result of the laboratory trial mixes may be adjusted, if necessary, during the construction of the trial length. Thereafter, neither the materials nor the mix proportions shall be varied in any way except with the written approval of the Engineer.

Maintenance of Roads

Flexible Pavement

The scope and type of maintenance work to be carried out shall be in accordance with the provisions of the Contract or as instructed by the Engineer. Maintenance treatments required under the Contract or instructed by the Engineer may include pothole and patch repair, crack-sealing, fog spray, dusting, slurry sealing, surface dressing, overlays and specialist repairs. The materials (particularly patching and overlay materials) used in maintenance operations shall be of a standard not less than those specified for the original construction.

The work shall include the removal of all failed material, in the pavement courses and, if necessary, below the pavement, until the root cause of the failure is removed, the trimming of the completed excavation to provide firm vertical faces; the replacement of material of at least as high a standard as that which was originally specified for the pavement layer; the application of tack coat on to the sides and base of excavations prior to placing of any bituminous materials and the compaction, trimming and finishing of the surfaces of all patches to form a smooth continuous surface, level with the surrounding road.

All materials used for the pothole and patch repair of bituminous surface and underlying layers shall be in accordance with these Specifications and shall be of the same type as specified for the original construction. A mix superior to the one on the existing surface may also be used for repair work. An emulsified bitumen/modified bitumen mix compatible with the existing layer shall also be considered appropriate. Materials used for patching shall not be of lesser bearing capacity or of a greater porosity than the adjacent previous construction. Non-bituminous material shall not be used for patching bituminous materials.

Each pothole and patch repair area shall be inspected and all loose and defective material removed. The area shall be cut/trimmed to a regular shape either with jack hammers or with hand tools suitable for the purpose. The edges of the excavation shall be cut vertically. The area shall be thoroughly cleaned with compressed air or any appropriate method approved by the Engineer to remove all dust and loose particles. Layers below the level of the bituminous construction shall be filled using material of the equivalent specification to the original construction, which shall particularly include the specified standards of compaction.

The mixture to be used in bituminous patching shall be either a hot mix or a cold mix in accordance with the appropriate Clauses of these Specifications or any other approved patching material. Mixing shall be done in a plant of suitable capacity. The bituminous mixture shall be placed in layers of thickness not more than 100 mm (loose) and shall be compacted in layers with roller/plate compactor/hand roller/rammer to the compaction standards defined in the appropriate Clauses of these Specifications. While placing the final layer, the mix shall be spread slightly proud of the surface so that after rolling, the surface shall be flush with the adjoining surface. If the area is large, the spreading and levelling shall be done using appropriate tools and equipment. During the process of compaction, the surface levels shall be checked using a 3 m straight edge.

The area to be treated with fog seal shall be thoroughly cleaned using compressed air, scrubbers, etc. The cracks shall be cleaned with a compressed air jet to remove all dirt, dust, etc. The fog seal shall be applied at the rate of 0.5-1.0 litre/sq.m of emulsion, or as otherwise instructed by the Engineer, using equipment, such as, a pressure tank, flexible hose and spraying bar or lance. Traffic shall be allowed on to the surface only after the seal has set to a non-tacky and firm condition so that it is not picked up by the traffic.

Crack filling shall be carried out using a binder of a suitable viscosity, normally a slow-curing bitumen emulsion, as instructed by the Engineer. For wider cracks, in excess of an average of 3 mm in width, the application of emulsion shall be preceded by an application of crusher dust, or other fine material or a suitable premix acceptable to the Engineer.

Bitumen for use in crack sealing shall be of a slow curing type as instructed by the Engineer. Dust for crack sealing, when used, shall be crusher dust or some other suitable fine material approved by the Engineer, passing the 2.36 mm sieve but with a maximum of 10 percent passing the 0.075 mm sieve.

If crusher dust or other graded fine material is to be used it shall be placed in the cracks before the application of binder and the cracks filled to a level approximately 5 mm below road surface level. The surface of the road shall be swept clear of dust prior to the application of binder or premix. Binder shall be poured into the cracks, taking care to minimise spillage. If spillage onto the road surface does occur, dust shall be applied to the excess bitumen until it is blotted up. Where a crack-filling mix is used, a squeegee shall be used to force the premix into the cracks wider than 10 mm.

Maintenance of Cement Concrete Road

The work shall consist of repair of spalled joint grooves of contraction joints, longitudinal joints and expansion joints in a concrete pavement using epoxy mortar or epoxy concrete. The type/grade of epoxy compatible with the coefficient of thermal expansion of concrete shall be used with either processed fine aggregate or fine stone chips to produce a dry mix for repairing spalled or damaged edges.

Spalled or broken edges shall be shaped neatly with a vertical cut with chisels into the shape of rectangle. Small pneumatic chisels also may be used, provided the cutting depth can be controlled. The depth of the cut shall be the minimum to effect repair. After shaping the spalled area, it shall be cleaned and primed. The epoxy mortar/concrete is then applied using hand tools like trowels, straight edges, brushes etc. The repaired edge shall be in line with the joint groove and shall be flush with the concrete slabs. During the repair work, any damage noticed to the joint sealant shall be made good by raking out the affected portion and resealing.

Although the epoxy mixes set in 2-3 hours' time, it is desirable to divert the traffic for 12 hours or as per the recommendation of the manufacturer.

- **Construction sequencing for Bridges Structures**

Construction sequence for Bridge structures:

(1) Initially process starts with the site clearance. In the present case, it is the seabed that needs to be made accessible for construction of foundation. Sufficient dewatering technique shall be adopted. In case of bridge in approaches, site needs to be made accessible for construction of foundation;
(2) Piles are bored cast In-situ type. Piling activity shall be carried out by means of underwater concreting techniques in waterway section and in approach road section piling activity shall be carried out with normal piling techniques;
(3) Further, pile cap shall be cast in-situ after the section of seabed is made free from water in water way section and in approach road section the pile cap shall be cast in-situ after the soil is excavated to required extent. Dowels shall be projected from pile-cap for the construction of wall piers in flood regulator portion and for the construction of abutments/piers in approach road section;
(4) Wall piers shall be cast in-situ with pedestals on top of it;
(5) Post-tensioned I-Girders shall be casted at casting yard. The location of casting yard shall be suitably identified. Prestressing of I-Girders shall be done at casting yard itself.
(6) The girders shall then be transported to the location of flood regulator over the embankment constructed beyond the flood regulator;
(7) The Girders shall be lifted and placed in position over the wall piers/abutment cap/pier cap with the help of cranes. The girders shall be temporarily supported over the wall piers/abutment cap/pier cap;
(8) Diaphragm and deck slab shall be cast in-situ by taking support for shuttering from the girders;
(9) After 28 days of casting of Deck slab and diaphragm, the entire superstructure shall be now lowered and supported over the bearings. Installation of bearings shall be carried out by this time;
(10) Further, wearing coat for road bridges and other components over the deck slab shall be constructed; and
(11) For railway bridges, further activity included laying of wearing coat, ballast filling, laying of sleepers and then rail.

- **Construction sequencing for Railway Line**

The stages involved in the formations for railways shall be in the following order:

(i) Soil survey and exploration. This activity shall be carried out in three stages;
(a) Reconnaissance Survey;
(b) Preliminary Survey; and
(c) Final Location Survey.
(ii) Checking the suitability of sub soil and devise ground improvement techniques. Design of formation including slope stability analysis;
(iii) Execution of earthworks;
(iv) Quality control of earthworks;
(v) Erosion control of slopes and Construction of Drains;
(vi) Formation of blanket layer;
(vii) Laying of Ballast Track;
(viii) Fixing of OHE mast / Electrification Works and S&T Works; and
(ix) Testing and commissioning.

2.3.10 Benefits

(a) Economic benefits

The construction of the dyke cum road is expected to generate direct and indirect benefits. The direct economic benefits that will accrue because of the project include VOC and travel time savings. The following categories of benefits for Kalpasar have been quantified in monitory values:
(1) Savings in Vehicle Operation Costs (VOC);
(2) Savings in Value of Passenger Time (VOT); and
(3) Carbon credits.

Broadly benefits can be quantified both for Road and Railways and the same are described in the following sections.

(b) Savings in Vehicle Operation Costs (VOC)

Savings in vehicle operation cost is accounts for distance savings to the passenger and commercial vehicles. Savings is calculated by assessing the cost savings before and after the project. Based on the analysis of distance between major origin-destination pairs, an average distance a vehicle will take to traverse from various regions of South Gujarat to Saurashtra before Kalpasar project is 489 Km, while after the project the average travel distance will 374 km. Hence an average distance savings of 115 Km has been considered for economic viability analysis and the VOC were obtained based on primary surveys conducted in this study and vehicle operation cost for train is calculated based on the inputs from Indian Railways year book and they are presented in **Table 2.129**.

Table 2.129: Mode Wise Vehicle Operating Cost (VOC)

Veh Type	Car	Bus	Mini Bus	LCV	Trucks	MAV	Passenger Train	Freight Train
VOC per Vehicle (Rs. per Km)	7.4	14.8	11.1	14.8	24.4	30.5	816	5,682

(c) Savings in Value of Time (VOT)

Time cost savings due to reduction in travel distance and reduction in congestion due to Kalpasar project were accounted for savings in value of time. Hourly wage rate were considered for calculating the VOT savings for passenger vehicles & passenger rail, suitable conversion factors were considered for vehicle units to train units. Commodity holding cost estimated based on IRC-SP: 30-2019 were considered for calculating savings in VOT of commercial vehicles. Details of the VOT considered for this study is presented in **Table 2.130.**

Table 2.130: Mode wise Value of Time (VOT)

Mode	Car	Bus/train	Mini Bus	LCV	Trucks	MAV
VOT per Vehicle (Rs. Per Hour)	369	2,602	781	13.6	98.5	155.2

(d) Carbon credits

A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or carbon dioxide equivalent. Carbon Credit is maintained in the form of an Electronic Certificate, similar to that of a De-Materialized (Demat) Share Certificate.

Carbon credits and carbon markets are a component of national and international attempts to mitigate the growth in concentrations of greenhouse gases (GHGs). **One carbon credit is equal to one ton of carbon dioxide, or in some markets, carbon dioxide equivalent gases**. The different greenhouse gases have differing amounts of effect measured in units of Global Warming Potential (GWP). The GWP unit is defined as the greenhouse forcing due to one unit of CO_2 in its lifetime.

- **Emission trading**

An emission trading (also known as cap and trade) is a market-based approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants.

A central authority (usually a governmental body) sets a limit or cap on the amount of a pollutant that can be emitted. The limit or cap is allocated or sold to firms in the form of emissions permits which represent the right to emit or discharge a specific volume of the specified pollutant. Firms are required to hold a number of permits (or credits) equivalent to their emissions. The total number of permits cannot exceed the cap, limiting total emissions to that level.

Firms that need to increase their emission permits must buy permits from those who require fewer permits. The transfer of permits is referred to as a trade. **In effect, the buyer is paying a charge for polluting, while the seller is being rewarded for having reduced emissions**. Thus, in theory, those who can reduce emissions most cheaply will do so, achieving the pollution reduction at the lowest cost to society.

The Kyoto mechanism is the only internationally-agreed mechanism for regulating carbon credit activities, and, crucially, includes checks for additionality and overall effectiveness. Its supporting organisation, the United Nations Framework Convention on Climate Change (UNFCCC), is the organisation with a global mandate on the overall effectiveness of emission control systems, although enforcement of decisions relies on national co-operation.

The GHGs considered under the Kyoto Protocol are Carbon Dioxide, Methane, Nitrous Oxide, Hydro fluorocarbons, per fluorocarbons, and sulfur hexafluoride. Kyoto Protocol has the provision for four international mechanisms that allow for flexibility in achieving GHG emission reductions. The four mechanisms are bubble policy, joint implementation (JI), clean development mechanism (CDM), and international emissions trading (IET).

- **Emission from transport sector**

Emissions from the transport sector depend mainly on type of transport and fuel apart from type of combustion engine, emission mitigation techniques, maintenance procedures and vehicle age. The major pollutant emitted from transport are Carbon dioxide (CO_2), Methane (CH_4), Carbon monoxide (CO), Nitrogen oxides (NO_x), Nitrous oxide (N_2O), Sulphur dioxide (SO_2), Non-methane volatile organic compounds (NMVOC), Particulate matter (PM) and Hydrocarbon (HC). Diesel is used in public passenger and cargo vehicles, while private two wheelers, light motor vehicles (passenger), cars and jeeps use gasoline.

Table 2-131: Emission from different vehicle types in India (g/km)

MODE	Car	Bus	M.Bus	LCV	2 Axle Truck	3 Axle Truck	MAV
CO2	216.0	515.2	515.2	515.2	515.2	515.2	515.2
CO	1.4	3.6	3.6	5.1	3.6	3.6	3.6
NOx	0.4	12.0	12.0	1.3	6.3	6.3	6.3
CH4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
SO2	5.2	1.4	1.4	1.4	1.4	1.4	1.4
PM	0.1	0.6	0.6	0.2	0.3	0.3	0.3
HC	0.2	0.9	0.9	0.1	0.9	0.9	0.9

Source : Emissions from India's transport sector: Statewise synthesis, T.V. Ramachandra et. al.

- **Global warming potential**

Global warming potential (GWP) is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by convention equal to 1). GWP is calculated over a specific time interval and this time interval must be stated whenever a GWP is quoted or else the value is meaningless.

Under the Kyoto Protocol, the values of GWP calculated for the IPCC (Intergovernmental Panel on Climate Change) Assessment Report (as given in Table 6-3) are to be used for converting the various greenhouse gas emissions into comparable CO_2 equivalents.

The GHGs with relatively long atmospheric lifetimes (e.g., CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) tend to be evenly distributed throughout the atmosphere, and consequently global average concentrations can be determined.

However, the short-lived GHGs such as water vapor, carbon monoxide, tropospheric ozone, ozone precursors (e.g., NOx, and NMVOCs), and tropospheric aerosols (e.g., SO2 products and carbonaceous particles), vary regionally so it is difficult to quantify their global radiative forcing impacts. No GWP values are attributed to these gases, which are short-lived and spatially inhomogeneous in the atmosphere.

Table 2.132 GWP values for greenhouse gases

Common Name	Chemical Formula	GWP for given Time Horizon		
		20 yr	100 yr	500 yr
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	82.5 ± 25.8	29.8 ± 11	10.0 ± 3.8
Nitrous oxide	N_2O	273 ± 118	273 ± 130	130 ± 64
Oxides of Nitrate	NO_x	Not available		
Sulphur Dioxide	SO_2	Not available		
Particulate Matter	PM	Not available		
Hydrocarbons	HFC-32	2693 ± 842	771 ± 292	220 ± 87
	CFC-11	8321 ± 2419	6226 ± 2297	2093 ± 865

Source: 2021 IPCC AR6, Table 7.15

- **Reduction in emission due to Kalpasar**

Reduction in emissions due to distance savings via GKDP road are quantified based on the number of vehicles and distance saved in a year per different vehicle type, as follows:

Ei = 365* (∑Veh-kmwithout GKDP - ∑Veh-kmwith GKDP) * Eijkm

Where,
Ei = emission of GHG (i) in tons
Ei, j, km = emission of GHG (i) in tons from vehicle type (j) per driven kilometre

- **Calculation of carbon credit**

The reduction in emissions calculated in tons for different gases are converted to CO_2 equivalents by multiplying with the corresponding GWP values of gases.

Table 2.133 Carbon credits in million tonnes

Year	Carbon Credit in Million Tonnes	Carbon Credit in Million Rs
2041	5,20,460	625
2051	7,51,985	902
2061	9,99,929	1,200
2071	12,43,215	1,492
2081	13,85,112	1,662
2091	14,53,845	1,745
2101	15,00,156	1,800

2.3.11 Future development scenario

Transportation Development – Khambat region:

Khambhat region will have an accelerated development due to various road and rail projects.

Various major road network improvement projects that are in various stages of implementation within project influence area are summarised below,

- Delhi-Mumbai Expressway
- Ahmedabad Dholera Expressway
- Coastal Road from Dahej to Valsad
- Widening of roads connecting Sanand, Bagodra, Dhanduka, Barwala, Vallabhipur, Limbda, Bhavnagar, Amreli, Mahuva, Veraval, Porbandar, and Dwarka.
- Necklace Road along sea connecting Bhavnagar-Dahej, Dahej to NH-48 via Vagara and coastal road along Tarapur-Bhilad-Tithal-Ubhrat-Khambhat.

Some of the major railway development projects within project influence area are,

- Western Dedicated Freight Corridor
- Delhi Mumbai Industrial Corridor

- Mumbai-Ahmedabad High speed rail

Detailed description of abovementioned projects are given in sub-section 2.3.3 (d).

Following are the impacts due to above mentioned development projects,
(1) Various investment regions/ industrial areas are expected to be developed in phases and Dholera SIR is the first node taken up for development as part of DMIC project in Gujarat;
(2) Logistics Parks to be developed in Palanpur, Ahmedabad, Vapi and Vadodara in Gujarat; will boost infrastructural development in general and power sector in particular;
(3) DFC has potential to trigger western industrial corridor i.e., Delhi-Mumbai Industrial Corridor; and
(4) Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad, and Sabarmati will get boost in tourism, employment and economies of the cities and towns within the project's influence area due to development of world-class railway stations and maintenance depots.

As per 2011 census, Khambhat region had a population of 4.7 million, which is projected to have a population of 5.6 million in the year 2021 based on past year growth trend. In the year 2031 and 2041, Khambhat region is assumed to have a same growth rate as that of previous decade due to project opening. The population in Khambhat region is projected to be around 10 million in the period of 2071-2101.

Table 2.134: Projected Population in Khambhat Region

Year	Population in Lakhs	(CAGR (%)
2011	47.02	-
2021	56.10	1.8%
2041	79.83	1.8%
2071	99.85	0.7%
2101	106.61	0.2%

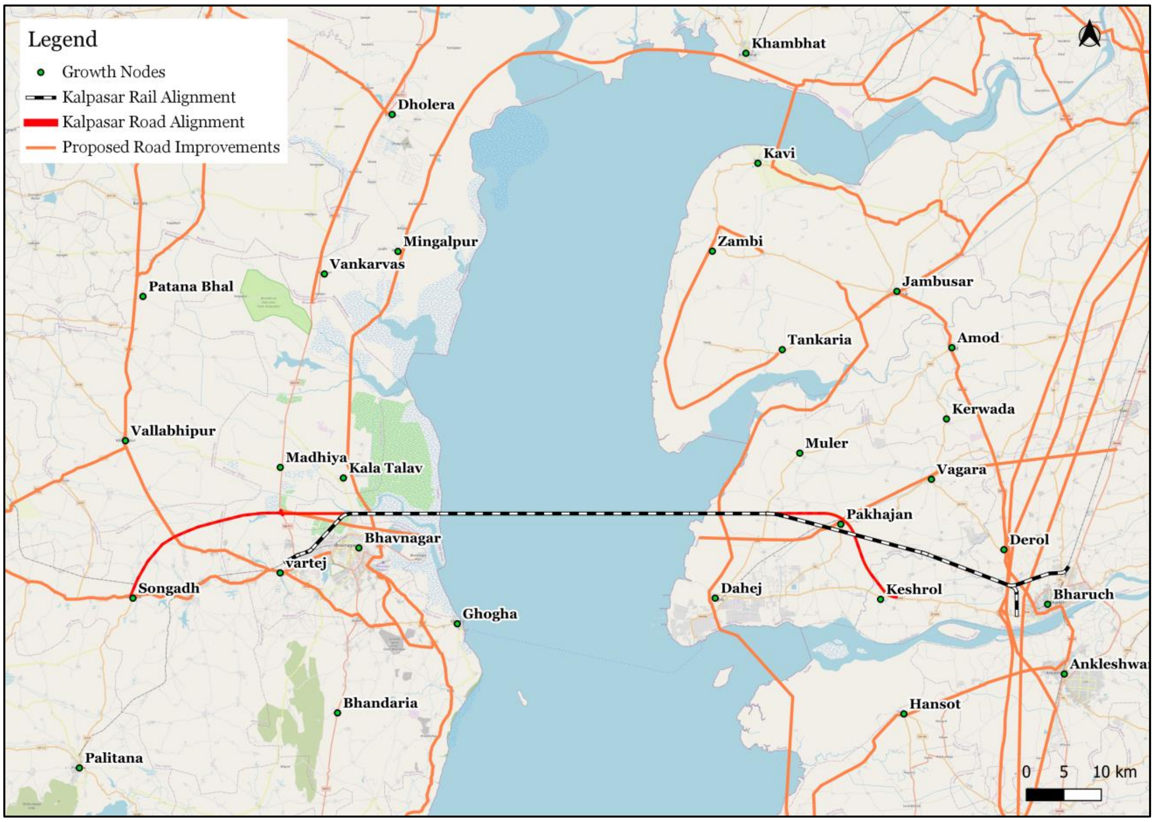


Figure 2.85: Accelerated Growth Nodes due to Kalpasar Project

Bharuch and Bhavnagar is expected to grow rapidly similar to Surat once Kalpasar Project is implemented. A regular commuter rail will be introduced to connect Bhavnagar to Surat via Bharuch. This is expected to trigger business travel. Bharuch will become major hub for various transportation modes as it will have excellent access to dedicated freight corridor (DFC), high-speed rail (HSR), Delhi-Mumbai expressway and Kalpasar road and rail linkages.

Various other small towns and villages such as Pakhajan, Keshrol, Dahej, Muler, Amod, Vagara, Jambusar, Tankaria, Zambi, Hansot, Zambi, Khambhat, Dholera, Vankarvas, Kala Talav, Ghogha, Vartej, Madhiya, Vallabhipur, Songadh, Bhandaria and Pallitana are expected to have an accelerated growth due to transport link over the Kalpasar dyke and they are shown in **Figure 2.85**.

In order to ensure smooth dispersal of traffic from Kalpasar link, access roads are proposed to be developed on Bharuch side as well as at Bhavnagar side.

8 interchanges are proposed to be developed at Songadh on NH 8E, SH 36 Crossing, NH 751 Crossing, Lakdiya Pull, Goladra on SH 6 (Dahej- Amod Road), Pakhajan, Sadathala and Bharuch – Dahej Road (SH-6). All this connecting roads are expected to have an accelerated growth due to improved connectivity between south Gujarat and Saurastra region.

Overall the above projects will improve the regional connectivity and ensures sustainable growth of Khambhat region.

2.3.12 Discussion

(a) Summary

Kalpasar Project with a multi-lane road and rail over the dyke will provide a new transportation link between South Gujarat and Saurashtra reducing the distance between these two regions substantially and will bring about profound change in travel pattern. These regions will benefit immensely due to reduced logistics costs which will pave the way for competitiveness and increased economic activity.

Traffic has been forecasted on Kalpasar transportation link by developing a travel demand model till 2101 duly taking into account future demographic and economic scenarios. Traffic forecast has been made for three scenarios (optimistic, most-likely and pessimistic). The summary of traffic forecast and lane requirements for Road are presented below in **Table 2.135**.

Table 2.135: Summary of traffic forecast and lane requirement for road system

Year	Traffic Forecast on Road (in PCUs)			Lane Requirement (Road)		
	Optimistic	Most Likely	Pessimistic	Optimistic	Most Likely	Pessimistic
2022	22,375	22,375	22,375	2	2	2
2031	52,713	49,011	45,185	4	4	4
2041	81,251	74,826	71,674	6	4	4
2051	1,21,434	1,07,860	99,920	8	8	6
2061	1,64,676	1,51,083	1,36,171	10	10	10
2071	2,06,275	1,91,816	1,70,657	14	12	12
2081	2,32,746	2,18,864	1,87,895	16	14	12
2091	2,43,709	2,22,382	1,90,625	16	14	12
2101	2,53,147	2,24,167	1,94,132	16	14	12

Rail traffic forecast has been carried based on the existing rail passenger and freight movements, future projects and likely shift of traffic from road to rail. Initially, double track for mixed operations has been considered, however, by 2045, double line will be saturated. In order to meet the traffic demand beyond 2045, there is an option of third line or option of providing of two dedicated double line (one for passenger and one for freight operations). Considering the long horizon and uncertainty in forecast, it is suggested to have dedicated operations for passenger and freight separately. Further, Rail can take surplus demand from road and it is most sustainable mode of transport and offers much more capacity than road.

The dedicated operations will allow higher speed of operations for passengers and more load carrying capacity and timely delivery of goods (as against the existing practice of prioritizing the passenger operations, which is resulting in average speed of 25 kmph for freight trains).The traffic forecast, Capacity requirement and capacity utilization of dedicated passenger and freight operations (2 double track line) is presented below in **Table 2.136.**

Table 2.136: Traffic forecast and capacity utilization for rail system

Traffic Forecast for Railway System

Year	Passenger Trains per day	Freight Trains per day	Capacity Requirement for Passenger dedicated passenger line	Capacity Requirement for dedicated freight line	Capacity Utilization for Passenger trains	Capacity Utilization for Freight trains
2022	63	10	Double track	Single track	16%	13%
2031	78	25	Double track	Single track	20%	31%
2041	119	47	Double track	Single track	30%	59%
2051	139	65	Double track	Single track	35%	81%
2061	155	77	Double track	Single track	39%	96%
2071	167	84	Double track	Double track	42%	30%
2081	174	88	Double track	Double track	44%	31%
2091	178	89	Double track	Double track	45%	32%
2101	179	89	Double track	Double track	45%	32%

For the purpose of planning the transport corridor, optimistic scenario has been considered in view of the long horizon of traffic forecast. Based on the Traffic forecast (for Optimistic Scenario), 16-lanes and 2 double Rail lines (one for passenger and one for freight train will be required) is proposed. The required ROW for the Transportation Corridor is 130m to accommodate 16 lane Road and Two double Rail lines.

Total length of road alignment is 100.5 Km, for effective dispersal of traffic from the Kalpasar Dyke it is proposed to extend the road on both sides (Bhavnagar and Bharuch side) of the dam and traffic shall be dispersed effectively from the proposed interchanges at 8 locations. Interchange locations are summarized below in **Table 2.137**.

Table 2.137: Interchange location for Kalpasar

S.No	Interchange location	Chainage	Direction	Type of Interchange
1	Near Songadh on NH 8E	00+000	Bhavnagar	Trumpet Interchange
2	On SH 36 Crossing	09+800	Bhavnagar	Flyover with Slip roads
3	On NH 751 Crossing	23+500	Bhavnagar	Cloverleaf interchange
4	Near Lakdiya Pull	32+250	Bhavnagar	Flyover with slip roads
5	Near Goladra on SH 6 (Dahej- Amod Road)	83+660	Bharuch	Flyover with Slip roads
6	Pakhajan	93+800	Bharuch	Flyover with Slip roads
7	Sadathala	98+730	Bharuch	Flyover with Slip roads
8	On Bharuch – Dahej Road (SH-6)	104+500	Bharuch	Flyover with slip roads

Total length of rail alignment is 97.5 Km, proposed railway alignment is integrated with existing railway line on Bhavnagar side and Bharuch side. New railway terminals are proposed at 2 locations, one at Bhavnagar side and another at Bharuch side. The chainage detail of the proposed rail terminals is described below in **Table 2.138**.

Table 2.138: Chainage detail for proposed rail terminal

S.No	Chainage (m)	Direction	Location
1	6+519	Bhavnagar	Ramdev Nagar (Outskirts of Bhavnagar)
2	96+511	Bharuch	Outskirts of Bharuch (connecting HSR line)

Road alignment is designed as a National Highway with design speed of 100 Kmph. Median opening is provided at 5km interval for the purpose of emergency U-Turn.

Rail alignment is designed as semi-high speed rail for passenger line and as a dedicated freight corridor (DFC) for freight line.

Structural components of both road and rail are designed as PSC Post tensioned I-Girder with cast In-situ deck slab with a span of 21m. Design loadings and load combinations are considered as per prevailing IS and IRC standards.

ITS facility and equipment is an indispensable component for a fully access-controlled toll road. Accordingly, the ITS shall be installed on viaducts and the Bridge portions from commencement of operation.

(b) Recommendations

Road over the Kalpasar dyke is designed with highway standards. It is recommended to provide road interchanges at 8 locations for smooth dispersal of traffic as described in **sub-section 2.3.4 (d) (iii).**

Passenger railway system over the Kalpsar dyke is designed with semi high speed rail standards and the freight railway system is designed with dedicated freight corridor standards. Railway terminals are proposed at 2 locations (one at Bhavnagar side and another at Bharuch side). It is recommended to integrate the proposed railway alignment with the high-speed rail station at Bharuch which is under construction. For continuous flow of train traffic from other regions of Gujarat and other states of India, a connecting railway line is recommended to connect the proposed railway link over the Kalpasar dyke with the Delhi-Mumbai mainline.

2.3.13 Detailed drawings

Detailed drawing showing the plan and profile of road and rail and bridge design drawings are given in **Annexure-2K to Annexure-2M**

2.3.14 Cost estimates

(a) Materials and specifications of Bridge Structures

- **General**

Materials to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work covered under these Specifications.

If any material, not covered in these Specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements consented by the Engineer.

- **Cement**

Cement to be used in the works shall be any of the following types and with prior consent of the Engineer:
(1) Ordinary Portland Cement, 33 Grade, conforming to IS:269;
(2) Rapid Hardening Portland Cement, conforming to IS: 8041;
(3) Ordinary Portland Cement, 43 Grade, conforming to IS:8112;
(4) Ordinary Portland Cement, 53 Grade, conforming to IS:12269; and
(5) Sulphate Resistant Portland Cement, conforming to IS:12330.

Cement conforming to IS:269 shall be used only after ensuring that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 500 kg/cum of concrete.

Cement conforming to IS: 8112 and IS: 12269 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28-day range can be achieved by finer grinding and higher constituent ratio of Tricalcium Silicate and Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine tune the mix design from strength considerations.

Cement conforming to IS: 12330 shall be used when sodium sulphate and magnesium sulphate are present in large enough concentration to be aggressive to concrete. It shall not be used under such conditions where concrete is exposed to risk of excessive chlorides and sulphates attack both. The recommended threshold values as per IS: 456 are sulphate concentration in excess of 0.2 per cent in soil substrata or 300 ppm (0.03per cent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the seacoast, chemical factories, agricultural land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. Cement conforming to IS:12330 shall be carefully selected from strength considerations to ensure that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 500 kg/cum of concrete,

Cement conforming to IS: 8041 shall be used only for precast concrete products with prior consent of the Engineer.

Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO_3) shall in no case exceed 2.5 per cent and 3.0 percent when tri-calcium aluminate per cent by mass is up to 5 or greater than5 respectively. Use of Fly Ash as shall not be permitted.

- **Coarse Aggregates**

For plain and reinforced cement concrete (PCC and RCC) works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel etc.. They shall not consist pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials beyond the tolerance limits specified in the relevant IS Codes. Coarse aggregate having positive alkali-silica reaction shall not be used. All coarse aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS:2386, Parts I to VIII.

Marine aggregates shall not be used.

The maximum value of flakiness index for coarse aggregate shall not exceed 35 percent. The coarse aggregate shall satisfy the requirements of grading as specified in Table 1.1 below

Table 2.139: Requirements of Coarse Aggregates

IS Sieve Size	Percent by Weight Passing the Sieve		
	40 mm	20 mm	12.5mm
63mm	100	-	-
40mm	95-100	100	-
20mm	30-70	95-100	100
12.5mm	-	-	90-100
10mm	10-35	25-55	40-85
4.75mm	0-5	0-10	0-10

- **Sand / Fine Aggregates**

For masonry work, sand shall conform to the requirements of IS: 2116.

For plain and reinforced cement concrete (PCC and RCC) works, fine aggregate shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorised sand washing machines / screw type mechanical washers should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS:383 and tests for conformity shall be carried out as per IS: 2386, (Parts I to VIII). The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Creek / Marine sand shall not be used in permanent works.

- **Steel**

Reinforcement / Untensioned Steel

For plain and reinforced cement concrete (PCC and RCC) or pre-stressed concrete (PSC) works, the reinforcement / untensioned steel as the case may be, shall consist of the following grades of reinforcing bars as specified in Table 1.2 below.

Table 1.2: Requirements of Reinforcement / Untensioned Steel

S.No	Grade Designation	Bar Type confirming to governing IS Specifications	Characteristic Strength f_y MPa	Elastic Modulus GPa
1	S 240	Grade 1 Mild Steel & Medium Tensile Steel bars conforming to IS: 432 Part I Mild Steel Bar	240	200
2	2S 500	Cold twisted bars conforming to IS: 1786 High Yield Strength Deformed Bars (HYSD) / TMT bars	500	200

Other grades of bars conforming to IS:432 and IS:1786 shall not be permitted.
All the steel shall be procured only from the primary steel producers and having BIS license.

Primary steel producers are those steel (crude and / finished steel) producers using iron ore as the basic raw material / input. It therefore, includes in-house iron making followed by production of liquid steel & crude steel with / without in-house rolling. So all Integrated Steel Plants adopting BF-BOF route and major producers adopting Corex-BOF or DRI-EAF or MBF-EOF technology would fall under this category.

All reinforcing steel shall be free from loose small scales, rust and coats of paint, oil mud etc. Every bar shall be inspected before assembling on the work and defective, brittle or burnt bar shall be discarded. Cracked ends of bars shall be discarded.

- **Water**

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. As a guide, the following concentrations represent the maximum permissible values:
(1) To neutralize 200 ml sample of water. using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal NaOH;
(2) To neutralize 200 ml sample of water, using methyl orange as an indicator, it should not require more than 10 ml of 0.1 normal HCl; and
(3) The permissible limits for solids shall be as follows when tested in accordance with IS:3025:

Permissible Limits (Max.)
Organic: 200 mg/lit
Inorganic: 3000 mg/lit
Sulphates (SO4): 500 mg/lit
Chlorides (Cl): 2000 mg/lit for PCC works & 1000 mg/lit for RCC works
Suspended matter: 2000 mg/lit

All samples of water (including potable water) shall be tested, and suitable measures taken where necessary to ensure conformity of the water to the requirements stated herein.
(1) The pH value shall not be less than 6; and
(2) In case of doubt regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time tests as specified below:

(i) The sample of water taken for testing shall represent the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water;

(ii) Average 28 days compressive strength of at least three 15cm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS:516;

(iii) The initial setting time of test block made with the appropriate cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by + 30 minutes from the initial setting time of control test block prepared and tested in accordance with the requirements of IS:4031; and

(iv) Water found satisfactory for mixing is also suitable for curing concrete. However, water used for curing should not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or iron compounds is objectionable.

- **Concrete Admixtures**

General

Admixtures are materials added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or hardened state.

Concrete admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers having proven track record, quality assurance and full-fledged laboratory facilities for the manufacture and testing of concrete.

Physical & Chemical Requirements

All admixtures shall conform to the requirements of IS:9103. In addition, the following conditions shall be satisfied:

(i) "Plasticisers" and "Super-Plasticisers" shall meet the requirements indicated for "Water reducing Admixture";

(ii) Except where resistance to freezing and thawing and to disruptive action of deicing salts is necessary, the air content of freshly mixed concrete in accordance with the pressure method given in IS: 1199 shall not be more than 1 percent higher than that of the corresponding control mix;

(iii) Calcium chloride or admixtures containing calcium chloride shall not be used in structural concrete containing reinforcement, prestressing tendons or the embedded metal;

(iv) Admixtures containing Cl, SO3 ions, nitrates and admixtures based on thiocyanate shall not be used;

(v) Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times;

The tests that shall be performed along with permissible variations in the same are indicated below:

Dry Material Content: to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer.

(a) Ash content to be within 1 per cent of the value stated by the manufacturer;

(b) Relative Density (for liquid admixtures): to be within 2 per cent of the value stated by the manufacturer.

(vi) Use of such admixtures does not have adverse effect on the properties of concrete or mortar particularly with respect to strength, volume change durability and has no deleterious effect on reinforcement;
(vii) All tests relating to the concretes admixtures shall be conducted periodically at an independent laboratory having NABL certification and compared with the data given by the manufacturer;
(viii) While qualifying the admixture, the infra-red spectrograph plot should be given. Each batch of supply should be tested for infra-red Spectrograph and prove the consistency of supply; and
(ix) When an expanding agent is used, the total unrestrained expansion shall preferably be between 4% to 6%. Aluminum powder as an expanding agent shall not be permitted.

Handling & Storage of Materials
All materials shall be stored as per IS: 4082.

Cement: Cement of different specifications shall be stacked separately and quality of stored cement actually used in any member or part of the structure shall fulfill the design and construction requirement of the same. Cement shall be stored at work site in such a manner as to prevent deterioration either through moisture or intrusion of foreign matter. Wherever bulk storage containers are used, their capacity should be sufficient to cater to the requirement at site and should be cleaned at least every 3 months. Cement older than 3 months should not be used.

Aggregates: Coarse Aggregates supplied in different sizes shall be stacked in separate stockpiles and shall be mixed only after the quantity required for each size has been separately weighed or measured. The quantity of coarse aggregates thus recombined shall be that required for a single batch of concrete.

Steel: The storage of all reinforcing steel shall be done in such a manner as will assure that no deterioration in its quality takes place. The coil of HTS wires & strands shall be given anti-corrosive treatment such as water-soluble oil coating before wrapping it in hessian cloth or other suitable packing. During transportation, it shall be ensured that no damage is done to coils while loading and unloading. Care shall be taken to avoid mechanically damaging, work hardening or heating prestressing tendons while handling.

Any material, which has deteriorated or has been damaged, corroded or contaminated, shall not be used for concrete work.

All the materials even though stored in approved godowns / places must be subjected to acceptance test prior to their immediate use.

Tests and Standards of Acceptance
Cement: A sample shall be tested from every batch of cement delivered on site or once for every 1000 bags whichever is more frequent. Tests shall be carried out for fineness, initial and final setting time and compressive strength (IS: 4031) and results approved by Engineer before use. The methods and procedures for sampling shall be in accordance with IS: 3535. Engineer may require any other form of sampling and tests including chemical analysis (IS: 4032) in case the cement supplied is of doubtful quality.

Steel: Physical tests as per IS: 2062 and IS: 1786. Various physical tests shall be carried out as per IS: 226, IS: 1608, IS: 1599 and IS: 1387.

All materials shall be subjected to an acceptance test prior to their immediate use.

- **Concrete Works**

General

This section refers to the construction of concrete structures including concrete mix design, trial mix, testing and workmanship for concreting. The work shall consist of furnishing and placing structural concrete and incidental construction in accordance with these Specifications.

Materials

All the materials shall confirm to the requirements as specified in section "Materials for structures" of these specifications.

Grades of Concrete

The grades of concrete shall be designated by the characteristic strength as given in Table 9.1 below, where the characteristic strength is defined as the strength of concrete below which not more than 5 percent of the test results are expected to fall.

Table 2.140: Grades of Concrete

S. No.	Grade Designation	Specified Characteristic Compressive Strength of 150mm cubes at 28 days in MPa
1	M 10	10
2	M 15	15
3	M 20	20
4	M 25	25
5	M 30	30
6	M 35	35
7	M 40	40
8	M 45	45
9	M 50	50
10	M 55	55

The lowest grades of concrete in structures, corresponding minimum cementitious material contents, maximum water-cement ratios and minimum cover shall be maintained as indicated in table below based on the environmental exposure conditions

Table 2.141: Durability Recommendations for Service Life of at Least 100 Years (20 mm Aggregate)

Exposure Condition	Maximum water / cement ratio	Minimum cement content, kg/m^3	Minimum grade of concrete	Minimum Cover, mm
Moderate	0.45	340	M 25	40
Severe	0.45	360	M 30	45
Very Severe	0.40	380	M 40	50

Exposure Condition	Maximum water / cement ratio	Minimum cement content, kg/m³	Minimum grade of concrete	Minimum Cover, mm
Extreme	0.35	400	M 45	75

For plain cement concrete with or without surface reinforcement, the minimum grade of concrete can be lowered by 5 MPa and maximum water / cement ratio exceeded by 0.05.

For all foundations and elements below ground level, minimum cover shall be 75 mm.

Concrete used in any component or structure shall be specified by designation along with prescribed method of design of mix i.e. "Design Mix". For all items of concrete, only "Design Mix" shall be used.

Proportioning of Concrete

Mix Design shall be carried out to identify the proportion of materials, including admixtures to be used.

Requirements of Consistency

The mix shall have the consistency which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain uniform consistency.

The optimum consistency for various types of structures shall be as indicated in Table below or as consented by the Engineer. The slump of concrete shall be checked as per IS:516.

Table 2.4: Optimum Consistency Requirements

Sl. No.	Type of Structure	Slump (mm)
1	Structures with exposed inclined surface requiring low slump concrete lo allow proper compaction	25
2	Plain cement concrete	25
3	RCC structures with widely spaced reinforcements; e.g. solid columns, piers, abutments, footings, well steining	40-50
4	RCC structures with fair degree of congestion of reinforcement e.g. pier and abutment caps, box culverts well curb, well cap, walls with thickness greater than 300 mm	50-75
5	RCC and PSC structures with highly congested reinforcements e.g. deck slab girders, box girders, walls with thickness less than 300 mm	75-125

- **Requirements for Designed Mixes**

(1) Target Mean Strength

The target mean strength of specimen shall exceed the specified characteristic compressive strength by at least the current margin.

The current margin for a concrete mix shall be determined and shall be taken as 1.65 times the standard deviation of sample test results taken from at least 40 separate batched of concrete of nominally similar proportions produced at site by the same plant under similar supervision, over a period exceeding 5 days, but nit exceeding 6 months.

Concrete of each grade shall be analysed separately to determine its standard deviation. The standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete of that grade obtained as specified in the "Tests and Standards of Acceptance" of this section.

Estimated standard deviation Sd = V.I.A2 / (n -1)

Where, A is the deviation of the individual test strength from the average strength of n samples and n is the number of sample test results.

When significant changes are made in the production of concrete batches (for example changes in the materials used, mix design, equipment, or technical control), the standard deviation value shall be separately calculated for such batches of concrete and current margin as well as target mean strength shall be worked out again.

Where there is insufficient data to satisfy the above, the current margin for the initial design mix shall be taken as given in Table below

Table 2.5: Current Margin for Initial Mix Design

Concrete Grade	Current Margin (MPa)	Target Mean Strength (MPa)
M 15	10	25
M 20	10	30
M 25	11	36
M 30	12	42
M 35	12	47
M 40	12	52
M 45	13	58
M 50	13	63
M 55	14	69

The initial current margin given in the Table 2.5 shall be used till sufficient data is available to determine the current margin as per sub-clause (i) above

The concrete mixes shall be designed to produce the grade of concrete having the required workability, durability and characteristic strength.

(2) Trail Mixes

The initial trail mixes shall generally be carried out in an established laboratory. In all cases complete testing of materials forming the constituents of proposed Design Mix shall have been carried out prior to making trial mixes. When the site laboratory is utilized for preparing initial mix design, the concreting plant and means of transport employed to make the trial mixes shall be similar to that proposed to be used in the works. Test cubes shall be taken from trial mixes as follows.

For each mix, set of six cubes shall be made from each of three consecutive batches. Three cubes from each set of six shall be tested at an age of 28 days and three at an earlier age approved by the Engineer. The cubes shall be made, cured, stored, transported and tested in accordance with these specifications. The average strength of the nine cubes at 28 days shall exceed the specified characteristic strength by the current margin minus3.5 MPa.

(3) Control of Strength of Design Mixes

(i)Adjustment to Mix Proportion:

Adjustments to mix proportions arrived at in the trial mixes shall be made subject to the approval of Engineer, in order to minimise the variability of strength and to maintain the target mean strength. Such adjustments shall not be taken to imply any change in the current margin;

(ii)Change of Current Margin:

When required by the Engineer, the Contractor shall recalculate the current margin in accordance with procedure specified above. The recalculated value shall be adopted as consented by the Engineer, and it shall become the current margin fur concrete produced subsequently;

(iii)Additional Trail Mixes:

During production, the Contractor shall carry out trial mixes and tests, if required by the Engineer, before substantial changes are made in the material or in the proportions of the materials to be used, except when adjustments to the mix proportions are carried out in accordance with sub-clause (i) above

Additional Requirements

Additional requirements shall also consist of the following overall limits of deleterious substances in concrete:

The total chloride content of all constituents of concrete as a percentage of mass of cement in mix shall be limited to 0.15% for Reinforced Concrete Works.

The total sulphuric anhydride (SO_3) content of all the constituents of concrete as a percentage of mass of cement in the mix shall be limited to 4%.

Size of Coarse Aggregates

The size (maximum nominal) of coarse aggregates for concrete to be used in various components shall be 20mm for Reinforced Cement Concrete structures. The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

Batching & Mixing

In proportioning concrete, the quantity of cement, aggregate and water should be determined by weigh batching. Any solid admixture that may be added, may be measured by weight, liquid and paste admixtures by volume or weight. Batching plant should conform to IS 4925. All measuring equipment should be maintained in a clean serviceable condition and their accuracy periodically checked, Coarse and fine aggregates shall be batched separately. The grading of the aggregates should be controlled by blending the different sizes of aggregates in right proportion. The amount of added water shall be adjusted to compensate moisture contents in aggregates.

Concrete shall be mixed in a batching and mixing plant. Hand mixing shall not be permitted. The plant shall be at a location considering the properties of the mixes and the transportation arrangements available with the Contractor. Mixing shall be continued till materials are uniformly distributed and a uniform colour of the entire mass is obtained, and each individual particle of the coarse aggregate shows complete coating of mortar. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

Transportation, Placing & Compaction of Concrete

Concrete shall be transported and placed as near as practicable to its final position without re-handling, so that no contamination, segregation or loss of its constituent materials takes place. Concrete shall not be freely dropped into place from a height exceeding 1.5 meters.

Ready mixed Concrete:

(1) Ready Mixed Concrete may be used. It shall confirm to the specifications of concrete as specified herein and IS: 4926;

(2) The quality of admixtures like water reducing agent, retarders, super plasticisers cum retarders etc. should meet the requirements of section-"Materials for Structures" of these Specifications and its suitability tested as per IS: 9103 at the time of finalizing the mix design;

(3) Under any circumstances, retempering of concrete shall not be allowed;

(4) Ready mixed concrete shall be transported in transit agitators confirming to IS: 5892. Agitating speed of the agitators during transit shall not be less than 2 revolutions per minute and not more than 6 revolutions per minute; and

(5) The concrete shall be delivered completely to the site of work within 1½ hours (when the atmospheric temperature is above 20°C) and within 2 hours (when the atmospheric temperature is at or below 20°C) of adding the mixing water to the dry mix of cement and aggregate or adding the cement to the aggregate, whichever is earlier. Time of such introduction shall be recorded on the delivery note together with the weight of constituents of each mix. In case, location of site of construction is such that this time period is considered inadequate, increased time period may be specified provided that properties of concrete have been tested after lapse of the proposed delivery period at the time of finalising mix design.

When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of excessive quantity of water and without segregation of its ingredients.

In case of pumped concrete conveyed by pressure through rigid pipe or flexible hose and discharged directly into the desired area, the pumping rate should be 10 to 70m3 per hour. Effective pumping range is 300m horizontally and 90m vertically.

All formwork and reinforcement contained in it shall be cleaned and made free from standing water and dust.

All corners of concrete shall have chamfers of 25mm.

No concrete shall be placed in any part of the structure until the consent of the engineer has been obtained.

If concreting is not started within 24 hours of the consent being given, it shall have to be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a proper construction joint is formed.

Except where otherwise consented to by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 450 mm when internal vibrators are used. Concrete cover blocks of the same strength and density as parent concrete shall be used.

Concrete when deposited shall have a temperature of not less than5 degrees Celsius, and not more than 40 degrees Celsius, It shall be compacted in its final position within 30 minutes of its discharge fromthe mixer or agitator (in case of Ready Mixed Concrete) as the case may be,

No concrete shall be allowed without vibration except under water concreting or tremie concreting.

Concrete shall be thoroughly compacted by vibration during placing and worked around the reinforcement, tendons or duct formers, embedded fixtures and into corners of the formwork to produce a dense homogeneous void- free mass having the required surface finish. To achieve proper compaction mechanical vibrators shall be used. The vibrators can be internal or external type and depending on the shape and size of the member, both the types may be used in combination. When internal vibrators are used, they shall be used vertically to the full depth of the layer being placed and shall penetrate into the layer below while it is still plastic to the extent of 100mm. The vibrator shall be kept in place until air bubbles cease to escape from the surface and then withdrawn slowly to ensure that no hole is left in concrete, care being taken to see that it remains in continued operation while being withdrawn. Vibrators should not be used to move the concrete as it can cause honeycombing.

Internal vibrators shall be inserted in an orderly manner and distance between insertions should be about 1.5 times the radius of the area visibly affected by vibration. For horizontal and vertical operations of the vibrators, the spacing of points of vibration shall be such that the zones of influence overlap.

The use of vibrators complying IS: 2505, IS:2506, IS; 2514 and IS: 4656 for compacting the concrete is recommended. Over-vibration and under vibration of concrete should be avoided.

Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns.

Concrete should be compacted before setting commences and should not be subsequently disturbed

Bearing areas for members shall be finished to true plane so as to give uniform bearing on the entire area. Bearing plane shall be horizontal even for the bridges on grade.

Clear Cover to reinforcement

The minimum requirement of clear cover shall be as per above section. Clear cover shall not be less than the size of the bar or the maximum aggregate size plus 5mm. In case of a bundle of bars, it should be equal to or greater than the size of single bar of equivalent area plus 5mm.

Construction Joints

Construction joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown on the drawings, except with prior consent of the Engineer in case of emergencies. The joints shall be provided in a direction perpendicular to the member axis. Cold joints should be totally eliminated.

Concreting shall be carried out continuously up to the construction joints, the position and arrangement of which shall be predetermined by the designer.

Properly designed reinforcement shall be provided for transfer of full tensile stress across the joints prior to casting of the next lift.

Position of Construction Joints:

(1) Construction joints should be positioned to minimise the effect of the discontinuity on the durability, structural integrity and appearance of the structure;
(2) As far as possible, joints should be positioned in non-aggressive zones, but if aggressive zones cannot be avoided, joints should be sealed;
(3) Joints should be positioned where they are readily accessible for preparation and concreting, the preparation of the joints is more likely to be satisfactory where the cross section is relatively small and where reinforcement is not congested;
(4) As far as possible, joints for fair faced concrete should be located where they conform with the architectural features of the construction. Unless they are masked in this way, the position of the joints are always obvious, even when the concrete is given a textured finish;
(5) If substantial changes in the cross section of a member are necessary, the joints should be formed where they minimise stresses caused by temperature gradients and shrinkage; and
(6) Joints should be located away from regions of maximum stress caused by loading, particularly where shear and bond stress are high. Construction joints between slabs and ribs in composite beam should be avoided.

Preparing the surface of the Joint

(1) The minimum number of joints should be used and their construction should be simple. They should be either horizontal or vertical, because concreting sloping surfaces are usually unsatisfactory;
(2) Where concrete is placed in vertical members e.g. walls, columns and the like, the lift of concrete shall finish level or at right angles to the axis of the member, the joint line matching the features of the finished work. Concreting shall be carried out continuously upto the construction joint;
(3) Laitance, both on the horizontal and vertical surfaces of the concrete, should be removed before fresh concrete is cast. The surface should be roughened to promote good adhesion. Various methods for removal can be used but they should not dislodge the coarse aggregate particles. Concrete may be brushed with a stiff brush soon after casting while the concrete is still fresh, and while it has only slightly stiffened;

(4) If the concrete has partially hardened, it may be treated by wire brushing or with a high pressure water jet, followed by drying with an air jet, immediately before the new concrete is placed;
(5) Fully hardened concrete should be treated with mechanical hand tools or grill blasting, taking care not to split or crack aggregate particles;
(6) The best time for treating the joint is a matter of judgment because it depends on the rate of setting and hardening (which is itself dependent on the temperature of the concrete). Before further concrete is cast, the surface should be thoroughly cleaned to remove debris and accumulated rubbish, one effective method, being air jet;
(7) Where there is likely to be a delay before placing the next concrete lift, protruding reinforcement should be protected. Before the next lift is placed, rust, loose mortar or other contamination should be removed from the bars and where conditions are particularly aggressive and there has been a substantial delay between lifts, the concrete should be cut back to expose the bars for a length of about 50mm to ensure that contaminated concrete is removed; and
(8) In all cases, when construction joints are made, to essential it is ensured that the joint surface is not contaminated with release agents, dust or curing membrane, and that the reinforcement is fixed firmly in position at the correct cover.

Concreting at Construction Joints

(1) When the formwork is fixed for the next lift, it should be inspected to ensure that no leakage can occur from the fresh concrete. It is a good practice to fix 6mm thick sponge which seals the gap completely; and
(2) The practice of first placing a layer of mortar or grout is not recommended. The old surface should be soaked with water without leaving puddles, immediately before starting concreting, then the new concrete should be thoroughly compacted against it. When fresh concrete is cast against existing mature concrete, the older surface should be thoroughly cleaned and soaked to prevent the absorption of water from the new concrete. Standing water should be removed shortly before the new concrete is placed and the new concrete should be thoroughly vibrated in the region of the joint.

Concreting Under Water

When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used shall be subject to the consent of the Engineer before any work is started. The weight of the coarse aggregates shall not be less than one and half times, not more than twice that of the fine aggregate

Concrete shall not be placed in water having temperature below5 degrees Celsius, The temperature of the concrete, when deposited, shall not be less than 16 degrees Celsius, nor more than 40 degrees Celsius.

Coffer dams (wherever required) or forms shall be sufficiently tight to ensure still water conditions, if practicable, and in any case to reduce the flow of water to less than 3 meters per minute through the space into which concrete is to be deposited. Coffer dams or forms in still water shall be sufficiently tight to prevent loss of mortar through the joints in the walls. Pumping shall not be done while concrete is being placed or until 24 hours thereafter.

To minimise the formation of laitance, great care shall be exercised not to disturb the concrete as far as possible while it is being deposited.

All under water concreting shall be carried out by tremie method only using tremie of appropriate diameter. The number and spacing of the tremies should be worked out to ensure proper concreting. The concrete production and placement equipment should be sufficient to enable the underwater concrete to be completed uninterrupted within the stipulated time. Necessary stand-by equipment should be available for emergency situation.

Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation of seams avoided. In the exceptional cases of interruption of concreting which can be resumed within 2 hours, the tremie shall not be taken out of the concrete. Instead it shall be raised and lowered slowly from time to time to prevent the concrete around tremie from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200mm for easy displacement of partly set concrete. All tremie tubes shall be properly cleaned before and after use.

Tremie - The concrete should be coherent and slump shall be more than 150mm but it should not exceed 180mm. When concrete is carried out under water a temporary casing should be installed to the full depth of bore hole or 2m in to no collapsible stratum, so that fragments of ground cannot drop from the sides of the hole in the concrete as it is placed. The temporary casing may not be required except near the top when concreting under drilling mud. The hopper and tremie should be embedded in the placed concrete through which the water cannot pass. The top section of tremie shall be a hopper large enough to hold one entire batch of the mix or the entire contents of the transporting bucket if any. The tremie pipe shall be not less than 200mm in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of the water in which it is suspended, even if a partial vacuum develops inside the pipe. Preferably, flanged stee! pipe of adequate strength for the job should be used. A separate lifting device shall be provided for each tremie pipe with its hopper at the upper end. Unless the lower end of the pipe is equipped with an approved automatic check valve, the upper end of the pipe shall be plugged before deliverir concrete to the tremie pipe through the hopper, so that when the concrete is forced the hopper to the pipe, it will force the plug (and along with it any water in the pipe pipe and out of the bottom end, thus establishing a contiguous stream of concrete / necessary to raise the tremie pipe by 25cm to 30cm slowly in order to cause a uniform flow of the concrete, but the tremie shall not be emptied to avoid flow of water into the pipe. At all times even while changing/adding pipes to tremie, the bottom of tremie pipe shall be at least 600mm below the top of concrete as ascertained by sounding. This will cause the concrete to build up from below instead of flowing out over the surface, and thus avoid formation of laitance layers. If the charge in the tremie is lost while depositing, the tremie shall be raised above the concrete surface, and unless sealed by a check value, it shall be replugged at the top end, as at the beginning, before refilling for depositing concrete.

In case of withdrawal of tremie out of the concrete either accidentally or to remove a choke in the tremie, the tremie may be reintroduced in the following manner to prevent impregnation of laitance or scum lying on top of the concrete deposited in the bore. The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug should be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm should be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing the laitance/scum. The tremie will be pushed further in steps making fresh concrete sweep away the laitance/scum in its way. When tremie is buried by about 0.60m to 1.0m, concreting may be resumed.

In case of concreting through tremie or such tubes which are subsequently withdrawn, the concrete shall be placed in sufficient quantity to ensure that during withdrawal of the tube a sufficient head of concrete is maintained to prevent the in-flow of soil and water or bentonite slurry.

No concrete shall be allowed to come in contact with sea water within 72 hours of casting.

Protection & Curing

Concreting operations shall not commence until adequate arrangements for concrete curing have been made by the Contractor. Curing and protection of concrete shall start immediately after compaction of the concrete to protect it from:

(1) Premature drying out particularly by solar radiation and wind;
(2) High internal thermal gradients;
(3) Leaching out by rain and flowing water;
(4) Rapid cooling during the first few days after placing;
(5) Low temperature or frost;
(6) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement; and
(7) Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied.

Moist Curing

The concrete should be kept constantly wet for a minimum period of 14(fourteen) days. Water should be applied on unformed surfaces as soon as it can be done without marring the surface and on formed surfaces immediately after the forms are stripped. The concrete shall be kept constantly wet by ponding or covered with a layer of sacking, canvas, hessian or a similar absorbent material. When air temperature is expected to drop below 5°C during the curing period, additional covering of cotton/gunny bags, straw or other suitable blanketing material shall be provided so that concrete temperature at surface does not fall below 10°C.

Curing Compound

Approved curing compounds may be used in lieu of moist curing with the permission of the engineer. Such compounds shall be applied to all exposed surfaces of the concrete along with stripping of form work. Tests shall be done to ascertain:

(1) Loss of moisture in concrete with and without curing compound.
(2) Cube strength of concrete with moist curing and curing compound

Permeability of concrete

Curing compound shall not be used on any surface requiring further finishing to be applied. All construction joints shall be moist, cured and no curing compound will be permitted in locations where concrete surfaces are required to be bonded together.

Curing compounds shall be continuously agitated during use. Concrete to be cured by this method shall receive two applications of curing compound.

Steam Curing

Steam curing can be advantageously used to save time of curing of concrete for transfer of pre-stress. The optimum steam curing cycle for a particular situation can only be determined by trial and error. However, it has been found satisfactory to use a pre-steaming period of 4 to 5 hour or rate of temperature rise between 22-33°C per hour and a maximum curing temperature of 66-82°C for a period such that entire curing cycle does not exceed 18 hour. Rapid temperature changes during the cooling period should be avoided and drop in ambient temperature in the enclosure is not sharper than 20°C per hour. The reuse of casting beds and forms along with 18 hour steam curing makes it a total 24 hour cycle. Pre-stress to members in pretension beds should be transferred immediately after the termination of steam curing while the concrete and forms are still warm, otherwise the temperature within the enclosure shall be maintained at over 15°C until the pre-stress is transferred to the concrete. The steam curing will be considered complete when the concrete has reached the minimum strength at 'Strength at Stress transfer' or handling strength.

Finishing

Immediately after the removal of forms, exposed bars or bolts, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes filled with suitable epoxy mortar.

All construction and expansion joints in the completed work shall be left carefully tooled and free from any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

Immediately on removal of forms, the concrete work shall be examined by the Engineer before any defects are made good.

The work that has sagged or contains honeycombing to an extent detrimental to structural safety or architectural appearance shall be rejected.

Open Foundations

Where the bearing surface is earth, a layer of M-15 concrete shall be provided below foundation concrete. Thickness of lean concrete shall be 100mm minimum, unless otherwise specified.

Before laying lean concrete layer, the earth surface shall be cleaned of all loose materials. No construction joint shall be provided in lean concrete.

For foundation concrete work, side formwork shall be used. Form work for top of foundation shall also be provided, if top has slopes steeper than 1(vertical) to 3(horizontal). Where concrete is laid in slope without top form work, the slump of the concrete shall be carefully maintained to ensure that compaction is possible without slippage down of freshly placed concrete.

Foundation concrete of required dimensions and shape shall be laid continuously up to the location of construction joint shown on the drawings. Dewatering, where necessary for laying the concrete shall be carried out.

Form work shall be removed not earlier than 24 hours after placing of concrete. Where form work has been provided for top surface, the same shall be removed as soon as concrete has hardened.

Before backfilling is commenced, loose sand on foundation shall be removed & disposed. Protective works where provided shall be completed before the floods so that the foundation does not undermined.

- **Substructure**

Pier & Abutment

(a) In case of concrete piers, the number of horizontal construction joints shall be kept minimum. Construction joints shall be avoided in splash zones unless specifically consented by the Engineer and provided they are treated in accordance with special provisions. No vertical joint shall be provided;
(b) In case of tall piers and abutments, use of slip form shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which shall be furnished by the Contractor. The concrete shall also be subject to additional specifications as necessary;
(c) In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of abutment shall be followed by filling up of embankment in layers to the full height to allow for the anticipated movement during construction period before casting of super-structure; and
(d) Where pier type abutments are provided without wing walls and return walls, the earth fill around the abutment shall be protected by providing properly designed stone pitching an slopes and apron at toe of the fill.

Retaining wall

In case of cantilever return walls, no construction joint shall generally be permitted. For gravity type retaining walls, no horizontal construction joint shall be provided. Vertical expansion gap of 20mm shall be provided in retaining wall at every 10-meter interval.

Weep holes

Weep holes shall be provided through Retaining wall, abutments. Weep holes shall be provided with 100mm dia pipe for structures in plain / reinforced concrete. Weep holes in the ballast wall shall be provided with 75mm dia pipes. Weep holes shall extend through full width of the concrete with slope 1 vertical : 20 horizontal towards draining face. Spacing of the weep holes shall generally be 1m in either direction in a staggered manner with the lowest at about 150mm above the low water level or ground level whichever is higher.

- **Superstructure**

Prestressed Concrete Construction

(1) PSC Girder may be precast or cast- in-situ as consented by the Engineer. Girders shall be cast in single pour and may be post-tensioned or pre-tensioned. Where precast construction is required to be adopted, selection of casting yard and details of methodology and of equipment for shifting and launching of girders shall be subject to consent of the Engineer. In case of cast- in-situ construction, the sequence of construction including side shifting of girders, if applicable, and placing on bearings shall be subject to the consent of the Engineer. The PSC girder constituting the top flange, web and the bottom flange shall be concreted in a single operation without any construction joint. The portions of deck slab near expansion joints shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, if consented by the Engineer; and
(2) Box girders may be simply supported or continuous. Simply supported box girders. It shall preferably be cast in single pour. However if unavoidable due to exceptional cases, the construction joint may be provided subject to consent of the Engineer. In the case of continuous box girders the sequence of construction and location of construction joints shall be subject to consent of the Engineer. The portions of deck slab near expansion joints

shall be cast along with reinforcements and embedments for expansion joints. For this purpose, the portion of deck slab near expansion joints may be cast in a subsequent stage, subject to consent of the Engineer.

Tolerances

Tolerances for the finished concrete bridge structures shall be as specified in Table 2.6 below

Table 2.6: Tolerances for Finished Concrete Structures

Description	Tolerances
Shift from Alignment	25 mm
Deviation from plumb or specified batter for face of exposed retaining wall	1 in 250, subjected to a maximum value of 0.5 times the least lateral dimension of retaining wall.
Cross section dimensions of retaining wall	-5 mm +20 mm
Plan dimensions of footing (formed)	+50 mm -25 mm
Plan dimensions of footing (unformed excavation)	+75 mm -0 mm
Thickness of footing	+ No limit -5%
Footing eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm
Reduced level of top of footing	+-5 mm

Tests and Standards of Acceptance of Concrete

Concrete shall conform to the surface finish and tolerance as prescribed in these specifications for respective components

Random sampling and lot by lot of acceptance inspection shall be made for the 28 days cube strength of concrete.

Concrete under acceptance shall be notionally divided into lots for the purpose of sampling, before commencement of work. The delimitation of lots shall be determined by the following:

(a) No individual lot shall be more than 30 cu.m. in volume;
(b) At least one cube forming an item of the sample representing the lot shall be taken from concrete of the same grade and mix proportions cast on any day; and
(c) Different grades of mixes of concrete shall be divided into separate lots.

Sampling & testing

Concrete for making 3 test cubes shall be taken from a batch of concrete at point of delivery into construction, according to procedure hid down in IS: 1199.

A random sampling procedure to ensure that each of the concrete batches forming the lot under acceptance inspection has equal chance of being chosen for taking cubes shall be adopted.

150 mm cubes shall be made, cured and tested at the age of 28 days for compressive strength in accordance with IS:516. The 28-day test strength result for each cube shall form an item of the sample.

Test specimen and sample strength

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or for any other purpose. Additional cubes may also be required for testing cubes cured by accelerated methods as described in IS: 9013. The specimen shall be tested as described in IS: 516.

The test strength of the sample shall be the average of the strength of 3 cubes. The individual variation should not be more than $\pm$ 15 percent of the average.

Frequency: The minimum frequency of sampling of concrete of each grade shall be in accordance with Table 2.7 below:

Table 2.7: Minimum Frequency of Sampling of Concrete

S. No.	Quantity of concrete in work (m^3)	No. of samples
1	1-5	1
2	6-15	2
3	16-30	3
4	31-50	4
5	51 and above	4 plus one additional sample for each additional 50 m^3 or part thereof

Acceptance Criteria

(1) Compressive Strength: When both the following conditions are met, the concrete complies with the specified compressive strength:

(i)The mean strength determined from any group of four consecutive test results complies with the appropriate limits in Column A of Table below; and

(ii)Any individual test results complies with the appropriate limits in Column B of Table below.

(2)Flexural strength: When both the following conditions are met, the concrete complies with the specified flexural strength.

(i)The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm2; and

(ii)The strength determine from any test result is not less than the specified characteristic strength less 0.3 N/mm2.

Table 2.8: Characteristic Compressive Strength Compliance Requirement

Specified Grade	Group of Test Results	A	B
		The mean of the group of test result exceeds the specified characteristic compressive strength by at least:	**Any individual test resu lt is not less than the characteristic compressive strength less:**

M 20 & above	Any consecutive 4 samples	3 N/mm²	3 N/mm²

Quantity of Concrete Represented by Strength Test Results:
(i) The quantity of concrete represented by a group of 4 consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches;
(ii) For the individual test result requirements given in Column B of Table above or in item (ii) of para (2) above only the particular batch from which the sample was taken shall be at risk;
(iii) Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60m3.

If the concrete is deemed not to comply pursuant to the Flexural Strength Criteria, the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken:
(1) Concrete of each grade shall be assessed separately;
(2) Concrete shall be assessed daily for compliance; and
(3) Concrete is liable to be rejected if;
(i) It is porous or honey combed;
(ii) Its placing has been interrupted without providing a proper construction joint;
(iii) The reinforcement has been displaced beyond the tolerance specified; or
(iv) Construction tolerances have not been met.

However, the hardened concrete may be accepted after carrying out suitable remedial measures.

Stripping Time of Formwork:
(1) The scheme for removal of the formwork (i.e de-shuttering and de-centering) shall be planned in advance and shall be subject to consent of the Engineer. Formwork shall be so removed as not to cause any damage to concrete;
(2) Forms shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected at the time of removal of formwork. The strength referred to shall be that of concrete using the same cement and aggregates, with the same propositions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the formwork shall be left longer as it would assist the curing; and
(3) In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the periods as specified in Table below

Table 2.9: Stripping Time of Forms

Member	Minimum time for striping of the Form
Walls, Columns & Vertical faces of all structural members	24 to 48 hours
Slabs (Props left under)	3 days
Beam soffits (props left under)	7 days
Removal of props under slabs	

Spanning upto 4.5m Spanning over 4.5m	7 days 14 days
Removal of props under beams Spanning upto 4.5m Spanning over 4.5m	 14 days 21 days

(4) The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab or beam as the case may be together with any live load likely to occur during curing or further construction;
(5) Where the shape of the element is such that the formwork has reentrants angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed; and
(6) The forms should be so constructed as to be removable in the sections without marring or damaging the surface of the concrete. Forms should be removed as soon as possible in order to make necessary repairs and finish the surface. As soon as forms are removed, list of major/minor defects noticed in concrete should be prepared. Repairing methodology should be approved by the Engineer. After making necessary repairs, the surface should be finished with wood float so as to free from streaks, discolorations or other imperfections. Plastering should not be permitted and a steel trowel should not be used to finish surfaces.

- **Steel Reinforcements**

Material

All the materials for steel reinforcement shall confirm to the requirements as specified in section “Materials for Structures” of these Specifications.

Protective Coating

In order to offer adequate resistance against corrosion, reinforcement bars may be provided with suitable protective coating depending upon the environmental conditions. In aggressive environments (severe and extreme), application of cement slurry coating after removal of rust and other loose material from the surface of reinforcement bar will generally be sufficient. However specialist literature may be referred to in extreme exposure conditions.

Protection of Reinforcement

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paint. This may be ensured either by using reinforcement fresh from factory or thoroughly cleaning all reinforcement to remove rust using any suitable method such as sand blasting, mechanical wire brushing.

Portion of uncoated reinforcing steel and dowels projecting from concrete shall be protected within one week after initial placing of concrete with neat cement mixed with water to a consistency of thick paint. This coating shall be removed not more than one week before placing of the adjacent pour concrete. If the coating on the bar is damaged during transportation or handling and cannot be repaired shall be rejected.

Bending of Reinforcement

Bars shall be bent cold Bars shall not be bent or straightened in a manner that will damage the parent material or the coating. Bars shall not be heated to facilitate straightening. Any reinforcement, which is bent, should not be rebent at the location of the original bend. Where the temperature of steel is below 5°C, special precautions may be necessary such as reducing the speed of bending or with the Engineer's approval, increasing the radius of bending. Reinforcement shall be bent and fixed in accordance with the procedures specified in IS: 2502 and shall not be straightened that will injure the material.

Placing of Reinforcement

(1) All reinforcement shall be placed and maintained in the position as shown in the drawings;

(2) Cover and spacing of steel shall be uniform and as specified in the Specifications and as shown in the drawings;

(3) Reinforcement steel shall be adequately secured and bound together at all intersections with 1.6mm dia. mild steel wire in accordance with IS:280 or approved reinforcement clips so that it maintains its position during casting and vibration of concrete. Free ends of the binding wires used to tie bars shall be bent into the member. For aggressive environment, galvanized binding wire shall be used;

(4) Crossing bars should not be tack welded for assembly of reinforcement;

(5) All steel fabrics shall be lapped two meshes unless otherwise shown on the drawing and securely bound to the supporting bars with 1.6mm dia mild steel wire (IS:280) or approved reinforcement clips;

(6) Sufficient spacers shall be provided as shall, be necessary to maintain specified concrete cover to the reinforcement and preventing displacement before and during the placement of the concrete. Spacers should be of such material and design as will be durable, will not lead to the corrosion of reinforcement and will not cause spalling of concrete cover. Spacer block made from cement, sand and small aggregates should match the mix proportion of concrete as far as is practicable with a view to being comparable in strength, durability and appearance. Use of wood, tile or porous material will not be allowed for this purpose. Concrete cover blocks shall contain the binding wire to secure it to the reinforcement;

(7) Subject to the reduction in bond stress, bars may be arranged as pairs in contact or in groups of three or four bars bundled in contact. Bundled bars shall be tied together to ensure the bars remaining together. Bars larger than 32mm diameter shall not be bundled except in columns. Bars shall not be used in a member without stirrups. Bars in a bundle should terminate at different parts spaced at least 40 times the bars size apart except for bundles stopping at support;

(8) Layers of reinforcements shall be separated by spacer bars at approximately one-meter intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater;

(9) Reinforcements bars shall be adequately secured by chairs/ties/hangers so that it will maintain its position during casting and vibration of concrete;

(10) The coated reinforcing steel shall be held in place by use of plastic-coated binding wires especially manufactured for the purpose; and

(11) No concreting shall be done until the reinforcement has been inspected by the Engineer.

Bar Splices

(1) Lapping:

(i) All reinforcement shall be furnished in full length as indicated in drawings. No splicing of bars, except where shown on the drawings will be permitted without consent of the Engineer. Lengths of splice, wherever required, shall be as indicated on drawings and consented by Engineer. Lapped splices shall be staggered & located at points along the span where stresses are low;

(ii) Lap Length : Lap splices shall not be used for bars larger than 32 mm. When bars are lapped, the length of the lap shall at least equal the anchorage length required to develop the stress in smaller of the two bars lapped. Length of lap provided, however shall neither be less than 25 times the smaller bar size plus 150mm in tension reinforcement nor be less than 20 times the smaller bar size plus 150mm in compression reinforcement; and

(iii) The lap length calculated in the preceding paragraph shall be increased by a factor of 1.4 if any of the following conditions apply:

(a) The nominal cover to the lapped bars from the top of the section as intended to bed cast is less than twice the bar size;

(b) The clear distance between the lap and another pair of lapped bars is less than 150 mm;

(c) A corner bar is being lapped and the nominal cover to either face is less than twice the bar size;

(d) Where conditions (a) and (b) or conditions (a) and (c) apply the lap length shall be increased by a factor of 2.0;

(e) Lap splices are considered to be staggered if the centre to centre distance of the splices is not less than 1.3 times the lap length; and

(f) In case of bundled bars, lapped splices of bundled bars shall be made by splicing one bar at a time; such individual splices within a bundle shall be so staggered that in any cross section there are not more than four bars in a bundle.

(2) Welding Joints or Mechanical Connections:

Welded joints or mechanical connections in reinforcement may be used with the approval of the Engineer but in the case of important connections, test shall be made to prove that the joints are of the full strength of bars connected. All welders and welding operators to be employed shall have to be qualified by tests prescribed in IS: 2751 and inspection of welds shall conform to IS: 822.

Welded joints may be permitted in cold worked bars conforming to IS: 1786 provided that the carbon equivalent calculated from the chemical composition of the bar is 0.4% or less. Welding of the cold worked bars may be done in accordance with the recommendations of IS: 9417. When cold-worked bars are welded, the stress at the weld should be limited to the strength of mild steel bars without cold-working.

Welded joints should not be located near the bends in the reinforcement. Wherever possible, joints in the parallel bars of principal tensile reinforcement should be staggered. The welded joints may preferably, be placed in region^ low stresses.

Bars may be joined with mechanical devices eg. by special grade steel swaged on to bars in end to end contact or by screwed couplers or using bottle nuts.

- **Inspection & Maintenance of PSC I-Girder:**

Cracking in Prestressed Concrete Structures:

Cracking can occur in the vicinity of anchorages on account of bursting and spalling forces. At midspan, the cracking in the tensile face may be on account of higher super imposed loads. Cracks can appear in the compressive face because of higher initial prestressing force but such cracks close up under the passage of trains.

Cracking in PSC girders can occur in many cases because of construction sequence, e.g. the 'I' girders are precast and the transverse RCC slab and diaphragms are cast in place after erection of the girders. This sequence can lead to cracks at the interface of RCC slab and top of precast 'I' girder and interface of diaphragms and webs of 'I' girder (Fig. below). These cracks basically occur on account of differential shrinkage between the concrete of pre-cast element and cast-in-place element. Obviously, these cracks cannot be avoided and should not be viewed as serious cracks at the first instance. They must be kept under observation along with the camber of the girder. These cracks may be grouted / sealed. But before taking any remedial action, these should be kept under watch and allow them to develop fully, otherwise after any grouting these cracks can reappear.

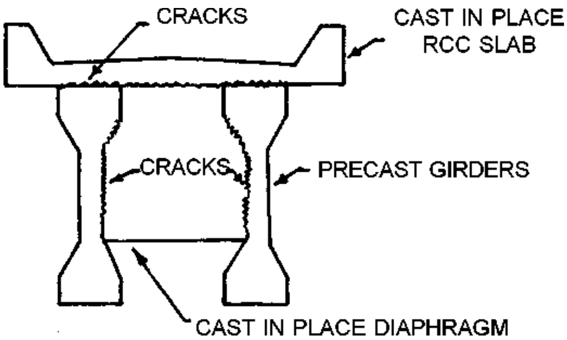


Figure 2.86: Cracks at interface of precast and cast in place concrete elements

Loss of Camber:

Indian Railways Bridge Manual (IRBM), 1998 vide Para 1107.15 prescribes yearly recording of camber at centre of span. The camber of prestressed concrete girders should be recorded and compared with the previous values. Temperature has great influence on the deflection. Therefore, temperature of girder should be recorded and the deflection should be measured around the same temperature at which it was originally done. For camber measurement, method given in IRBM at Annexure 11/ 4 or any other suitable method may be adopted.

Loss of camber may be caused by:

1.Settlement
2.Overloading
3.Deterioration of concrete
4.Stress corrosion of reinforcement
5.Loss of prestress

Progressive loss of camber is an important indication of deterioration in the condition of bridge and, therefore, should be thoroughly investigated. Any loss of camber may indicate serious problem at the interface at the junction of 'I' girder and slab.

Locations to be specifically looked for defects:

Table below lists out the salient defects, which should be specially looked for during general /routine inspection of various elements of Prestressed Superstructure.

Table 2.142: Defects to be looked during routine maintenance

Location	Look for

All over	• General condition of the structure and prestressed components in particular condition of concrete • corrosion signs • Scaling of concrete • Spalling of concrete • Efflorescence • Condition of construction joints
Anchorage Zone (at deck slab)	• Cracks Bursting/ crushing at the time of Stressing and subsequent poor sealing of cracks • Rusting • Condition of cable end sealing
Top and bottom of deck slab	• Cracks developed due to excessive tension Delamination Blocking of drainage Worn out wearing coat • Damage by abrasive action of ballast (once in 5 years) • Seepage • Corrosion signs • Leaching • Scaling • Damage due to accident or any other causes
Top and bottom flange of l-girder	• Spalling/scaling • Rust streak along reinforcements/cable cracks
Diaphragms	• Cracks at junction • Diagonal cracks at corners • Diagonal/vertical cracks around opening • Conditions of diaphragm opening
Junction of slab and girder (in case of girders)	• Separation

Non-Destructive Testing:

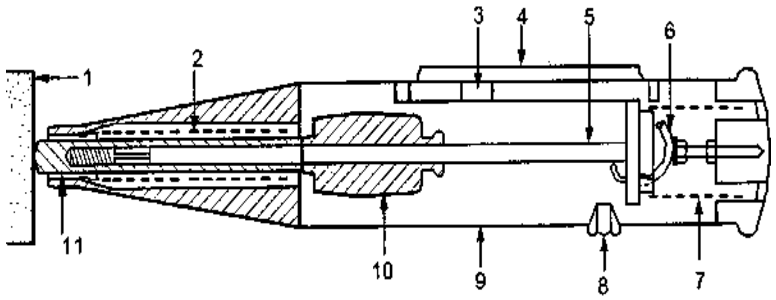
The present method of bridge inspection is mostly visual which enables subjective assessment of the condition of the bridge. Moreover, visual inspection system is not capable of assessing hidden defects, if any. For detailed and quantitative assessment of the health of the bridge, non-destructive tests (NDT) should be used.

A variety of non-destructive methods are available which can be used for estimation of strength and other properties of bridge structures. These methods can be used individually or in combination to assess the various properties of structures.

The various NDT methods for assessing the condition of concrete bridges are given below:

Rebound hammer (Schmidt Hammer):

This is a simple, handy tool, which can be used to provide a convenient and rapid indication of the compressive strength of concrete. It consists of a spring-controlled mass that slides on a plunger within a tubular housing. The schematic diagram showing various parts of a rebound hammer is given in below figure:



1. Concrete surface; 2. Impact spring; 3. Rider on guide rod; 4. Window and scale; 5. Hammer guide; 6. Release catch; 7. Compressive spring; 8. Locking button; 9. Housing; 10. Hammer mass; 11. Plunger

Figure 2.87: Components of Rebound Hammer

The test is based on the principle that the rebound of an elastic mass depends on the hardness of the surface against which mass strikes. When the plunger of rebound hammer is pressed against the surface of the concrete, the spring controlled mass rebounds and the extent of such rebound depends upon the surface hardness of concrete. The surface hardness and therefore the rebound is related to the compressive strength of the concrete. The rebound value is read off along a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

Ultrasonic pulse velocity tester:

Ultrasonic instrument is a handy, battery operated portable instrument used for assessing elastic properties or concrete quality. The apparatus for ultrasonic pulse velocity (UPV) measurement consists of the following equipments

(a)Electrical pulse generator
(b)Transducer – one pair
(c)Amplifier
(d)Electronic timing device

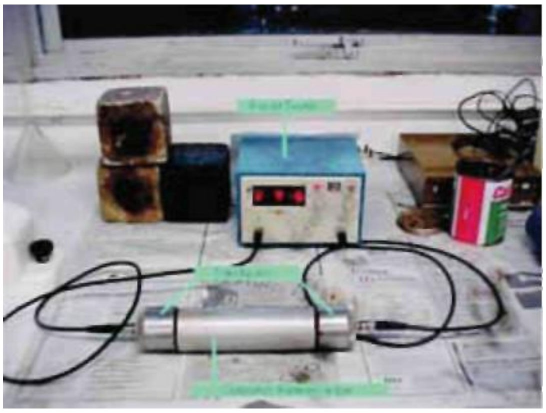


Figure 2.88: Ultrasonic pulse velocity equipment

The method is based on the principle that the velocity of an ultrasonic pulse through any material depends upon the density, modulus of elasticity and Poisson's ratio of the material. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity etc. The ultrasonic pulse is generated by an electro acoustical transducer. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves is developed which includes longitudinal (compression), shear (transverse) and surface (Reyleigh) waves. The receiving transducer detects the onset of longitudinal waves, which is the fastest.

For good quality concrete pulse velocity will be higher and for poor quality it will be less. If there is a crack, void or flaw inside the concrete, which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passed around the discontinuity, thereby making the path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the materials and mix proportions of concrete. Density and modulus of elasticity of aggregate also significantly affect the pulse velocity.

The quality of concrete in terms of uniformity can be assessed using the guidelines given in the Table below.

Table 2.143: Criterion for concrete quality grading (As per IS 13311(Part 1) : 1992)

Sr. No.	Pulse velocity in km/sec.	Concrete quality grading
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3.0	Doubtful

Pull-off test:

Pull-off tester is microprocessor based, portable hand operated mechanical unit used for measuring the tensile strength of in-situ concrete. The tensile strength obtained can be correlated with the compressive strength using previously established empirical correlation charts. The apparatus for pull off test consists of 50 mm diameter steel disk and a pull-off tester. One commercially available pull-off tester is shown in Figure below.

The pull-off test is based on the concept that the tensile force required to pull a metal disk, together with a layer of concrete, from the surface to which it is attached, is related to compressive strength of concrete. In this test, a steel disk is glued to the surface of the concrete with the help of epoxy resin. A pulling force on the metal disk through a bolt screwed axially to it is applied and the disk together with a layer of concrete is jacked off. From the recorded tensile force a nominal pull-off tensile strength is calculated on the basis of the disk diameter (usually 50 mm). To convert this pull-off tensile strength into a cube compressive strength, a previously established empirical correlation chart is used.

Pull-out Test:

The pull-out test measures the force required to pull an embedded metal insert with an enlarged head, from a concrete specimen or a structure. Figure below illustrates the configuration of a pull-out test.

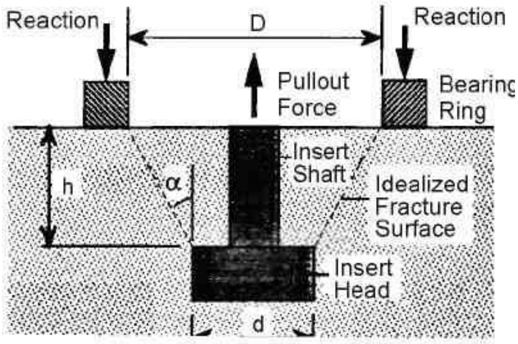


Figure 2.89: Arrangement for Pull-off test

The test is considered superior to the rebound hammer and the penetration resistance test, because large volume and greater depth of concrete are involved in the test. The pull-out strength is proportional to the compressive strength of concrete. The pull-out strength is of the same order of magnitude as the direct shear strength of concrete and is 10 to 30% of the compressive strength. The pull-out test subjects the concrete to slowly applied load and measures actual strength property of the concrete.

Penetration Resistance Test (Windsor Probe):

The Windsor Probe is basically a hardness tester and provides an excellent means of determining the relative strength of concrete in the same structure or relative strength in different structures. This test is not expected to determine the absolute values of strength of concrete in the structure.

This test estimates the strength of concrete from the depth of penetration by metal rod driven into concrete by a specific amount of energy generated by standard charge of powder. The penetration is inversely proportional to the compressive strength of concrete. In other words, larger the exposed length of the probe, greater the compressive strength of concrete.

In this test, a probe of diameter 6.35 to 7.94 mm and length of about 79.5 mm is used. Probe is threaded into the probe driving head and fired into the concrete using a template. Exposed length is correlated to the compressive strength of the concrete.

This test can be used for testing compressive strength of concrete and gives strength up to 75 mm below surface. The local damage caused to the member may be repaired. There are requirement of minimum edge distance, probe spacing and member thickness. If the minimum recommended dimension is not complied with, there can be danger of splitting of members.

Rebar locators:

These are portable, battery operated equipments used for measuring the depth of cover concrete; location and size of steel reinforcement embedded in the concrete. The equipment consists of data logger, diameter probe, depth probe and calibration block. The equipment works on normal batteries and thus does not require any electric connection. The equipment is available with different commercial names i.e. Pachometer, Profometer, Fe-Depth meter etc. The instrument is based upon measurement of change of an electromagnetic field caused by the steel embedded in the concrete. The reinforcement bar is detected by magnetizing it and inducing a circular eddy current through it. After the end of pulses the eddy current dies away, creating a weaker magnetic field as an echo of the initial pulse. This eddy current echo is measured which gives indication about the depth of the bar, the size of bar and orientation of the bar.

Before conducting core cutting in reinforced concrete, this test is required to be conducted to locate the position of rebars. Proper access is essential for carrying out field measurement. Cover to reinforcement can be measured up to 100 mm with an accuracy of – 15% and bar diameter with accuracy of 2 to 3 mm.

Covermeter:

The equipment is similar to rebar locator and used for locating reinforcement and estimation of its cover. It consists of a highly permeable U-shape magnetic core on which two coils are mounted. When an alternating current is passed through one of these coils, the current induced in the other coil can be measured.

The cover is measured by placing the probe over the surface of the concrete and dial reading directly gives the cover to the reinforcement depending upon the diameter of the bar.

For locating the reinforcement, the search head is moved slowly from one end to another end in perpendicular direction to main bars. The sound of buzzer/beep will be strongest when the bar will come just above or below the probe, thus the location of main bar is detected.

Half-Cell Potential measurement:

This test is useful for monitoring corrosion in the reinforcement. When there is active corrosion, current flow through the concrete between anodic and cathodic sites is accompanied by an electric potential field surrounding the corroding bar. The equi-potential lines intersect the surface of the concrete and the potential at any point can be measured using the half-cell potential method.

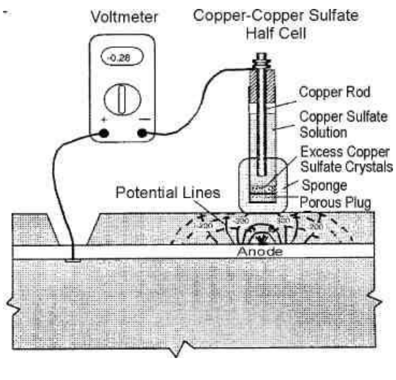


Figure 2.90: Apparatus for Half-Cell Potential measurement

The apparatus includes copper-copper sulphate half-cell, connecting wires and a high impedance voltmeter. This half-cell is composed of a copper bar immersed in a saturated copper sulphate solution. It is one of the many half cells that can be used as a reference to measure the electrical potential of embedded bars. A high impedance voltmeter (normally greater than 10 M) is used so that there is very little current through the circuit. The copper-copper sulphate half-cell makes electrical contact with the concrete by means of porous plug and a sponge that is moistened with a wetting solution (such as liquid detergent).

The half-cell potential readings are indicative of the probability of corrosion activity of the reinforcing bars located beneath the copper-copper sulphate reference cell. However, this is true only if that reinforcing steel is electrically connected to the bar attached to the voltmeter.

Resistivity test:

This instrument is used to measure the electrical resistance of the cover concrete. This method indicates the likelihood of corrosion of steel and the location where corrosion is likely to occur. The resistivity test combined with Half Cell potentiometer test gives more reliable results about the corrosion condition of the rebar. This is based on the principle that the corrosion of steel in concrete is an electro-chemical process, which generates a flow of current and can dissolve metals. The lower the electrical resistance, more readily the corrosion current flows through the concrete and the greater is the possibility of corrosion.

Figure 2.91: Resistivity meter

The limits of possible corrosion are related with resistivity as under –
when $p \geq 120\Omega$-m- Corrosion is unlikely
when p = 80 to 120Ω-m - Corrosion is possible
when p < 80 0Ω-m- Corrosion is fairly certain
Where, (p) is resistivity.

Test for carbonation of concrete:

Carbonation of concrete in cover results in loss of protection to the steel against corrosion. The depth of carbonation can be measured by spraying the freshly fractured concrete surface with a 0.2% solution of phenolphthalein in ethanol. Since phenolphthalein is a pH indicator, the area with pink colour presents uncarbonated concrete and the remaining (colourless) portion, the carbonated area. The change in colour occurs at around pH 10 of concrete.

The test must be applied only to freshly exposed surfaces, because reaction with atmospheric carbon dioxide starts immediately. Relating carbonation depth to concrete cover is one of the main indicators of corrosion.

Test for chloride content of concrete:

The presence of chloride in the concrete is the contributory factor towards corrosion of reinforcement.

Portable equipments are available in the market, which can be used for rapid on site measurement of chloride content of concrete. The chloride content of concrete can also be determined by chemical analysis of concrete in the laboratory.

A rotary percussion drill is used to collect a pulverized sample of concrete and a special acid extracts the chlorides. The amount of acid soluble chloride is determined directly by a chloride sensitive electrode connected to a electrometer.

If different samples are obtained from different concrete depths, it can be established whether the chloride contamination was there in the original concrete or the same has come from the environment.

Acoustic Emission technique:

This method can be used for detection of cracks in concrete as well as steel structures. This method can be helpful in determining the internal structure of the material and to know the structural changes during the process of loading.

Acoustic emission is the sound (both audible and sub-audible), that are generated when a meterial undergoes irreversible changes, such as those due to craking. In general, acoustic emissions are defined as the class phenomena whereby transient elastic waves are generated by the rapid release of energy from localised sources within a material. These waves propagate through the material and their arrival at the surface can be detected by the piezoelectric transducers.

Acoustic emission test may be carried out in the laboratory or in the field. Basically one or more acoustic emission transducers are attached to the specimen. The specimen is then loaded slowly and the resulting acoustic emissions recorded for further processing. The test is generally conducted in two ways:

(1) When the specimens are loaded till failure to know about structural changes during loading;

(2) When the specimen are loaded to some predetermined level to assess whether the material meets certain design or fabrication criteria.

Endoscopy Technique:

Endoscopy consists of inserting a rigid or flexible viewing tube into holes drilled into concrete bridge components or cable ducts and view them with light provided by optical glass fibers from an external source. This is a most useful method for inspecting or detecting voids in the grout and corrosion in steel in the cable ducts. It is also useful for detail examination of other part of the bridge structure, which could not otherwise be assessed. Endoscopes are available as attachments for a camera or a TV monitor. It, however, needs an experienced engineer to make assessment of most likely locations of voids in the grout and probable points of entry of chlorides into the ducts.

Boroscope:

Tis method can be used for concrete, steel and masonry structures. The method is most commonly used on concrete and masonry structures. A boroscope is used to look inside inaccessible or small voids. For example, if cable ducts are not injected, it is possible to inspect the strands by means of an endoscope through a contact drilling (here a drilled hole from the surface to the cable duct). For steel structures the method is usually used for investigation of closed profiles to gain information regarding the condition of the interior surfaces of the closed profiles.

- **Maintenance:**

Bridges represent a considerable capital asset not only because of the heavy investment required in constructing or replacing them but also because some of them form part of the historic and cultural heritage of a country. None of the bridges is endowed with an eternal life. Lack of maintenance generally results in reduced life and deterioration in the bridge structure. The adage “Prevention is better than cure” and “A stitch in time saves nine” are eminently true for bridges, where defects can rapidly lead to serious consequences if action is not taken in time. Demands made on bridges as also problems in attending to them have increased over the years. Therefore, it is essential to prolong the life of structures and rehabilitate them wherever necessary and possible.

Symptoms and remedial measures:

Some of the common symptoms and remedial measures thereof are listed below:

Nature of Problem	Remedial measures
PSC Girders:	
Cracks in anchorage zone	Epoxy grouting Replace the girder
Spalling/crushing	Guniting
Shear cracks, Flexural cracks	Epoxy grouting.

- **Repairs:**

  The Important defect in concrete structures, which require repairs are:
  a) Hollowness of the structure;
  b) Honeycombed concrete;
  c) Cracks;
  d) Disintegration of material; and
  e) Loose joints due to leaching etc.

Cement pressure grouting and epoxy injection can be adopted for repairing deficiencies a, b and c above. For repairing the disintegrated masonry concrete or spalled concrete, guniting is normally done.

Before attempting repair of any crack, a full investigation should be made to determine the cause of the crack and remedial action taken. Cracks may be separated into two classes for the purposes of deciding upon the type of repair.

i) Dormant cracks which are not likely to open, close or extend further. These are also called ‘dead’ cracks; and

ii) Live cracks which may be subjected to further movement. If repairs do not have to be carried out immediately, observation over a period of time will enable cracks to be classified and will assist diagnosis of the cause.

In prestressed concrete structures, the cracks may also occur due to degradation of concrete, corrosion of reinforcement and structure’s mechanical behavior.

Repair of cracks in prestressed concrete girders:

In reinforced concrete, cracks wider than 0.3 to 0.4 mm should be sealed and filled with injection. A crack resulting from a rare load-application can be repaired (if it is wider than 0.3 to 0.4 mm) by pressure injection with a suitable epoxy formulation so that the integrity is restored. Dormant cracks in excess of about 0.4 mm width, must be cleaned and then filled and sealed with epoxy injection for widths upto about 2 to 3 mm, and with fine cement grout for wider cracks.

Materials used for filling the cracks:

The material used for crack injection must be such as to penetrate easily into the crack and provide durable adhesion between the cracked surfaces. Currently, the following fluid resins are used for crack injection (together with hardeners):

i) Epoxy resin (EP);
ii) Polyurethane resin (PUR);
iii) Acrylic resin; and
iv) Unsaturated polyester resin (UP).

The formulations of commercially available injection resins vary widely in their properties, and care must be exercised in making proper selection. Important properties of any injection resin are its resistance to moisture penetration and alkaline attack from the cement. Where tensile strength is a requirement, the tensile strength of the resin should approach that of the concrete as closely as possible. Therefore, a stiff and highly adhesive resin is desirable. These properties are available in epoxy or unsaturated polyester resins. After hardening of the injection material, the ‘stiffness’ of crack will depend upon the elasticity of the resin.

The polyurethane or acrylic resin is recommended where moisture resistance is a requirement. Some epoxy based low-viscous resin will penetrate to the crack-root even when the crack width at the surface is only about 0.2 mm. Comparable results can be obtained from unsaturated polyester and polyurethane resins. Acrylic resins are capable of sealing fine cracks because of their low viscosity. However, in all cases, this requirement can only be fulfilled with an appropriately long ‘reaction time’. Fast reactive systems will only close the crack at its surface, which may not be desirable.

Although cement paste is relatively inexpensive, its use is limited to crack widths of approximately 2 mm or more because of its limited viscosity. Cement glues and mortars are of importance in such applications as injection of voids, hollows, cavities, honeycombing, and sealing of ducts, etc. For these applications the use of appropriate additives is recommended to reduce viscosity, shrinkage and the tendency for settlement. Improvement of workability will be obtained if the cement suspension is formed by using high speed mixers.

The following table gives general idea about selection of materials for repair of cracks.

Table 2.144: Selection of materials for repair of cracks

Type of Crack	Width (mm)	Type of material	Mode of application and/or principle
Shrinkage cracks	<0.2	Two component epoxy injection	Surface treatment which works through capillary action
Structural cracks	0.2-1.0	Two component epoxy injection	Low pressure treatment which works through capillary action
	1.0-2.0	Two component epoxy injection and solvent free epoxy	Low pressure injection
	2.0-5.0	Solvent free epoxy thixotropic	Low pressure injection with hand pump
	5.0-15.0	Polymer modified cement based grout	Grout with injection by gravity or hand pump
	>15.0	Non shrink grout	Cut and fill non-shrink grout

Crack injection steps:

As a rule, the following steps are necessary for injection:
i) Thoroughly cleaning the cracks with high pressure clean air;
ii) Drilling the injection holes and blowing-clean the holes and cracks. Space the ports at the desired depth of penetration since the resin generally travels as far into the crack as along the face of the crack. If the cracks are less than 0.2 mm wide, entry ports should not be spaced more than 150 mm apart. If the cracks are more than 600 mm in depth, intermediate ports should be inserted. Port spacing in cracks extending the full depth of the member are given in below table;

Table 2.145: Spacing of Ports

Thickness of member (m)	Ports on one side or all sides	Spacing of ports
0.3 & less	One side	Thickness of member.
0.3 – 0.6	All available sides	Not greater than thickness of member.
Greater than 0.6	All available sides	Thickness of member with immediate ports.

iii) Fixing of flanged injection nipples along the cracks. A 'V' groove may be cut near the ports for facilitating proper fixing of the nipples;
iv) Covering the crack surface between nipples by a thixotropic liquid sealant.
v) Mixing the injection material;
vi) Injecting the injection material through the nipples against gravity (unless the crack is horizontal), in a progressive serial order; and
vii) Re-injection and testing, if required or found necessary.

Injection equipment and injection process:

Different injection equipments are available, depending on whether the materials are premixed or used separately. In the case of 'premixed components' equipment, the resin and hardener are mixed first and subsequently injected into the crack using this equipment.

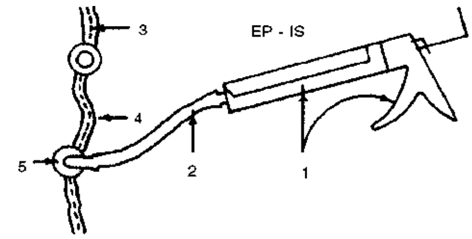
Typical 'premixed components' equipment consists of:
i) A hand grease gun;
ii) An air pressure tank;
iii) A high pressure tank; and
iv) A hose-pump

With these equipment, rather high pressures can be applied. The pot life of the mixture is an important parameter in the application by such equipments.

Therefore, the length of the crack that can be injected in one go is subject to the volume of material mixed for use and its pot life.

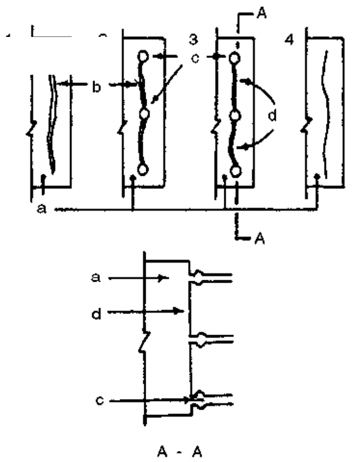
In the case of 'separate components' equipment, resin and hardener are separately transported to the 'mixing-head' by means of fully automatic dispensing equipment. Therefore, pot-life is only of secondary importance here.

A distinction must be made between low pressure injection (upto 2 MPa) and high pressure injection (upto 30 MPa). The penetration speed of the injection resin does not increase proportionately, with increasing pressure.



1. Injection gun. 2. Plastic tube. 3. Crack 4. Thixotropic compound. 5. Flanged injection nipple.

FIG. 7.4 a CRACK INJECTION



1. Untreated crack in face of wall 2. Crack cleaned and injection nipples fixed 3. Crack sealed with thixotropic compound and ready for injection 4. EP-IS system injected and nipples removed

(a) Concrete wall (b) Crack (c) Injection nipples
(d) Adhesive securing nipples and sealing cracks

Fig. 7.4 b Sequence of operation

Figure 2.92: Crack Injection and Sequence of Operation

The viscosity of the resin strongly influences the rate of injection, especially for small crack widths and in reaching the crack root.

Spalled Concrete - Hand applied repairs:

In the case of repair to spalled concrete, it is particularly necessary to distinguish between mechanical damage caused by corrosion of reinforcement. Mechanical damage is usually relatively simple to repair. Corrosion of reinforcement, however, may be caused by contamination of the concrete with aggressive ions such as chlorides or by reduction in alkalinity of the concrete, and in either case restoration of the damaged member to its original state may be inadequate.

Preparation:

Whatever the cause of damage, preparation of the structure for repair is vitally important. Application of a sound patch to an unsound surface is useless because the patch will eventually come away, taking some of the unsound material with it. Similarly, contamination that has once caused trouble must not be allowed to remain where it is likely to cause trouble again. Any attempt to take short cuts over preparation is a false economy.

The first step must be to remove unsound concrete. The area to be cut out should be delineated with a saw, cut to a depth of about 5 mm in order to provide a neat edge but the remainder of the cutting out can be done with percussive tools. Feather edges should be avoided if at all possible - edges should be cut for a depth of at least 10 mm as shown in **Figure 2.93**. If any corroded reinforcement is present, the concrete should be cut back far enough to ensure that all corroded areas are exposed so that they can be cleaned.

Dust should be removed, as far as possible, from the surface of the concrete before patching material is applied, especially when resin-based compounds are to be used. Oil free compressed air jets are effective on small areas but they merely tend to redistribute dust on large areas. For these, industrial vacuum cleaners can be more effective.

Choice of material:

The basic choice of repair system is between those based on Portland cement and those based on synthetic resins. In reinforced concrete, they protect reinforcement from corrosion in different ways. Cement based materials provide an alkaline environment for the steel (pH of the order of 12) and, in these conditions, a passivating film forms on the surface of the steel. Corrosion will occur if the alkalinity of the concrete surrounding the steel is reduced by carbonation i.e. a penetration of carbon dioxide from atmosphere or if aggressive ions such as chlorides are present. Consequently, the provision of an adequate thickness of dense concrete cover is important. Resin based materials do not generally provide an alkaline environment; they normally rely for their protective effect on providing cover that will exclude oxygen and moisture, without which corrosion would not take place.

Application of cement-based system:

After the surface has been prepared, a bonding coat should be applied to all exposed surfaces. It can consist of slurry of cement and water only; but it is always desirable to incorporate a polymer admixture.

Typical proportions would be two part (by volume) cement to one part polymer latex, but the supplier's advice may vary. The first layer of patching material should be applied immediately after the bonding coat, while the latter is still wet. If some delay is inevitable, there are resin-based bonding agents that have a longer 'open time' than cement slurry. If reinforcing bars cross the repair they may provide a good mechanical anchorage for the patch, especially if the concrete has been cut away behind them.

Hand applied repairs usually consist of cement and sand mortar in proportions of 1:2.5 or 1:3, using coarse sand. If a smooth surface finish is required it may be necessary to use finer sand for the final layer. Repair mortar should be as stiff as possible consistent with full compaction and it should be rammed into place as forcibly as possible. An experienced operator can judge the degree of workability that is best suited to a particular job.

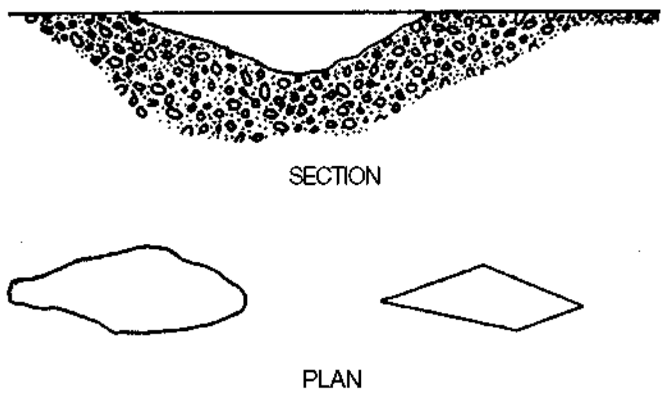


Fig 7.5 (a) Incorrect method of cutting out

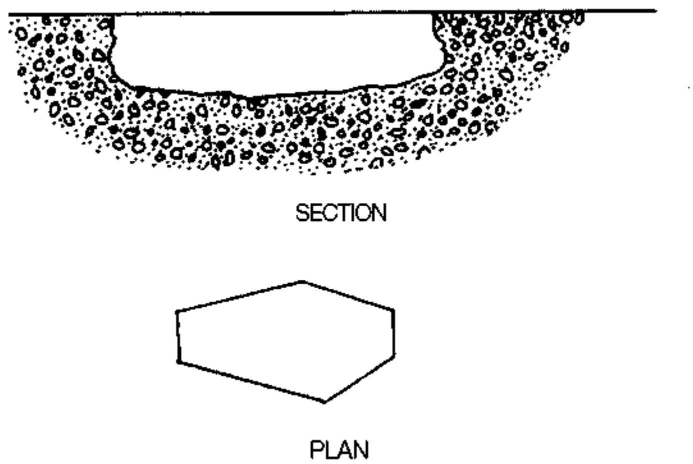


Fig. 7.5 (b) Correct method of cutting out

Figure 2.93: Correct and Incorrect method of Cutting Out

Repairs should be built up in layers and each layer should normally be applied as soon as the preceding one is strong enough to support it. The thickness of each layer should not normally exceed 20 mm. If there is likely to be a delay between layers, the first should be scratched as in normal rendering practice in order to provide a key, and a fresh bonding coat should be applied when work is resumed.

Application of resin based system:

The requirements for preparation for resin-based repairs are generally similar to those for cement-based repairs. Removal of dust is particularly important.

Resin based materials are usually supplied as two or three constituents that must be mixed together immediately before use. This must be done thoroughly, especially when epoxy resins are involved. Use of mechanical mixers or stirrers is advisable.

It is necessary to apply a primer or tack coat of unfilled resin to the freshly exposed surface of concrete and reinforcement. In general one coat will be enough, but two coats may be needed in some cases, especially if the substrate is porous.

With the majority of resin-based systems, the patching material must be applied while the primer is still tacky and each successive layer of patching material must be applied before the previous one has cured too much.

Resin based materials cure by chemical reaction which starts immediately after the constituents are mixed, so they have a limited 'pot life', which decreases with increasing temperature. This must be borne in mind when repair work is being planned, and the quantity of material to be mixed in any one batch must be chosen so that it can be used before it becomes too stiff.

Curing:

Resin-based repairs do not generally need any protection during their curing period, which is usually quite brief. Repairs consisting of cement, aggregates and water require careful curing by covering with absorbent material that is kept damp, preferably covered in turn by polythene or similar sheets which are sealed at the edges. Shading from the sun may be necessary. Alternate wetting and drying must be prevented because of the alternating stresses that it would cause.

Guniting:

This process of depositing a dense layer of sand cement mixture can be used profitably for repairing spalled concrete structures or weathered stone or brick masonry. The mortar or concrete is conveyed through a hose and pneumatically projected at high velocity on to the surface. The force of jet impinging on the surface compacts the material. Generally, a relatively dry mixture is used and so the material is capable of supporting itself without sagging or sloughing even during vertical and overhead applications.

Equipments and Materials:

The equipment used for this process is a cement gun (conforming to IS:6433), which is operated throughout by compressed air. The sand used should comply with the requirements given in IS: 383 and graded evenly from fine to coarse as per zone II and zone III grading with a nominal maximum size of 6 mm. One part of cement shall be added to 3 parts of sand. The optimum moisture content for sand is in the range of 3 to 6%. This mixture is placed in the feeding chamber and by the action of compressed air it is fed into the working chamber through a cone valve controlled from outside. The mixture is then agitated through an agitator mounted on a vertical shaft. The mixing time shall be not less than 1 minute. The mixed material is carried in suspension by compressed air through the delivery hose to a nozzle. As the material passes through the nozzle body, it is hydrated with water introduced in the form of a fine needle spray controlled through a valve in the nozzle body. The water-cement ratio for concrete used in this process is normally in the range of 0.35 to 0.50. For a length of hose upto 30 m the air pressure at the nozzle shall be 3.0 kg per sq.cm or more. Where the length exceeds 30 m, the pressure shall be increased by 0.35 kg per sq.cm for each additional lead of 15 m and by 0.35 kg per sq.cm. for each 7.5 m that a nozzle is raised above the gun. The water pressure at the discharge nozzle shall be sufficiently greater than the operating air pressure to ensure that water is intimately mixed with the other material

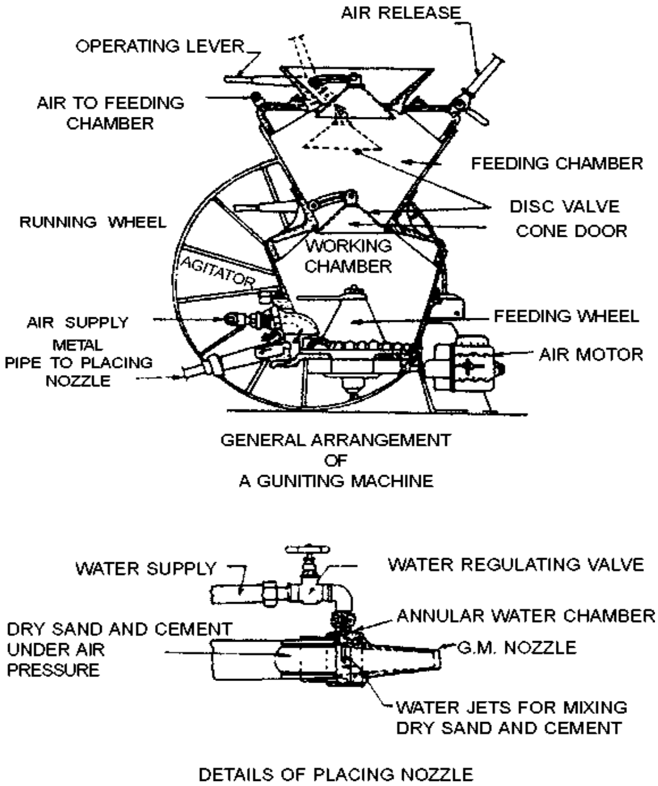


Figure 2.94: Guniting machine

Procedure:

In case of repairs to existing deteriorated concrete all unsound materials shall be first removed. The exposed reinforcement shall be cleaned free of rust, scales, etc. In the case of stone masonry all weathered or disintegrated part of stone shall be knocked down with a chisel and/or a heavy hammer so as to expose sound and undamaged part of the stones. The stone or brick masonry surface shall be cleared of all loose mortar, dust, moss, etc. and washed down with a strong jet of air or water. If mortar at the joint is weak, the joint shall be raked to about 10 mm depth and all loose and dry mortar scraped out from inside.

The form work, if required, shall be of plywood or other suitable material fixed in proper alignment and also to proper dimensions. For repair work the reinforcement shall be fixed to existing masonry or concrete by using wire nails or dowels at one metre intervals. Depending on the thickness and nature of work, reinforcement may consist of either round bars or welded wire fabric. Hard-drawn wire fabric consisting 3 mm dia wires at 10 cm centers in both directions can be used. The minimum clearance between reinforcement and formwork shall be 12 mm for mortar mix and 50 mm for concrete mix.

Each layer of shotcrete (concrete placed by guniting) is built up by making several passes or loops of the nozzle over the working area. The distance of the nozzle from the working face is usually between 0.5 and 1.5 m. The nozzle shall be held perpendicular to the surface of application. The amount of rebound concrete varies with the position of work, angle of nozzle, air pressure, cement content, water content, size and grading of aggregate, amount of reinforcement and thickness of layer.

Rebound of concrete with different positions of work is shown in Table given below

Table 2.146: Rebound of concrete

Type of surface	% Rebound
Slabs	05 to 15%
Sloping and vertical walls	15 to 30%
Overhead work	25 to 50%

Rebound shall not be worked back into construction. If it does not fall clear of the work it should be removed. Rebound shall not be salvaged and included in later batches. Where a layer of shotcrete is to be covered by a succeeding layer, it shall first be allowed to take its initial set. Then all laitance, loose material and rebound shall be removed by brooming. Surfaces shall be kept continuously wet for at least 15 days after guniting.

(b) Materials and specifications of Railway Tracks

Following material specifications shall be followed broadly for the project corridor. However, these specifications are for guidance and final material specifications and selection of materials shall be as per Railways Requirement / Codes and their latest amendments.

Rails: As per Indian Railways Permanent Way Manual, the rails may be of 60 kg 90 UTS and shall be manufactured as per the Indian Railway Standards specification for flat bottom rail (IRS-T-12). Rail fastenings manufacture shall conform with RDSO Specification, IRS-T-1.

Sleepers & Fastenings: Mono-block Pre-stressed concrete sleepers shall be used and shall be manufactured to conform to RDSO specification No IRS: T-39 (Plain Track) and IRS: T-45 (Turnout sleepers). Fastenings of railway sleepers like Elastic Rail Clip, Grooved Rubber Sole Plate shall conform to RDSO specification IRS-T: 31 and IRS -T-47 respectively. Further, Liners shall conform to RDSO specifications IRS: T-44.

Ballast: Ballast shall be Crushed Stone ballast to be used on all lines including points and crossings shall be conforming to RDSO specifications for Track Ballast No. IRS -GE -1, June 2016 with latest amendments.

Formation: The formation shall conform to relevant Railway Manuals and Amendments.

(c) Rate analysis

- **Rate Analysis for Transport Corridor-Railway Line**

General

Detailed Cost estimate was carried out based on the given work order. The cost estimation is carried out taking into consideration in available Schedule of Rates of Government of Gujarat and considered five per cent escalation and some of the rates are considered from the DSR. Wherever the rates are not listed in the scheduled of rates for specific items in such case, the rates available from the in-house data base have been considered for the purpose of estimation.

Methodology

Quantities of various components are worked out based on preliminary engineering,
(1) Rate analysis template published by MORTH is used.
(2)Unit rates considered are as per "*Gujarat Schedule of Rates for the year 20*16 and DSR *Schedule of Rates for the year 2022;*
(3) Unit rates for key materials (cement, Reinforcement etc.,) have been collected from market and used;
(4) Aggregate rates are considered from the market and conveyance and royalty charges have been included in the same; and
(5) Bitumen rates are considered from the latest IOCL and BPCL from the nearby areas.

The following lead distance was considered for various items in the Rate Analysis to arrive the cost. The distance were mentioned in **Table 2-147.**

Table 2-147 Lead distance for various material sources

No	**Material**	**Lead Distance considered (km)**
1	Metal	54
2	Sand	10
3	Earthwork	72

The complete rate analysis book is annexed with this report as **Annexure-2O**

(d) Bill of quantities

➢ Bill of Quantities for Transport Corridor-Road

Table 2.148: Bill of Quantities for Road over Flood regulator Portion (From Km 23+500 to Km 83+500)

BILL NO 1 : SITE CLEARANCE

Item	Description	Unit	Quantity	Rate	Amount
1.01	Clearing and grubbing road land complete as per Technical specifications Clause 201	Ha	353.40	25269.00	8930064.60
				TOTAL FOR BILL No : 1	**8930065**
BILL NO 2 : EARTH WORK					
2.01	Earthwork in excavation necessary for the construction of roadway in all types of soil all complete as per MoRTH Spec.(Fifth Revision) Cl.301				
	a) Ordinary soil	Cum	1,20,250	79.00	9499783.97
	b) Soft rock	Cum			
	c) Hard rock	Cum			
2.02	Construction of embankments with approved material from borrow area with all leads and lifts all complete as per drawings and MoRTH Spe. Cl 305	Cum	28,02,353	1187.00	3326393464
				TOTAL FOR BILL NO : 2	**3,33,58,93,247.51**
BILL NO 3 : PAVEMENT					
1: SUB-BASES, BASES (NON- BITUMINOUS)					
1.01	Construction of Subgrade and Earthen Shoulders (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet	Cum	26,44,890.00	1313.00	3,47,27,40,570

Item	Description	Unit	Quantity	Rate	Amount
	requirement of table No. 300-2)				
1.02	**Granular Subbase By Mix in Place Method** (Construction of granular sub-base by providing close graded material, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density, complete as per clause 401)	Cum	7,27,602.75	2,754	2,00,38,17,974
1.03	**Wet Mix Macadam laying Using Mechanical Paver** (Providing, laying, spreading and compacting graded stone aggregate to wet mix macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub- base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.)	Cum	27,888.75	2,813	7,84,51,054
2: BASES AND SURFACE COURSES (BITUMINOUS)					
2.01	Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.75 kg/sqm using mechanical means	Sqm	1,09,620.00	28	30,69,360
2.02	**Tack Coat on Bituminous surfaces** (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 to 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.)	Sqm	90,000.00	8	7,20,000

Item	Description	Unit	Quantity	Rate	Amount
2.03	**Dense Graded Bituminous Macadam-II** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.5 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects.)	Cum	4,536.00	9,463	4,29,24,168
2.04	**Dense Graded Bituminous Macadam-I** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects)	Cum	-	-	-
2.05	**Bituminous Concrete Grading -II** (Providing and laying bituminous concrete with higher capacity batch type hot mix plant using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects)	Cum	3,600.00	9,630	3,46,68,000
3: CEMENT CONCRETE PAVEMENTS					

Item	Description	Unit	Quantity	Rate	Amount
3.01	**Dry Lean Cement Concrete** Sub- base (Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing.)	Cum	5,83,760.81	3,623	2,11,49,65,424
3.02	**Cement Concrete Pavement** (Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with 43 grade cement @ 400 kg per cum, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing)	Cum	11,32,275.00	7,385	8,36,18,50,875
				TOTAL COST FOR BILL NO: 3	**16,11,32,07,424**
BILL NO 4 : DRAIN					
4.01	Earthwork in excavation in all types of soil for construction and realignment of drains / pipes including disposal of surplus excavated earth with all leads and lifts complete as per drawings and MoRTH Spec Cl 309 and 2903				
	a) Ordinary soil	Cum	2,62,153.50	108.00	2,83,12,578.00

Item	Description	Unit	Quantity	Rate	Amount
4.02	Providing and placing plain cement concrete M-15 grade levelling course for drains all complete as per drawings and MoRTH Spec Section 1700.	cum	10,363.50	5,580.00	5,78,28,330.00
4.03	Reinforced cement concrete M-25 grade road side drains including centering & shuttering but excluding reinforcement all complete as per drawings & MoRTH Spec Sections 1500 & 1700.	Cum	47,250.00	6,471.00	30,57,54,750.00
4.04	Providing and placing HYSD/TMT reinforcement bars of shape and dimensions in drains and inlets complete as per drawings and MoRTH Spec Sections 1600.	Mt	2,835.00	1,07,614.00	30,50,85,690.00
				TOTAL FOR BILL NO: 4	**69,69,81,348.00**
BILL NO 5 : BUS BAY AND TRUCK LAY BAY					
1.00	**Dry Lean Cement Concrete** Sub- base (Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing.)	Cum	3,063.10	3623.00	1,10,97,622.45

Item	Description	Unit	Quantity	Rate	Amount
2.00	**Cement Concrete Pavement** (Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with 43 grade cement @ 400 kg per cum, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing)	Cum	6,126.21	7,385	4,52,42,032.44
3.00	**Construction of Subgrade and Earthen Shoulders** (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	Cum	14,168.04	1,313	1,86,02,639.39
4.00	**Granular Subbase By Mix in Crusher Method** (Construction of granular sub-base by providing close graded material, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density, complete as per clause 401)	Cum	3,428.04	2,754	94,40,812.57
5.00	**Cast in Situ Cement Concrete M20 kerb** (Construction of cement concrete kerb with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M-10 grade foundation 150 mm thick, foundation having 50 mm projection beyond kerb stone, kerb stone laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 408)	Rm	3,726.85	286	10,65,879.27
6.00	Painting concrete Kerb complete with ordinary paint as per MoRTH Spec (fifth revision) Cl 803.	Sqm	1,267.13	105	1,33,048.57

Item	Description	Unit	Quantity	Rate	Amount
7.00	**Turfing Lawns with Fine Grassing including Ploughing, Dressing** (Turfing lawns with fine grassing including ploughing, dressing including breaking of clods, removal of rubbish, dressing and supplying doobs grass roots at 10 cm apart, including supplying and spreading of farm yard manure at rate of0.6 cum per 100 sqm)	Sqm	3,033.87	68	2,06,303.41
8.00	Laying of pavement marking with hot applied thermoplastic paints conforming to ASTM D36/BS-3262 (Part - I) as per drawing & MoRTH Spec (fifth revision) Cl 803.	Sqm	3,722.70	377	14,03,457.90
				TOTAL FOR BILL NO: 5	**8,71,91,796.00**
BILL NO 6 : ROAD FURNITURE					
5.01	Cast in Situ Cement Concrete M20 kerb (Construction of cement concrete kerb with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M-10 grade foundation 150 mm thick, foundation having 50 mm projection beyond kerb stone, kerb stone laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 408)	m	1,25,100.0	286.00	3,57,78,600.00
5.02	Cast in Situ Cement Concrete M 20 Kerb with Channel (Construction of cement concrete kerb with channel with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M10 grade foundation 150 mm thick, kerb channel 300 mm wide, 50 mm thick in PCC M20 grade, sloped towards the kerb, kerb stone with channel laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 408)	m	-	0	-

Item	Description	Unit	Quantity	Rate	Amount
5.03	Supply & Fixing precast cement concrete cylindrical Bollard of Per No size as per specifications &700mm height (450mm above finish level) manufactured by M-30 grade of concrete by vibro compaction process using FRP moulds &with washed fine grit finish on the exposed surface of the bollard of approved water base PU paint colour & texture, (single &Double strip) as per detal drawing as directed by engineer in charge.	Nos	-	0	-
5.04	**Road Marking** with Hot Applied Thermoplastic Compound with Reflectorising Glass Beads on Bituminous Surface (Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250 gms per sqm area, thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC:35 .The finished surface to be level, uniform and free from streaks and holes.)	Sqm	47,670.33	377.00	1,79,71,715.67
5.05	**Kilo Metre Stone** (Reinforced cement concrete M15grade kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc)				
(i)	5th kilometre stone (precast)	No's	12.00	4254.00	51,048.00
(ii)	Ordinary Kilometer stone (Precast)	No's	48.00	2496.00	1,19,808.00
(iii)	Hectometer stone (Precast)	No's	241.00	774.00	1,86,534.00
5.05	**Retro- reflectorised Traffic signs** (Providing and fixing of retro-reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminium sheeting, 1.5 mm thick supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing)				
	i) 750mm Octagonal	Nos	1.00	5876.00	5,876.00
	ii) 600mm Circular	Nos	30.00	3565.00	1,06,950.00
	iii) 600mm Traingular	Nos	44.00	2759.00	1,21,396.00
	iv) 900mm Traingular	Nos	-		-
	v) 600mm x 1550mm Rectangular	Nos	-		-

Item	Description	Unit	Quantity	Rate	Amount
	vi) 600mm x 500mm rectangular	Nos	-		-
5.06	**Retro- reflectorised Traffic signs** (Providing and fixing of retro-reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over existing lamp post or electrical poles.				-
	i) 750mm Octagonal	Nos			-
	ii) 600mm Circular	Nos			-
	iii) 600mm Traingular	Nos			-
	iv) 900mm Traingular	Nos			-
	v) 600mm x 1550mm Rectangular	Nos			-
	vi) 600mm x 500mm rectangular	Nos			-
5.07	**Retro- reflectorised Traffic signs** (Providing and fixing of retro-reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed on Walls.				-
	i) 750mm Octagonal	Nos			-
	ii) 600mm Circular	Nos			-
	iii) 600mm Traingular	Nos			-
	iv) 600mm Octagonal	Nos			-
	v) 450mm x 600mm Rectangular	Nos			-
5.08	Direction and Place Identification signs upto 0.9 sqm size board. (Providing and erecting direction and place identification retro-reflectorised sign asper IRC:67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area not exceeding 0.9 sqm supported on a mild steel single angle iron post 75 x 75 x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 x 45 x 60 cm, 60 cm below ground level as per approved drawing)	Sqm	26.06	7848.00	2,04,487.49

Item	Description	Unit	Quantity	Rate	Amount
5.09	Direction and Place Identification signs with size more than 0.9 sqm size board. (Providing and erecting direction and place identification retro- reflectorised sign asper IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area exceeding 0.9 sqm supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm, 2 Nos. firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing)	Sqm	54.00	9281.00	5,01,174.00
5.10	**Overhead Signs** (Providing and erecting overhead signs with a corrosion resistant aluminium alloy sheet reflectorised with high intensity retro-reflective sheeting of encapsulated lense type with vertical and lateral clearance given in clause 802.2 and 802.3 and installed as per clause 802.7 over a designed support system of aluminium alloy or galvanised steel trestles and trusses of sections and type as per structural design requirements and approved plans)				-
A	Truss and Vertical Support	MT	12.50	71326.00	8,91,575.00
B	Aluminium alloy plate for overhead sign	MT	21.00	646.00	13,566.00
5.11	**Full Gantry Signs** (Providing and erectingFull Gantry signs with a corrosion resistant aluminium alloy sheet reflectorised with high intensity retro-reflective sheeting of encapsulated lense type with vertical and lateral clearance given in clause 802.2 and 802.3 and installed as per clause 802.7 over a designed support system of aluminium alloy or galvanised steel trestles and trusses of sections and type as per structural design requirements and approved plans)				-
A	Truss and Vertical Support	MT	10.00	71326.00	7,13,260.00
B	Aluminium alloy plate for overhead sign	MT	211.20	646.00	1,36,435.20

Item	Description	Unit	Quantity	Rate	Amount
5.11	**Road Delineators** (Supplying and installation of delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 15 cm wide stripes, fitted with 80 x 100 mm rectangular or 75 mm dia circular reflectorised panels at the top, buried or pressed into the ground and confirming toIRC-79 and the drawings.)	No's			
5.12	Road way indicators, hazard markers, object markers				
	i) 300mm x 900mm Rectangular	Nos	3.00	2663.4375	7,990.31
	ii) 450mm x 900mm Rectangular	Nos	26.00	3995.15625	1,03,874.06
5.13	**Road Markers/Road Stud** with Lense Reflector (Providing and fixing of road stud 100x 100 mm, die cast in aluminium, resistant to corrosive effect of salt and grit, fitted with lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm upto a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS 873 part 4:1973)	Nos	14,556.00	603.00	87,77,268.00
5.14	Providing and erecting High Mast Lighting on a steel circular hollow pole of standard specifications for street lighting, 30 m high fixed firmly in concrete foundation as per drawing and Techinical Specification	Nr.	6.00	525000.00	31,50,000.00
5.15	**Anti - Glare Devices in Median**				
A	**Plantation** (Plantation of shrubs and plants of approved species in the median. apart from cutting off glare from vehicle coming from opposite direction, these plants provide a pleasant envoirenment and are eco-friendly. The rate for this item is available in the chapter 11 on horticulture.)	km	123.95	300000	3,71,85,000.00
5.16	Providing and laying Pitching on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications				
A	Stone/Boulder	cum	3526.64	1691.00	59,63,543.12

Item	Description	Unit	Quantity	Rate	Amount
5.17	Providing and laying Filter material underneath pitching in slopes complete as per drawing and Technical specification	cum	1763.32	1325.00	23,36,396.99
5.18	Turfing Lawns with Fine Grassing including Ploughing, Dressing (Turfing lawns with fine grassing including ploughing, dressing including breaking of clods, removal of rubbish, dressing and supplying doobs grass roots at 10 cm apart, including supplying and spreading of farm yard manure at rate of0.6 cum per 100 sqm)	Sqm	136633.70	68.00	92,91,091.87
5.19	**Utility Cable Duct** Across the Road (Providing and laying of a reinforced cement concrete pipe duct, 300 mm dia, across the road (new construction), extending from drain to drain in cuts and toe of slope to toe of slope in fills, constructing head walls at both ends, providing a minimum fill of granular material over top and sides of RCC pipe as per IRC:98-1997, bedded on a 0.3 m thick layer of granular material free of rock pieces, outer to outer distance of pipe at least half dia of pipe subject to minimum 450 mm in case of double and triple row ducts, joints to be made leak proof, invert level of duct to be above higher than ground level to prevent entry of water and dirt, all as per IRC: 98 - 1997 and approved drawings.)				
(i)	Single Row for one utility service	Rm	4414.30	1308.00	57,73,909.63
(ii)	Double Row for two utility services	Rm			
(iii)	Triple Row for three utility services	Rm			
5.20	Providing and fixing **Solar Blinker** Light 300 mm dia, LED Aspect made of FRP/Poly carbonate with battery backup fitted on 150 mm dia MS pipe - 3.0 metre long from the ground level, firmly fixed to the ground by mean of properly designed foundation with M-15 grade cement concrete 60cm x 60cm x 60cm, below ground level.	Nos	4.00	15000	60,000.00

Item	Description	Unit	Quantity	Rate	Amount
5.21	Type - A, "W" : Metal Beam Crash Barrier (Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per clause 811)				
	i) W beam	m			
	ii) Thrie beam	m	1,35,157.00	4500	60,82,06,500.00
5.22	Tubular Steel Railing on Precast RCC posts, 1.2 m high above ground level (Providing, fencing and erecting 50 mm dia painted steel pipe railing in 3 rows on precast M20 grade RCC vertical posts1.8 metres high (1.2 m above GL) with 3 holes 50 mm dia for pipe, fixed 2 metres centre to, complete as per approved drawing)	m	-	-	-
5.23	Street Lighting (Providing and erecting street light mounted on a steel circular hollow pole of standard specifications for street lighting, 9 m high spaced 40 m apart, 1.8 m overhang on both sides if fixed in the median and on one side if fixed on the footpath, fitted with sodium vapour lamp and fixed firmly in concrete foundation.)				
(i)	**Single Arm**	each	-		-
(ii)	**Double Arm**	each	3,084.00	125000	38,55,00,000.00
iii)	**Lamp Post**	each	16,800.00	50000	84,00,00,000.00
				TOTAL FOR BILL NO: 6	**1,96,31,57,999.34**

BILL NO 7 : INTERSECTIONS

Item	Description	Unit	Quantity	Rate	Amount
1.01	**Construction of Subgrade and Earthen Shoulders** (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	Cum	3,749.83	1313.00	49,23,528.76
1.02	Plant Mix Method (Construction of granular sub-base by providing close graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401)	Cum	1,499.93	2,754	41,30,814.38
1.03	**Wet Mix Macadam laying Using Mechanical Paver** (Providing, laying, spreading and compacting graded stone aggregate to wet mix macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub- base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.)	Cum	1,874.92	2,813	52,74,138.00
1.04	**Cement Treated Crushed Stone Sub base** (Construction of granular sub-base by providing graded Material, mixing with cement in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with Mechanical Paver on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401)	Cum	-	-	-
1.05	Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.75 kg/sqm using mechanical means	Sqm	6,159.10	28	1,72,454.68
1.06	**Tack Coat on Bituminous surfaces** (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 to 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.)	Sqm	6,159.10	8	49,272.76

Item	Description	Unit	Quantity	Rate	Amount
1.07	**Dense Graded Bituminous Macadam-II** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.5 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects.)	Cum	307.95	9,463	29,14,176.08
1.08	**Dense Graded Bituminous Macadam-I** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects)	Cum	-	-	-
1.09	**Bituminous Concrete Grading -II** (Providing and laying bituminous concrete with higher capacity batch type hot mix plant using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects)	Cum	-	-	-

Item	Description	Unit	Quantity	Rate	Amount
1.10	**Pigmented Bituminous Concrete Grading** (Providing and laying Pigmented bituminous concrete with higher capacity batch type hot mix plant using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 per cent of mix, 3 to 4 % of Pigment and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects)	Cum	-	-	-
1.11	**Dry Lean Cement Concrete** Sub- base (Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing.)	Cum	-	3,623	-
1.12	**Cement Concrete Pavement** (Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with 43 grade cement @ 400 kg per cum, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing)	Cum	-	7,385	-
				TOTAL FOR BILL NO : 7	**1,74,64,384.67**

Table 2.149: Bill of Quantities for Approach Roads (From Km 0+000 to Km 23+500 & From Km 83+500 to Km 105+300)

BILL NO 1: SITE CLEARANCE

Item	Description	Unit	Quantity	Rate	Amount
1.01	Clearing and grubbing road land complete as per Technical specifications Clause 201	Ha	485.23	25269.00	12261276.87
				TOTAL FOR BILL No : 1	**12261277**
BILL NO 2 : EARTH WORK					
2.01	Earthwork in excavation necessary for the construction of roadway in all types of soil all complete as per MoRTH Spec.(Fifth Revision) Cl.301				
	a) Ordinary soil	Cum	25,333	79.00	2001281.72
	b) Soft rock	Cum			
	c) Hard rock	Cum			
2.02	Construction of embankments with approved material from borrow area with all leads and lifts all complete as per drawings and MoRTH Spe. Cl 305	45.3	79,93,123	1187.00	9487836860
				TOTAL FOR BILL NO : 2	**9,48,98,38,141.94**
BILL NO 3 : PAVEMENT					
1: SUB-BASES, BASES (NON- BITUMINOUS)					
1.01	Construction of Subgrade and Earthen Shoulders (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	Cum	15,76,061.50	1313.00	2,06,93,68,750

Item	Description	Unit	Quantity	Rate	Amount
1.02	**Granular Subbase By Mix in Place Method** (Construction of granular sub-base by providing close graded material, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density, complete as per clause 401)	Cum	4,58,810.97	2,754	1,26,35,65,411
1.03	**Wet Mix Macadam laying Using Mechanical Paver** (Providing, laying, spreading and compacting graded stone aggregate to wet mix macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub- base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.)	Cum	1,01,639.00	2,813	28,59,10,507
2: BASES AND SURFACE COURSES (BITUMINOUS)					
2.01	Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.75 kg/sqm using mechanical means	Sqm	3,99,504.00	28	1,11,86,112
2.02	**Tack Coat on Bituminous surfaces** (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 to 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.)	Sqm	3,28,000.00	8	26,24,000
2.03	**Dense Graded Bituminous Macadam-II** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.5 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects.)	Cum	16,531.20	9,463	15,64,34,746

Item	Description	Unit	Quantity	Rate	Amount
2.04	**Dense Graded Bituminous Macadam-I** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects)	Cum	-	-	-
2.05	**Bituminous Concrete Grading -II**(Providing and laying bituminous concrete with higher capacity batch type hot mix plant using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects)	Cum	13,120.00	9,630	12,63,45,600
3: CEMENT CONCRETE PAVEMENTS					
3.01	**Dry Lean Cement Concrete** Sub- base (Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing.)	Cum	3,10,609.43	3,623	1,12,53,37,981

Item	Description	Unit	Quantity	Rate	Amount
3.02	**Cement Concrete Pavement** (Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with 43 grade cement @ 400 kg per cum, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing)	Cum	5,96,043.30	7,385	4,40,17,79,771
				TOTAL COST FOR BILL NO: 3	**9,44,25,52,877**
BILL NO 4 : DRAIN					
4.01	Earthwork in excavation in all types of soil for construction and realignment of drains / pipes including disposal of surplus excavated earth with all leads and lifts complete as per drawings and MoRTH Spec Cl 309 and 2903				
	a) Ordinary soil	Cum	1,90,745.20	108.00	2,06,00,481.60
4.02	Providing and placing plain cement concrete M-15 grade levelling course for drains all complete as per drawings and MoRTH Spec Section 1700.	cum	8,495.20	5,580.00	4,74,03,216.00
4.03	Reinforced cement concrete M-25 grade road side drains including centering & shuttering but excluding reinforcement all complete as per drawings & MoRTH Spec Sections 1500 & 1700.	Cum	-	6,471.00	-
4.04	Providing and placing HYSD/TMT reinforcement bars of shape and dimensions in drains and inlets complete as per drawings and MoRTH Spec Sections 1600.	Mt	-	1,07,614.00	-

Item	Description	Unit	Quantity	Rate	Amount
			TOTAL FOR BILL NO: 4		**6,80,03,697.60**
BILL NO 5 : BUS BAY AND TRUCK LAY BAY					
1.00	**Dry Lean Cement Concrete** Sub- base (Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing.)	Cum	4,612.47	3623.00	1,67,10,963.84
2.00	**Cement Concrete Pavement** (Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with 43 grade cement @ 400 kg per cum, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing)	Cum	9,224.93	7,385	6,81,26,120.88
3.00	**Construction of Subgrade and Earthen Shoulders**(Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	Cum	21,334.58	1,313	2,80,12,305.65

Item	Description	Unit	Quantity	Rate	Amount
4.00	**Granular Subbase By Mix in Crusher Method** (Construction of granular sub-base by providing close graded material, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density, complete as per clause 401)	Cum	5,162.00	2,754	1,42,16,146.85
5.00	**Cast in Situ Cement Concrete M20 kerb** (Construction of cement concrete kerb with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M-10 grade foundation 150 mm thick, foundation having 50 mm projection beyond kerb stone, kerb stone laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 408)	Rm	5,612.00	286	16,05,031.60
6.00	Painting concrete Kerb complete with ordinary paint as per MoRTH Spec (fifth revision) Cl 803.	Sqm	1,908.08	105	2,00,348.35
7.00	**Turfing Lawns with Fine Grassing including Ploughing, Dressing** (Turfing lawns with fine grassing including ploughing, dressing including breaking of clods, removal of rubbish, dressing and supplying doobs grass roots at 10 cm apart, including supplying and spreading of farm yard manure at rate of0.6 cum per 100 sqm)	Sqm	4,568.50	68	3,10,658.14
8.00	Laying of pavement marking with hot applied thermoplastic paints conforming to ASTM D36/BS-3262 (Part - I) as per drawing & MoRTH Spec (fifth revision) Cl 803.	Sqm	3,722.70	377	14,03,457.90
				TOTAL FOR BILL NO: 5	**13,05,85,033.21**

BILL NO 6 : ROAD FURNITURE

Item	Description	Unit	Quantity	Rate	Amount
5.01	Cast in Situ Cement Concrete M20 kerb (Construction of cement concrete kerb with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M-10 grade foundation 150 mm thick, foundation having 50 mm projection beyond kerb stone, kerb stone laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 408)	m	1,13,700.0	286.00	3,25,18,200.00
5.02	Cast in Situ Cement Concrete M 20 Kerb with Channel (Construction of cement concrete kerb with channel with top and bottom width 115 and 165 mm respectively, 250 mm high in M 20 grade PCC on M10 grade foundation 150 mm thick, kerb channel 300 mm wide, 50 mm thick in PCC M20 grade, sloped towards the kerb, kerb stone with channel laid with kerb laying machine, foundation concrete laid manually, all complete as per clause 408)	m	-	0	-
5.03	Supply & Fixing precast cement concrete cylindrical Bollard of Per No size as per specifications &700mm height (450mm above finish level) manufactured by M-30 grade of concrete by vibro compaction process using FRP moulds &with washed fine grit finish on the exposed surface of the bollard of approved water base PU paint colour & texture, (single &Double strip) as per detal drawing as directed by engineer in charge.	Nos	-	0	-
5.04	**Road Marking** with Hot Applied Thermoplastic Compound with Reflectorising Glass Beads on Bituminous Surface (Providing and laying of hot applied thermoplastic compound 2.5 mm thick including reflectorising glass beads @ 250 gms per sqm area, thickness of 2.5 mm is exclusive of surface applied glass beads as per IRC:35 .The finished surface to be level, uniform and free from streaks and holes.)	Sqm	64,593.67	377.00	2,43,51,812.33
5.05	**Kilo Metre Stone** (Reinforced cement concrete M15grade kilometre stone of standard design as per IRC:8-1980, fixing in position including painting and printing etc)				
(i)	5th kilometre stone (precast)	No's	9.00	4254.00	38,286.00
(ii)	Ordinary Kilometer stone (Precast)	No's	36.00	2496.00	89,856.00

Item	Description	Unit	Quantity	Rate	Amount
(iii)	Hectometer stone (Precast)	No's	180.00	774.00	1,39,320.00
5.05	**Retro- reflectorised Traffic signs** (Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminium sheeting, 1.5 mm thick supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing)				
	i) 750mm Octagonal	Nos	1.00	5876.00	5,876.00
	ii) 600mm Circular	Nos	65.00	3565.00	2,31,725.00
	iii) 600mm Traingular	Nos	44.00	2759.00	1,21,396.00
	iv) 900mm Traingular	Nos	-		-
	v) 600mm x 1550mm Rectangular	Nos	-		-
	vi) 600mm x 500mm rectangular	Nos	-		-
5.06	**Retro- reflectorised Traffic signs** (Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over existing lamp post or electrical poles.				-
	i) 750mm Octagonal	Nos			-
	ii) 600mm Circular	Nos			-
	iii) 600mm Traingular	Nos			-
	iv) 900mm Traingular	Nos			-
	v) 600mm x 1550mm Rectangular	Nos			-
	vi) 600mm x 500mm rectangular	Nos			-
5.07	**Retro- reflectorised Traffic signs** (Providing and fixing of retro- reflectorised cautionary, mandatory and informatory sign as per IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed on Walls.				-
	i) 750mm Octagonal	Nos			-
	ii) 600mm Circular	Nos			-
	iii) 600mm Traingular	Nos			-

Item	Description	Unit	Quantity	Rate	Amount
	iv) 600mm Octagonal	Nos			-
	v) 450mm x 600mm Rectangular	Nos			-
5.08	Direction and Place Identification signs upto 0.9 sqm size board. (Providing and erecting direction and place identification retro-reflectorised sign asper IRC:67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area not exceeding 0.9 sqm supported on a mild steel single angle iron post 75 x 75 x 6 mm firmly fixed to the ground by means of properly designed foundation with M15 grade cement concrete 45 x 45 x 60 cm, 60 cm below ground level as per approved drawing)	Sqm	34.02	7848.00	2,67,020.35
5.09	Direction and Place Identification signs with size more than 0.9 sqm size board. (Providing and erecting direction and place identification retro- reflectorised sign asper IRC :67 made of encapsulated lens type reflective sheeting vide clause 801.3, fixed over aluminium sheeting, 2 mm thick with area exceeding 0.9 sqm supported on a mild steel angle iron post 75 mm x 75 mm x 6 mm, 2 Nos. firmly fixed to the ground by means of properly designed foundation with M 15 grade cement concrete45 cm x 45 cm x 60 cm, 60 cm below ground level as per approved drawing)	Sqm	116.37	9281.00	10,80,029.97
5.10	**Overhead Signs** (Providing and erecting overhead signs with a corrosion resistant aluminium alloy sheet reflectorised with high intensity retro-reflective sheeting of encapsulated lense type with vertical and lateral clearance given in clause 802.2 and 802.3 and installed as per clause 802.7 over a designed support system of aluminium alloy or galvanised steel trestles and trusses of sections and type as per structural design requirements and approved plans)				-
A	Truss and Vertical Support	MT	12.50	71326.00	8,91,575.00
B	Aluminium alloy plate for over head sign	MT	21.00	646.00	13,566.00

Item	Description	Unit	Quantity	Rate	Amount
5.11	**Full Gantry Signs** (Providing and erectingFull Gantry signs with a corrosion resistant aluminium alloy sheet reflectorised with high intensity retro-reflective sheeting of encapsulated lense type with vertical and lateral clearance given in clause 802.2 and 802.3 and installed as per clause 802.7 over a designed support system of aluminium alloy or galvanised steel trestles and trusses of sections and type as per structural design requirements and approved plans)				-
A	Truss and Vertical Support	MT	10.00	71326.00	7,13,260.00
B	Aluminium alloy plate for over head sign	MT	211.20	646.00	1,36,435.20
5.11	**Road Delineators** (Supplying and installation of delineators (road way indicators, hazard markers, object markers), 80-100 cm high above ground level, painted black and white in 15 cm wide stripes, fitted with 80 x 100 mm rectangular or 75 mm dia circular reflectorised panels at the top, buried or pressed into the ground and confirming toIRC-79 and the drawings.)	No's			
5.12	Road way indicators, hazard markers, object markers				
	i) 300mm x 900mm Rectangular	Nos	33.00	2663.4375	87,893.44
	ii) 450mm x 900mm Rectangular	Nos	35.00	3995.15625	1,39,830.47
5.13	**Road Markers/Road Stud** with Lense Reflector (Providing and fixing of road stud 100x 100 mm, die cast in aluminium, resistant to corrosive effect of salt and grit, fitted with lense reflectors, installed in concrete or asphaltic surface by drilling hole 30 mm upto a depth of 60 mm and bedded in a suitable bituminous grout or epoxy mortar, all as per BS 873 part 4:1973)	Nos	13,519.00	603.00	81,51,957.00
5.14	Providing and erecting High Mast Lighting on a steel circular hollow pole of standard specifications for street lighting, 30 m high fixed firmly in concrete foundation as per drawing and Techinical Specification	Nr.	6.00	525000.00	31,50,000.00
5.15	**Anti - Glare Devices in Median**				
A	**Plantation** (Plantation of shrubs and plants of approved species in the median. apart from cutting off glare from vehicle coming from opposite direction, these plants provide a pleasant	km	44.35	300000	1,33,05,000.00

Item	Description	Unit	Quantity	Rate	Amount
	envoirenment and are eco-friendly. The rate for this item is available in the chapter 11 on horticulture.)				
5.16	Providing and laying Pitching on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications				
A	Stone/Boulder	cum	50690.31	1691.00	8,57,17,311.21
5.17	Providing and laying Filter material underneath pitching in slopes complete as per drawing and Technical specification	cum	25345.15	1325.00	3,35,82,329.20
5.18	Turfing Lawns with Fine Grassing including Ploughing, Dressing (Turfing lawns with fine grassing including ploughing, dressing including breaking of clods, removal of rubbish, dressing and supplying doobs grass roots at 10 cm apart, including supplying and spreading of farm yard manure at rate of0.6 cum per 100 sqm)	Sqm	169729.63	68.00	1,15,41,615.13
5.19	**Utility Cable Duct** Across the Road (Providing and laying of a reinforced cement concrete pipe duct, 300 mm dia, across the road (new construction), extending from drain to drain in cuts and toe of slope to toe of slope in fills, constructing head walls at both ends, providing a minimum fill of granular material over top and sides of RCC pipe as per IRC:98-1997, bedded on a 0.3 m thick layer of granular material free of rock pieces, outer to outer distance of pipe at least half dia of pipe subject to minimum 450 mm in case of double and triple row ducts, joints to be made leak proof, invert level of duct to be above higher than ground level to prevent entry of water and dirt, all as per IRC: 98 - 1997 and approved drawings.)				
(i)	Single Row for one utility service	Rm	6034.06	1308.00	78,92,549.43
(ii)	Double Row for two utility services	Rm			
(iii)	Triple Row for three utility services	Rm			

Item	Description	Unit	Quantity	Rate	Amount
5.20	Providing and fixing **Solar Blinker** Light 300 mm dia, LED Aspect made of FRP/Poly carbonate with battery backup fitted on 150 mm dia MS pipe - 3.0 metre long from the ground level, firmly fixed to the ground by mean of properly designed foundation with M-15 grade cement concrete 60cm x 60cm x 60cm, below ground level.	Nos	4.00	15000	60,000.00
5.21	Type - A, "W" : Metal Beam Crash Barrier (Providing and erecting a "W" metal beam crash barrier comprising of 3 mm thick corrugated sheet metal beam rail, 70 cm above road/ground level, fixed on ISMC series channel vertical post, 150 x 75 x 5 mm spaced 2 m centre to centre, 1.8 m high, 1.1 m below ground/road level, all steel parts and fitments to be galvanised by hot dip process, all fittings to conform to IS:1367 and IS:1364, metal beam rail to be fixed on the vertical post with a spacer of channel section 150 x 75 x 5 mm, 330 mm long complete as per clause 811)				
	i) W beam	m			
	ii) Thrie beam	m	1,01,957.00	4500	45,88,06,500.00
5.22	Tubular Steel Railing on Precast RCC posts, 1.2 m high above ground level (Providing, fencing and erecting 50 mm dia painted steel pipe railing in 3 rows on precast M20 grade RCC vertical posts1.8 metres high (1.2 m above GL) with 3 holes 50 mm dia for pipe, fixed 2 metres centre to, complete as per approved drawing)	m	-	-	-
5.23	Street Lighting (Providing and erecting street light mounted on a steel circular hollow pole of standard specifications for street lighting, 9 m high spaced 40 m apart, 1.8 m overhang on both sides if fixed in the median and on one side if fixed on the footpath, fitted with sodium vapour lamp and fixed firmly in concrete foundation.)				
(i)	**Single Arm**	each	-		-
(ii)	**Double Arm**	each	1,480.00	125000	18,50,00,000.00
iii)	**Lamp Post**	each	-	50000	-
				TOTAL FOR BILL NO: 6	**86,80,33,343.74**

Item	Description	Unit	Quantity	Rate	Amount
BILL NO 7 : INTERSECTIONS					
1.01	**Construction of Subgrade and Earthen Shoulders** (Construction of subgrade and earthen shoulders with approved material obtained from borrow pits with all lifts & leads, transporting to site, spreading, grading to required slope and compacted to meet requirement of table No. 300-2)	Cum	64,085.79	1313.00	8,41,44,644.17
1.02	Plant Mix Method (Construction of granular sub-base by providing close graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401)	Cum	25,634.32	2,754	7,05,96,907.86
1.03	**Wet Mix Macadam laying Using Mechanical Paver** (Providing, laying, spreading and compacting graded stone aggregate to wet mix macadam specification including premixing the Material with water at OMC in mechanical mix plant carriage of mixed Material by tipper to site, laying in uniform layers with paver in sub-base / base course on well prepared surface and compacting with vibratory roller to achieve the desired density.)	Cum	1,323.00	2,813	37,21,599.00
1.04	**Cement Treated Crushed Stone Sub base** (Construction of granular sub-base by providing graded Material, mixing with cement in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with Mechanical Paver on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per clause 401)	Cum	-	-	-
1.05	Providing and applying primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.75 kg/sqm using mechanical means	Sqm	3,984.00	28	1,11,552.00

Item	Description	Unit	Quantity	Rate	Amount
1.06	**Tack Coat on Bituminous surfaces** (Providing and applying tack coat with bitumen emulsion using emulsion pressure distributor at the rate of 0.20 to 0.30 kg per sqm on the prepared bituminous surface cleaned with mechanical broom.)	Sqm	3,984.00	8	31,872.00
1.07	**Dense Graded Bituminous Macadam-II** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.5 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects.)	Cum	199.20	9,463	18,85,029.60
1.08	**Dense Graded Bituminous Macadam-I** (Providing and laying dense graded bituminous macadam with higher capacity batch type HMP using crushed aggregates of specified grading, premixed with bituminous binder @ 4.0 per cent by weight of total mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects)	Cum	-	-	-
1.09	**Bituminous Concrete Grading -II** (Providing and laying bituminous concrete with higher capacity batch type hot mix plant using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 per cent of mix and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects)	Cum	-	-	-

Item	Description	Unit	Quantity	Rate	Amount
1.10	**Pigmented Bituminous Concrete Grading** (Providing and laying Pigmented bituminous concrete with higher capacity batch type hot mix plant using crushed aggregates of specified grading, premixed with bituminous binder @ 5.4 per cent of mix, 3 to 4 % of Pigment and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 507 complete in all respects)	Cum	-	-	-
1.11	**Dry Lean Cement Concrete** Sub- base (Construction of dry lean cement concrete Sub- base over a prepared sub-grade with coarse and fine aggregate conforming to IS: 383, the size of coarse aggregate not exceeding 25 mm, aggregate cement ratio not to exceed 15:1, aggregate gradation after blending to be as per table 600-1, cement content not to be less than 150 kg/ cum, optimum moisture content to be determined during trial length construction, concrete strength not to be less than 10 Mpa at 7 days, mixed in a batching plant, transported to site, laid with a paver with electronic sensor, compacting with 8-10 tonnes vibratory roller, finishing and curing.)	Cum	17,626.29	3,623	6,38,60,039
1.12	**Cement Concrete Pavement** (Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub base with 43 grade cement @ 400 kg per cum, coarse and fine aggregate conforming to IS 383, maximum size of coarse aggregate not exceeding 25 mm, mixed in a batching and mixing plant as per approved mix design, transported to site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, admixtures as approved, curing compound, finishing to lines and grades as per drawing)	Cum	35,252.57	7,385	26,03,40,265
				TOTAL FOR BILL NO : 7	**48,46,91,909.43**

Table 2. 150: Summary of BOQ for Road over Flood regulator Portion (From Km 23+500 to Km 83+500)

S.No.	Bill of Items	Total Amount , Rs.	Total Amount , Rs. Crores	% Cost
1	BILL NO. 1: Site Clearance and Dismantling	89,30,065	**0.89**	**0.04**
2	BILL NO. 2: Earthwork	3,33,58,93,248	**333.59**	**15.01**
3	BILL NO. 3: Pavement	16,11,32,07,424	**1,611.32**	**72.51**
4	BILL NO.4 : Drain	69,69,81,348.00	**69.70**	**3.14**
5	BILL NO.5 : Rest areas and Bus bays	8,71,91,796.00	**8.72**	**0.39**
6	BILL NO.6 : Road Furniture	1,96,31,57,999.34	**196.32**	**8.83**
7	BILL NO.7 : Intersections	1,74,64,384.67	**1.75**	**0.08**
	Civil Work Cost (Rs. In Cr) (a)	**22,22,28,26,264**	**2,222.28**	**100.00**
	Total Civil Cost Including 18% GST (Rs. In Cr) (b)	26,22,29,34,991.59	**2,622.29**	
	Length (Km)	60	**60.00**	
	Per Km cost (Rs. In Cr)	43.70	**43.70**	
	Add physical contingency @ 1% of (a)	222228262.6	**22.22**	
	Total Cost including Physical Contingency of 1% (c)	**26,44,51,63,254.23**	**2,644.52**	
	Agency Charges 3% of (a)	66,66,84,787.92	**66.67**	
	Supervision 3% of (a)	66,66,84,787.92	**66.67**	
	Price escalation of 7.5% of (a)	1,66,67,11,969.80	**166.67**	
	2.5% Maintenance of (a)	55,55,70,656.60	**55.56**	
	Centages	3,55,56,52,202.25	**355.57**	
	Total Project Cost	**30,00,08,15,456.48**	**3,000.08**	

Table 2.151: Summary of BOQ for Approach Roads (From Km 0+000 to Km 23+500 & From Km 83+500 to Km 105+300)

S.No.	Bill of Items	Total Amount , Rs.	Total Amount , Rs. Crores	% Cost
1	BILL NO. 1: Site Clearance and Dismantling	1,22,61,277	**1.23**	**0.06**
2	BILL NO. 2: Earthwork	9,48,98,38,142	**948.98**	**46.30**
3	BILL NO. 3: Pavement	9,44,25,52,877	**944.26**	**46.07**
4	BILL NO.4 : Drain	6,80,03,697.60	**6.80**	**0.33**
5	BILL NO.5 : Rest areas and Bus bays	13,05,85,033.21	**13.06**	**0.64**
6	BILL NO.6 : Road Furniture	86,80,33,343.74	**86.80**	**4.24**
7	BILL NO.7 : Intersections	48,46,91,909.43	**48.47**	**2.36**
	Civil Work Cost (Rs. In Cr) (a)	**20,49,59,66,280**	**2,049.60**	**100.00**
	Total Civil Cost Including 18% GST (Rs. In Cr) (b)	24,18,52,40,210.15	**2,418.52**	
	Length (Km)	45.3	**45.30**	
	Per Km cost (Rs. In Cr)	53.39	**53.39**	
	Add physical contingency @ 1% of (a)	204959662.8	**20.50**	
	Total Cost including Physical Contingency of 1% (c)	**24,39,01,99,872.95**	**2,439.02**	
	Agency Charges 3% of (a)	61,48,78,988.39	**61.49**	
	Supervision 3% of (a)	61,48,78,988.39	**61.49**	
	Price escalation of 7.5% of (a)	1,53,71,97,470.98	**153.72**	
	2.5% Maintenance of (a)	51,23,99,156.99	**51.24**	
	Centages	3,27,93,54,604.77	**327.94**	
	Total Project Cost	**27,66,95,54,477.71**	**2,766.96**	

➢ Bill of Quantities for Transport Corridor-Rail

(A) Waterway Section:

SR. NO	ITEM no. IRUSSO R-2021	DESCRIPTION	UNITS	QTY
EARTHWORK BOQ (Waterway Section)				
1	011010	Preparation of foundation for Embankment by clearing, grubbing, Stripping topsoil (average 15cm), ploughing and pulverizing 15cm of top of soil with tractor trolley, mixing water to achieve OMC With water sprinkler or left for natural drying, as required, and compaction with vibratory roller of suitable capacity to achieve 98% MDD for laying first layer of soil for embankment construction	Sqm	40,365
2	012011	Earthwork in cutting(classified) in formation, trolley refuges, side drains	Cum	5,165
3	012012	Soft rock not requiring blasting in all conditions	Cum	2,070
4	012013	In hard rock requiring blasting with explosives and blasting /drilling equipment incl. All incidental work in all conditions. Rate includes cost of all explosive material	Cum	1,035
5	012014	In rock and very hard rock with hammer / chisel / pavement breaker etc. Where blasting is not permitted due to special circumstance and if specifically ordered in writing incl. Drilling and all incidental work in all conditions	Cum	1,550
6	011033	Earth work in Embankment	Cum	24,45,200

SR. NO	DESCRIPTION	UNITS	QTY
RAIL & FASTENING BOQ MAINLINE (Waterway Section – – 1 Track)			
1	Permanent way main line 60 Kg. Ist Class rails with Fastenings	MT	7,600
2	Fish Plates	Nos.	19,500
3	Fish bolts	Nos.	38,980
4	Bearing plate	Nos.	1,65,700
PSC SLEEPER BOQ MAINLINE (Waterway Section) – 1 Track			
1	PSC Sleeper for plain track	Nos.	82,850
BALLAST BOQ (Waterway Section)			
1	Providing and spreading 65 mm size track ballast for main	Cum	5,67,400

	line and loop line		
POINT & CROSSING BOQ (Waterway Section– 1 Track)			
1	60 Kg. 1 in 12 T/O with PSC Sleepers	Set	39
KILOMETER & Gradient POST BOQ (Waterway Section)			
1	Kilometre post	Each	130
2	Gradient post	Each	65
3	Hectometre Post	Each	650
4	Sign posts	Sqm	490
5	Boundary stones	Nos.	1,300
SUBGRADE BOQ (Waterway Section)			
1	Subgrade	Cum	21,65,500
TURFING BOQ (Waterway Section)			
1	Turfing	sqm	2,55,700
STONE PITCHING BOQ (Waterway Section)			
1	Stone Pitching	Cum	27,500
SIDE DRAIN BOQ (Waterway Section)			
1	OPC 53 grade	Tonne	2,910
2	Supply and applying shuttering oil mould releasing for concrete formwork to be applied either by brush or with spray machine to the entire satisfaction of Engineer in-charge.	Sqm.	66,500
3	All kinds of soils	cum	1,040
4	Providing and laying in position machine mixed, machine vibrated and machine batched Design Mix Cement Concrete M20 grade (cast -in-situ) using 20mm graded crushed stone aggregate and course sand of approved in Abutment, pier, wing wall and return walls of mass cement concrete above RCC raft including finishing complete as per specifications and direction of the Engineer in charge. Payment for cement, reinforcement and shuttering shall be paid extra.	cum	4,975
5	Centring and shuttering including strutting , propping etc. and removal of form for : Abutment , pier, wing walls and return walls	Sqm	66,500
DRAIN BOQ (Waterway Section)			
1	Drain in dam length	meter	60,000
2	Drain for connection between tracks	km	53.37
SEJ BOQ (Waterway Section)			
1	SEJ	no.	65

<u>(B) Approach Section and Connection:</u>

SR. NO	ITEM no. IRUSSOR-2021	DESCRIPTION	UNITS	QTY
EARTHWORK BOQ (Connection)				

SR. NO	ITEM no. IRUSSOR-2021	DESCRIPTION	UNITS	QTY
EARTHWORK BOQ (Connection)				
1	011010	Preparation of foundation for Embankment by clearing, grubbing, Stripping topsoil (average 15cm), ploughing and pulverizing 15cm of top of soil with tractor trolley, mixing water to achieve OMC With water sprinkler or left for natural drying, as required, and compaction with vibratory roller of suitable capacity to achieve 98% MDD for laying first layer of soil for embankment construction	Sqm	49,340
2	012011	Earthwork in cutting(classified) in formation, trolley refuges, side drains	Cum	3,090
3	012012	Soft rock not requiring blasting in all conditions	Cum	1,235
4	012013	In hard rock requiring blasting with explosives and blasting /drilling equipment incl. All incidental work in all conditions. Rate includes cost of all explosive material	Cum	620
5	012014	In rock and very hard rock with hammer / chisel / pavement breaker etc. Where blasting is not permitted due to special circumstance and if specifically ordered in writing incl. Drilling and all incidental work in all conditions	Cum	930
6	011033	Earth work in Embankment	Cum	1,04,62,300
MURUM BLANKET BOQ (Approach Section & Connections)				
1	012030	Murum Blanket	Cum	10,10,000

SR. NO	DESCRIPTION	UNITS	QTY
RAIL & FASTENING BOQ CONNECTINGLINE – 1 Track			
1	Permanent way main line 60Kg. Ist Class rails with Fastenings	MT	2,115
2	Fish Plates	Nos.	5,420
3	Fish bolts	Nos.	10,850
4	Bearing plate	Nos.	45,550
PSC SLEEPER BOQ MAINLINE (Approach Section) – 1 Track			

SR. NO	DESCRIPTION	UNITS	QTY
1	PSC Sleeper for plain track	Nos.	44,620
PSC SLEEPER BOQ CONNECTING– 1 Track			
1	PSC Sleeper for plain track	Nos.	23,030
BALLAST BOQ (Approach Section & Connections)			
1	Providing and spreading 65 mm size track ballast for main line and loop line	Cum	4,89,000
POINT & CROSSING BOQ (Approach Section & Connections– 1 Track)			
1	60 Kg. 1 in 12 T/O with PSC Sleepers	Set	21
Kilometer & Gradient POST BOQ (Approach Section & Connections)			
1	Kilometer post	Each	70
2	Gradient post	Each	35
3	Hectometer Post	Each	350
4	Sign posts	Sqm	265
5	Boundary stones	Nos.	700
SUBGRADE BOQ (Approach Section & Connections)			
1	Subgrade	Cum	18,66,000
TURFING BOQ (Approach Section & Connections)			
1	Turfing	sqm	5,17,500
STONE PITCHING BOQ (Approach Section & Connections)			
1	Stone Pitching	Cum	1,49,150
SIDE DRAIN BOQ (Approach Section & Connections)			
1	OPC 53 grade	Tonne	4,365
2	Supply and applying shuttering oil mould releasing for concrete formwork to be applied either by brush or with spray machine to the entire satisfaction of Engineer in-charge.	Sqm.	99,735
3	All kinds of soils	cum	1,560
4	Providing and laying in position machine mixed, machine vibrated and machine batched Design Mix Cement Concrete M20 grade (cast -in-situ) using 20mm graded crushed stone aggregate and course sand of approved in Abutment, pier, wing wall and return walls of mass	cum	7,460

SR. NO	DESCRIPTION	UNITS	QTY
	cement concrete above RCC raft including finishing complete as per specifications and direction of the Engineer in charge. Payment for cement, reinforcement and shuttering shall be paid extra.		
5	Centring and shuttering including strutting , propping etc. and removal of form for : Abutment , pier, wing walls and return walls	Sqm	99,735
6	Drain for the connection between tracks	km	53.37
DRAIN BOQ (Approach Section & Connections)			
1	Drain in dyke length	meter	8,000
BOUNDARY WALL BOQ (Approach Section & Connections)			
1	Boundary wall	meter	12,000
SEJ BOQ (Approach Section & Connections)			
1	SEJ	no.	35

- **Bill of Quantities for Railway Bridge Structures**

Table 2.152: BOQ for Bridge across flood regulator portion - Superstructure & Substructure- Railway Bridge - 22m EJ to EJ span (4 x 100 Nos. of spans) with substructure

S.No	Description of work	Unit	Nos	Quantity
1	Earthwork in excavation of foundations for structures including all leads and lifts as per joint and technical specification Clause 304.			
	Pilecap	cum	99	45494.46
			Total =	**45494.46**
2	Plain Cement Concrete in levelling course excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2100. **M15 grade**			
	M15 PCC below pilecap	cum	99	2967.03
			Total =	**2967.03**
3	Installation of Pile: Driving of Pile into the soil including bentonite			
	Pile (pile length of 35 metres is assumed)	Rm	1980	69300
			Total =	**69300**
4	Reinforced Cement Concrete in **foundation** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade foundation**			
	M35 - Pile (1.2m dia)	cum	1980	78376.32
	M35 - Pilecap	cum	99	35604.36

S.No	Description of work	Unit	Nos	Quantity
			Total =	**113980.68**
5	Reinforced Cement Concrete in **Substructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade Substructure**			
	M35 wall pier	cum	99	207524.79
			Total =	**207524.79**
6	Reinforced Cement Concrete in **Superstructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M55, M45 & M35 grade Superstructure**			
	M55 Girders	cum	1600	25584.96
	M45 Deck slab	cum	400	10713.77
	M45 Diaphragm	cum	1200	2626.08
	M35 Footpath & kerb	cum	400	3480.00
			M35 Total =	**3480.00**
			M45 Total =	**13339.85**
			M55 Total =	**25584.96**
7	Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.)			
		Lm	101	2504.80
			Total =	**2504.80**
8	M15 Grade wearing coat over deck slab			
		Cum	100	261.360
			Total =	**261.360**
9	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as per MORTH Technical Specification Section 1600. **(Fe 500 Grade & HTS Bars)**			

S.No	Description of work	Unit	Nos	Quantity
	Pile HYSD	MT	1980	8947.62
	Pilecap HYSD	MT	99	4416.79
	Pier HYSD	MT	99	29932.45
	Girders HYSD	MT	1600	2943.96
	Deck slab HYSD	MT	400	2075.88
	Diaphragm HYSD	MT	1200	1086.33
			Total =	**49403.03**
	Girder HT Steel Bars	MT	100	2112.40
			Total =	**2112.40**
10	Providing and fixing of Elastomeric, Pin & Metallic Guided Bearings			
	Elastomeric Bearing	cum	3200	60.480
	Pin Bearing	Nos	400	400
	Metallic Guided Bearing	Nos	400	400

Table 2.153: BOQ for Rail Bridges in approach (Block estimate)-Railway Bridge BOQ Summary- Total of 23 Bridges in approaches for Main line (3 track) & 7 bridges in Branch line (Single track)

S.No	Description of work	Unit	Quantity
1	Reinforced Cement Concrete in Foundation & Substructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade foundation & Substructure	Cum	1,92,621.60
2	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Superstructure	Cum	-
3	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M45 grade Superstructure	Cum	-
4	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M55 grade Superstructure	Cum	11,521.68
5	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as MORTH Technical Specification Section 1600. (Fe 500 Grade)	MT	26,969.26
6	Elastomeric Bearing	Cum	4.84
7	Pin Bearing	Nos	64.00

8	Metallic Guided Bearing	Nos	64.00
9	Spherical Bearing	Nos	32.00
10	High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as MORTH Technical Specifications	MT	395.81
11	Structural Steel of grade E350 including fabrication for Superstructure	MT	10,960.00

- **Bill of Quantities for Road Bridge Structures**

Table 2.154: BOQ for Bridge across flood regulator portion - Superstructure & Substructure- Left Main Carriageway Road Bridge - 22m EJ to EJ span (100 Nos. of spans) with substructure

S.No	Description of work	Unit	Nos	Quantity
1	Earthwork in excavation of foundations for structures including all leads and lifts as per joint and technical specification Clause 304.			
	Pilecap	cum	99	56671.34
			Total =	**56671.34**
2	Plain Cement Concrete in levelling course excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2100. **M15 grade**			
	M15 PCC below pilecap	cum	99	3695.96
			Total =	**3695.96**
3	Installation of Pile: Driving of Pile into the soil including bentonite			
	Pile (pile length of 35 metres is assumed)	Rm	2574	90090
			Total =	**90090**
4	Reinforced Cement Concrete in **foundation** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade foundation**			
	M35 - Pile (1.2m dia)	cum	2574	101889.81
	M35 - Pilecap	cum	99	44351.01
			Total =	**146240.82**

S.No	Description of work	Unit	Nos	Quantity
5	Reinforced Cement Concrete in **Substructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade Substructure**			
	M35 wall pier	cum	99	259145.37
			Total =	**259145.37**
6	Reinforced Cement Concrete in **Superstructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M45 & M35 grade Superstructure**			
	M45 Girders	cum	1500	25860.30
	M35 Deck slab	cum	100	24452.40
	M35 Diaphragm	cum	300	5575.63
	M35 Crash Barrier	cum	100	2625.00
			M35 Total =	**32653.03**
			M45 Total =	**25860.30**
7	Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.)			
		Lm	101	4393.50
			Total =	**4393.50**
8	Providing and laying mastic asphalt wearing course with paving grade bitumen, prepared by using mastic cooker and laid to required level and slope.			
		Cum	100	282.750
			Total =	**282.750**

S.No	Description of work	Unit	Nos	Quantity
9	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as per MORTH Technical Specification Section 1600. **(Fe 500 Grade & HTS Bars)**			
	Pile HYSD	MT	2574	11631.91
	Pilecap HYSD	MT	99	5495.49
	Pier HYSD	MT	99	37387.85
	Girders HYSD	MT	1500	4043.21
	Deck slab HYSD	MT	100	2790.06
	Diaphragm HYSD	MT	300	521.41
			Total =	**61869.93**
	Girder HT Steel Bars	MT	100	1238.10
			Total =	**1238.10**
10	Providing and fixing of Elastomeric Bearings			
	Elastomeric Bearing	cum	3000	56.70
			Total =	**56.70**

Table 2.155: BOQ for Bridge across flood regulator portion - Superstructure & Substructure- Right Main Carriageway Road Bridge - 22m EJ to EJ span (100 Nos. of spans) with substructure

S.No	Description of work	Unit	Nos	Quantity
1	Earthwork in excavation of foundations for structures including all leads and lifts as per joint and technical specification Clause 304.			
	Pilecap	cum	99	55909.00
			Total =	**55909.00**
2	Plain Cement Concrete in levelling course excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2100. **M15 grade**			
	M15 PCC below pilecap	cum	99	3646.24
			Total =	**3646.24**

S.No	Description of work	Unit	Nos	Quantity
3	Installation of Pile: Driving of Pile into the soil + Liner requirement			
	Pile	Rm	2574	90090
			Total =	**90090**
4	Reinforced Cement Concrete in **foundation** and substructure excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade foundation**			
	M35 - Pile (1.2m dia)	cum	2574	101889.81
	M35 - Pilecap	cum	99	43755.03
			Total =	**145644.84**
5	Reinforced Cement Concrete in S**ubstructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade Substructure**			
	M35 wall pier	cum	99	256159.53
			Total =	**256159.53**
6	Reinforced Cement Concrete in **Superstructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M45 & M35 grade Superstructure**			
	M45 Girders	cum	1500	24136.28
	M35 Deck slab	cum	100	24452.40
	M35 Diaphragm	cum	300	5575.63
	M35 Crash Barrier	cum	100	2625.00
			M35 Total =	**32653.03**
			M45 Total =	**24136.28**
7	Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring			

S.No	Description of work	Unit	Nos	Quantity
	compliance to the manufacturer's instructions for installation.)			
		Lm	101	4191.50
			Total =	**4191.50**
8	Providing and laying mastic asphalt wearing course with paving grade bitumen, prepared by using mastic cooker and laid to required level and slope.			
		Cum	100	269.750
			Total =	**269.750**
9	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as per MORTH Technical Specification Section 1600. **(Fe 500 Grade & HTS Bars)**			
	Pile HYSD	MT	2574	11631.91
	Pilecap HYSD	MT	99	5415.40
	Pier HYSD	MT	99	36889.48
	Girders HYSD	MT	1500	3773.66
	Deck slab HYSD	MT	100	2790.06
	Diaphragm HYSD	MT	300	521.41
			Total =	**61021.91**
	Girder HT Steel Bars	MT	100	1155.55
			Total =	**1155.55**
10	Providing and fixing of Elastomeric Bearings			
	Elastomeric Bearing	cum	3000	52.90
			Total =	**52.90**

Table 2.156: BOQ for Bridge across flood regulator portion - Superstructure & Substructure-Crest Road Superstructure - 22m EJ to EJ span (100 Nos. of spans)

S.No	Description of work	Unit	Nos	Quantity

1	Earthwork in excavation of foundations for structures including all leads and lifts as per joint and technical specification Clause 304.			
	Pilecap	cum	0	0.00
			Total =	**0.00**
2	Plain Cement Concrete in levelling course excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2100. **M15 grade**			
	M15 PCC below pilecap	cum	0	0.00
			Total =	**0.00**
3	Installation of Pile: Driving of Pile into the soil + Liner requirement			
	Pile	Rm	0	0
			Total =	**0**
4	Reinforced Cement Concrete in **foundation** and substructure excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade foundation**			
	M35 - Pile (1.2m dia)	cum	0	0.00
	M35 - Pilecap	cum	0	0.00
			Total =	**0.00**
5	Reinforced Cement Concrete in S**ubstructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M35 grade Substructure**			
	M35 wall pier	cum	0	0.00
			Total =	**0.00**
6	Reinforced Cement Concrete in **Superstructure** excluding reinforcement complete as per MORTH Technical Specifications Sections 1500, 1700 and 2200. **M45 & M35 grade Superstructure**			
	M45 Girders	cum	400	6896.00
	M35 Deck slab	cum	100	5060.00
	M35 Diaphragm	cum	300	1133.10
	M35 Crash Barrier	cum	100	1375.00

			M35 Total =	**7568.10**
			M45 Total =	**6896.00**
7	Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.)			
		Lm	101	1161.50
			Total =	**1161.50**
8	Providing and laying mastic asphalt wearing course with paving grade bitumen, prepared by using mastic cooker and laid to required level and slope.			
		Cum	100	74.750
			Total =	**74.750**
9	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as per MORTH Technical Specification Section 1600. **(Fe 500 Grade & HTS Bars)**			
	Pile HYSD	MT	0	0.00
	Pilecap HYSD	MT	0	0.00
	Pier HYSD	MT	0	0.00
	Girders HYSD	MT	400	1078.00
	Deck slab HYSD	MT	100	581.90
	Diaphragm HYSD	MT	300	275.89
			Total =	**1935.79**
	Girder HT Steel Bars	MT	100	330.12
			Total =	**330.12**
10	Providing and fixing of Elastomeric Bearings			
	Elastomeric Bearing	cum	800	15.12
			Total =	**15.12**

Table 2.157: BOQ for Road Bridges in approach (Block estimate)-Roadway Bridge BOQ Summary- Total of 32 Bridges in approaches, 1 Interchange ramp at Ch: 0+000 & 1 Clover leaf Ramp at Ch: 23+500 in approach

S.No	Description of work	Unit	Quantity
1	Reinforced Cement Concrete in Foundation & Substructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade foundation & Substructure	Cum	5,01,475.50
2	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Superstructure	Cum	-
3	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M45 grade Superstructure	Cum	54,127.55
4	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M55 grade Superstructure	Cum	-
5	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as MORTH Technical Specification Section 1600. (Fe 500 Grade)	MT	74,833.14
6	Elastomeric Bearing	Cum	18.79
7	Pin Bearing	Nos	31.00
8	Metallic Guided Bearing	Nos	31.00
9	Spherical Bearing	Nos	80.00
10	High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as MORTH Technical Specifications	MT	2,264.18
11	Structural Steel of grade E350 including fabrication for Superstructure	MT	-

(e) Costing

- **Costing for Road**

Total Project Cost

Detailed Bills of Quantities are prepared based on the design of all project components and costs worked out using the rates derived. Summary of Total cost is shown in Table 2.158.

Table 2.158: Summary of Cost Estimates for Road (Dyke and Approach Road)

S.No.	Bill of Items	Total Amount , Rs.

S.No.	Bill of Items	Total Amount , Rs.
1	BILL NO. 1: Site Clearance and Dismantling	2,11,91,341
2	BILL NO. 2: Earthwork	12,82,57,31,389
3	BILL NO. 3: Pavement	25,55,57,60,301
4	BILL NO.4 : Drain	76,49,85,045.60
5	BILL NO.5 : Rest areas and Bus bays	21,77,76,829.21
6	BILL NO.6 : Road Furniture	2,83,11,91,343.08
7	BILL NO.7 : Intersections	50,21,56,294.10
	Civil Work Cost (Rs.) (a)	**42,71,87,92,544**
	Total Civil Cost Including 18% GST (Rs.) (b)	50,40,81,75,201.73
	Length (Km)	105.3
	Per Km cost (Rs.)	97.09394289
	Add physical contingency @ 1% of (a)	427187925.4
	Total Cost including Physical Contingency of 1% (c)	**50,83,53,63,127.17**
	Agency Charges 3% of (a)	1,28,15,63,776.32
	Supervision 3% of (a)	1,28,15,63,776.32
	Price escalation of 7.5% of (a)	3,20,39,09,440.79
	5% Periodic Maintenance at every 5 year and 1% yearly routine maintanence of (a)	28,62,15,91,004.37
	Centages	34,38,86,27,997.79
	Total Project Cost (Rs.)	**85,22,39,91,124.97**
	Total Project Cost in Cr. (excluding maintenance)	**5,660.24**

Table 2.159: Summary of Cost Estimates for Road-Dyke portion (From Km 23+500 to Km 83+500)

S.No.	Bill of Items	Total Amount , Rs.
1	BILL NO. 1: Site Clearance and Dismantling	89,30,065
2	BILL NO. 2: Earthwork	3,33,58,93,248
3	BILL NO. 3: Pavement	16,11,32,07,424
4	BILL NO.4 : Drain	69,69,81,348.00
5	BILL NO.5 : Rest areas and Bus bays	8,71,91,796.00
6	BILL NO.6 : Road Furniture	1,96,31,57,999.34
7	BILL NO.7 : Intersections	1,74,64,384.67
	Civil Work Cost (Rs.) (a)	**22,22,28,26,264**
	Total Civil Cost Including 18% GST (Rs.) (b)	26,22,29,34,991.59
	Length (Km)	60
	Per Km cost (Rs.)	43.70489165
	Add physical contingency @ 1% of (a)	222228262.6
	Total Cost including Physical Contingency of 1% (c)	**26,44,51,63,254.23**

	Agency Charges 3% of (a)	66,66,84,787.92
	Supervision 3% of (a)	66,66,84,787.92
	Price escalation of 7.5% of (a)	1,66,67,11,969.80
	5% Periodic Maintenance at every 5 year and 1% yearly routine maintenance of (a)	14,88,92,93,596.92
	Centages	17,88,93,75,142.57
	Total Project Cost	**44,33,45,38,396.79**
	Total Project Cost in Cr. (excluding maintenance)	**2,944.52**

Table 2.160: Summary of Cost Estimates for Road-Approach Roads (From Km 0+000 to Km 23+500 & From Km 83+500 to Km 105+300)

S.No.	Bill of Items	Total Amount , Rs.
1	BILL NO. 1: Site Clearance and Dismantling	1,22,61,277
2	BILL NO. 2: Earthwork	9,48,98,38,142
3	BILL NO. 3: Pavement	9,44,25,52,877
4	BILL NO.4 : Drain	6,80,03,697.60
5	BILL NO.5 : Rest areas and Bus bays	13,05,85,033.21
6	BILL NO.6 : Road Furniture	86,80,33,343.74
7	BILL NO.7 : Intersections	48,46,91,909.43
	Civil Work Cost (Rs.) (a)	**20,49,59,66,280**
	Total Civil Cost Including 18% GST (Rs.) (b)	24,18,52,40,210.15
	Length (Km)	45.3
	Per Km cost (Rs.)	53.38905124
	Add physical contingency @ 1% of (a)	204959662.8
	Total Cost including Physical Contingency of 1% (c)	**24,39,01,99,872.95**
	Agency Charges 3% of (a)	61,48,78,988.39
	Supervision 3% of (a)	61,48,78,988.39
	Price escalation of 7.5% of (a)	1,53,71,97,470.98
	5% Periodic Maintenance at every 5 year and 1% yearly routine maintenance of (a)	13,73,22,97,407.46
	Centages	16,49,92,52,855.23
	Total Project Cost	**40,88,94,52,728.17**
	Total Project Cost in Cr. (excluding maintenance)	**2,715.72**

- **Costing for Rail**

Table 2.161: Summary of Costing-Railway Line

Length (Km):		**Waterway Section**	**Approach and Connection**
		61.9	53.3
Sl No.	**Description**	**Sub Head Cost**	

Length (Km):		Waterway Section	Approach and Connection
		61.9	53.3
Sl No.	**Description**	**Sub Head Cost**	
Formation			
1	Earthwork	3,54,73,95,836	15,08,58,38,137
2	Subgrade	72,09,71,087	62,12,69,754
3	Murum Blanketing	2,73,42,96,689	1,69,37,33,884
4	Side drain	6,90,92,080	14,29,94,023
5	Turfing	1,43,51,083	2,90,42,873
6	Stone Pitching	4,17,26,332	22,64,17,587
7	Drain	66,89,42,218	7,14,00,296
	Sub-Total Cost (Rs)	7,79,67,75,325	17,87,06,96,555
Structural Engg.- Permanent Way			
8	Rail and Fastenings	4,26,53,55,725	3,47,94,63,533
9	PSC Sleepers and fastenings	96,71,39,843	78,95,19,364
10	Ballast	78,65,90,246	67,78,14,599
11	Point and Crossing	34,49,14,628	18,57,23,261
12	KM and Gradient Post	19,19,475	10,33,563
13	Boundary Wall	-	4,20,00,000
14	SEJ	1,97,08,587	1,97,08,587
	Sub-Total Cost (Rs)	6,38,56,28,505	5,19,52,62,909
	S&T AND ELECTRIFICATION COST @ 30% of Civil Cost	4,82,94,27,715	7,38,73,61,501
	Total (Rs)	19,01,18,31,545	30,45,33,20,965
	GRAND TOTAL (Rs)	**49,46,51,52,510**	

Table 2.162: Block Cost Estimates for Railway Line – Waterway Section

EARTHWORK COSTING (Rs) (Waterway Section)						
SR.NO	**ITEM no. IRUSSOR-2021**	**DESCRIPTION**	**UNITS**	**RATE (Rs)**	**QTY**	**AMOUNT (Rs)**
1	011010	Preparation of foundation for Embankment by clearing, grubbing, Stripping topsoil (average 15cm), ploughing and pulverizing 15cm of top of soil with tractor trolley, mixing water to achieve OMC With water sprinkler or left for natural drying, as required, and compaction with vibratory roller of suitable capacity to achieve 98% MDD for laying first layer of soil for embankment construction	Sqm	547	40,365	2,20,82,077
2	012011	Earthwork in cutting (classified) in formation, trolley refuges, side drains	Cum	79	5,165	4,08,068
3	012012	Soft rock not requiring blasting in all conditions	Cum	202	2,070	4,18,595
4	012013	In hard rock requiring blasting with explosives and blasting /drilling equipment incl. All incidental work in all conditions. Rate includes cost of all explosive material	Cum	330	1,035	3,41,550
5	012014	In rock and very hard rock with hammer / chisel / pavement breaker etc. Where blasting is not permitted due to special circumstance and if specifically ordered in writing incl. Drilling and all incidental work in all conditions	Cum	795	1,550	12,32,185
6	011033	Earth work in Embankment	Cum	1,187	2,44,5200	2,90,24,52,400
					Total	2,92,69,34,876

EARTHWORK COSTING (Rs) (Waterway Section)						
SR.NO	**ITEM no. IRUSSOR-2021**	**DESCRIPTION**	**UNITS**	**RATE (Rs)**	**QTY**	**AMOUNT (Rs)**
					Add 20% above on MS Items	58,53,86,975
					Total	3,51,23,21,851
					1 % add for contingencies	3,51,23,219
					Grand total	**3,54,74,45,069**
MURUM BLANKET COSTING (Rs) (Waterway Section)						
1	012030	Murum Blanket	cum	1,660	16,30,500	2,70,73,80,030
					1 % add for contingencies	2,70,73,800
					Grand total	**2,73,44,53,830**

SR. NO	**DESCRIPTION**	**UNITS**	**RATE (Rs)**	**QTY**	**AMOUNT (Rs)**
RAIL & FASTENING COSTING (Rs) MAINLINE (Waterway Section)					
1	Permanent way main line 60 Kg. Ist Class rails with Fastenings	MT	92,087	7,600	69,98,91,742
2	Fish Plates	Nos.	8,060	19,500	15,71,61,722
3	Bearing plate	Nos.	1,200	1,65,700	19,88,40,000
				Total	1,05,58,93,464
				1 % add for contingencies	1,05,58,935
				Grand Total For 4 TRACKS	**4,26,58,09,594**
PSC SLEEPER COSTING (Rs) MAINLINE (Waterway Section)					
1	PSC Sleeper for plain track	Nos.	2,890	82,850	23,94,09,868

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
				1 % add for contingencies	**23,94,099**
				Grand Total For 4 Tracks	**96,72,15,867**
BALLAST COSTING (Rs) (Waterway Section)					
1	Providing and spreading 65 mm size track ballast for main line and loop line	Cum	1,373	5,67,400	77,88,69,980
				1 % add for contingencies	77,88,700
				Total	**78,66,58,680**
POINT & CROSSING COSTING (Rs) (Waterway Section)					
1	60 Kg. 1 in 12 T/O with PSC Sleepers	Set	21,89,100	39	8,53,74,908
				Add 1 % contingency	8,53,749.08
				Grand Total For 4 Tracks	**34,49,14,628**
KILOMETER & Gradient POST COSTING (Rs) (Waterway Section)					
1	Kilometre post	Each	320	130	41,600
2	Gradient post	Each	320	65	20,800
3	Hectometre Post	Each	160	650	1,04,000
4	Sign posts	Sqm	2400	490	11,76,000
5	Boundary stones	Nos.	301	1,300	3,91,300
				Total	17,33,700
				Add 10% escalation above	1,73,370
				TOTAL	19,07,070
				Add 1 % contingency	19,071
				Grand Total	**19,26,141**

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
SUBGRADE COSTING (Rs) (Waterway Section)					
1	Subgrade	Cum	333	21,65,500	**72,09,88,500**
TURFING COSTING (Rs) (Waterway Section)					
1	Turfing	Sqm	56	2,55,700	**1,43,51,546**
STONE PITCHING COSTING (Rs) (Waterway Section)					
1	Stone Pitching	Cum	1,518	27,500	**4,17,51,050**
SIDE DRAIN COSTING (Rs) (Waterway Section)					
1	OPC 53 grade	Tonne	8,292	2910	2,41,30,244
2	Supply and applying shuttering oil mould releasing for concrete formwork to be applied either by brush or with spray machine to the entire satisfaction of Engineer in-Charge.	Sqm.	11	66,500	7,48,208
3	All kinds of soils	cum	285	1,040	2,96,692
4	Providing and laying in position machine mixed, machine vibrated and machine batched Design Mix Cement Concrete M20 grade (cast -in-situ) using 20mm graded crushed stone aggregate and course sand of approved in Abutment, pier, wing wall and return walls of mass cement concrete above RCC raft including finishing complete as per specifications and direction of the Engineer in charge. Payment for cement, reinforcement and shuttering shall be paid extra.	cum	2,231	4,975	1,11,00,974
5	Centring and shuttering including strutting , propping etc. and removal of form for : Abutment , pier, wing walls and return walls	Sqm	312	66,500	2,07,63,442
				Total	5,70,39,561
				Add 20% above on MS Items	1,14,07,912
				Total	6,84,47,473

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
				Add 1% for Contingencies	6,84,475
				Grand Total	**6,91,31,947**
DRAIN COSTING (Rs) (Waterway Section)					
1	Drain in dyke length	meter	8,925	60,000	53,55,02,218
2	Drain for connection between tracks	km	25,00,000	53.37	13,34,40,000
				Total	**66,89,42,218**
SEJ COSTING (Rs) (Waterway Section)					
1	SEJ	no.	1,97,086	65	**1,28,10,582**

Table 2.163: Block Cost Estimates for Railway Line – Approach Section and Connecting Line

SR.NO	ITEM no. IRUSSOR-2021	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
EARTHWORK COSTING (Rs) (Approach Section & Connections)						
1	011010	Preparation of foundation for Embankment by clearing, grubbing, Stripping topsoil (average 15cm), ploughing and pulverizing 15cm of top of soil with tractor trolley, mixing water to achieve OMC With water sprinkler or left for natural drying, as required, and compaction with vibratory roller of suitable capacity to achieve 98% MDD for laying first layer of soil for embankment construction	Sqm	547	49,340	2,69,91,940
2	012011	Earthwork in cutting (classified) in formation, trolley refuges, side drains	Cum	79	3,090	2,44,110
3	012012	Soft rock not requiring blasting in all conditions	Cum	202	1,235	2,49,742

SR.NO	ITEM no. IRUSSOR-2021	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
4	012013	In hard rock requiring blasting with explosives and blasting /drilling equipment incl. All incidental work in all conditions. Rate includes cost of all explosive material	Cum	330	620	2,04,600
5	012014	In rock and very hard rock with hammer / chisel / pavement breaker etc. Where blasting is not permitted due to special circumstance and if specifically ordered in writing incl. Drilling and all incidental work in all conditions	Cum	795	930	7,39,490
6	011033	Earth work in Embankment	Cum	1,187	1,04,62,300	12,41,87,50,100
					Total	12,44,71,79,982
					Add 20% above on MS Items	2,48,94,35,996
					Total	14,93,66,15,978
					1 % add for contingencies	14,93,66,160
					Grand total	**15,08,59,82,138**
MURUM BLANKET COSTING (Rs) (Approach Section & Connections)						
1	012030	Murum Blanket	Cum	1,660	10,10,000	1,67,70,64,600
					1 % add for contingencies	1,67,70,646
					Total	**1,69,38,35,246**

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
RAIL & FASTENING COSTING (Rs) APPROACH SECTION					
1	Permanent way main line 60 Kg. Ist Class rails with Fastenings	MT	92,087	4,100	37,75,57,279

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
2	Fish Plates	Nos.	8,060	10,500	8,46,25,543
3	Bearing plate	Nos.	1,200	89,220	10,70,64,000
				Total	56,92,46,822
				1 % add for contingencies	56,92,468
				Grand Total For 4 Tracks	**2,29,97,57,161**
RAIL & FASTENING COSTING (Rs) CONNECTING LINE					
1	Permanent way main line 60 Kg. Ist Class rails with Fastenings	MT	92,087	2,115	19,47,64,304
2	Fish Plates	Nos.	8,060	5,420	4,36,82,899
3	Bearing plate	Nos.	1,200	45,550	5,46,60,000
				Total	29,31,07,203
				1 % add for contingencies	29,31,072
				Grand Total For 4 Tracks	**1,18,41,53,100**
PSC SLEEPER COSTING (Rs) MAINLINE (Approach Section)					
1	PSC Sleeper for plain track	Nos.	2,890	44,620	12,89,37,457
				1 % add for contingencies	12,89,375
				Grand Total For 4 Tracks	**52,09,07,326**
PSC SLEEPER COSTING (Rs) Connecting Line					
1	PSC Sleeper for plain track	Nos.	2,890	23,030	6,65,49,297
				1 % add for contingencies	6,65,493
				Grand Total For 4 Tracks	**26,88,59,160**
BALLAST COSTING (Rs) (Approach Section & Connections)					

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
1 1	Providing and spreading 65 mm size track ballast for main line and loop line	Cum	1,373	4,89,000	**67,12,50,300**
				1 % add for contingencies	67,12,503
				Total	**67,79,62,803**
POINT & CROSSING COSTING (Rs) (Approach Section & Connections)					
1	60 Kg. 1 in 12 T/O with PSC Sleepers	Set	21,89,100	21	4,59,71,104
				Add 1 % contingency	4,59,711
				Grand Total For 4 Tracks	**18,57,23,261**
KILOMETER & GRADIENT POST COSTING (Rs) (Approach Section & Connections)					
1	Kilometre post	Each	320	70	22,400
2	Gradient post	Each	320	35	11,200
3	Hectometre Post	Each	160	350	56,000
4	Sign posts	Sqm	2,400	265	6,36,000
5	Boundary stones	Nos.	301	700	2,10,700
				Total	9,36,300
				Add 10% escalation above	93,630
				TOTAL	10,29,930
				Add 1 % contingency	10,299
				Grand Total	**10,40,229**
SUBGRADE COSTING (Rs) (Approach Section & Connections)					
1	Subgrade	Cum	333	18,66,000	62,12,72,011

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
TURFING COSTING (Rs) (Approach Section & Connections)					
1	Turfing	sqm	56	5,17,500	**2,90,45,464**
STONE PITCHING COSTING (Rs) (Approach Section & Connections)					
1	Stone Pitching	Cum	1,518	1,49,150	**22,64,42,513**
SIDE DRAIN COSTING (Rs) (Approach Section & Connections)					
1	OPC 53 grade	Tonne	8,292	4,365	3,61,95,367
2	Supply and applying shuttering oil mould releasing for concrete formwork to be applied either by brush or with spray machine to the entire satisfaction of Engineer in-charge.	Sqm.	11	99,735	11,22,143
3	All kinds of soils	cum	285	1560	4,45,038
4	Providing and laying in position machine mixed, machine vibrated and machine batched Design Mix Cement Concrete M20 grade (cast -in-situ) using 20mm graded crushed stone aggregate and course sand of approved in Abutment, pier, wing wall and return walls of mass cement concrete above RCC raft including finishing complete as per specifications and direction of the Engineer in charge. Payment for cement, reinforcement and shuttering shall be paid extra.	cum	2,231	7,460	1,66,45,883
5	Centring and shuttering including strutting, propping etc. and removal of form for : Abutment, pier, wing walls and return walls	Sqm.	312	99,735	3,11,40,480
6	Drain for the connection between tracks	km	25,00,000	53.37	1,77,92,000
				Total	10,33,40,910
				Add 20% above on MS Items	2,06,68,182
				Total	12,40,09,092

SR. NO	DESCRIPTION	UNITS	RATE (Rs)	QTY	AMOUNT (Rs)
Add 1% for Contingencies					12,40,091
Grand Total					**12,52,49,183**
DRAIN COSTING (Rs) Dyke length (Approach Section & Connections)					
1	Drain in dyke length	meter	8,925	8,000	**7,14,00,296**
2	Drain for connection between tracks	km	25,00,000	53.37	13,34,40,000
BOUNDARY WALL COSTING (Rs) (Approach Section & Connections)					
1	Boundary wall	meter	3,500	12,000	**4,20,00,000**
SEJ COSTING (Rs) (Approach Section & Connections)					
1	SEJ	no.	1,97,086	35	**68,98,006**

(C) Maintenance Schedule and Costing:

Maintenance Costing is arrived based on the Maintenance Schedule anticipated to be carried out during the project operation period of 40 years from Year 2032 to 2071. The Schedule of maintenance is assumed to be carried out periodically every 5 years i.e 2037, 2042, 2047, 2052, 2057, 2062 & 2067 (total 7 maintenance interventions of 5 years schedule). Apart from this, it is also anticipated that every year (from 2032 except 5th years), there would be routine maintenance of project assets / items. The percent maintenance is assumed to be varying from item to item and considered to vary between 0.5 to 10% across items based on industry practice.

Table 2.164: Total Maintenance Cost Summary for 40 Years – Waterway and Approach Section+ Connections

SR. NO	PERIODICAL		YEARLY
	Water way section	**Approach section**	**Water way section & Approach section (115 KM)**
1	20,95,24,05,471	20,64,87,15,261	**20,19,40,00,000**
TOTAL (Rs)	**41,60,11,20,732**		
GRAND TOTAL (Rs)	**61,79,51,20,732**		

- **Costing for Road & Rail Bridge Structures**

Table 2.165: Costing for Railway Bridge across flood regulator portion - Superstructure & Substructure

S.No	Description of work	Unit	Quantity	Rate	Amount
1	Excavation for Structures (Earth work in excavation of foundation of structures as per MoRTH technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material.)	Cum	45,494	85	38,67,029
2	Plain Cement Concrete in levelling course excluding reinforcement complete as per drawings and Technical Specifications Sections1500, 1700 and 2100. M15 grade	Cum	2,967	5,902	1,75,11,411

S.No	Description of work	Unit	Quantity	Rate	Amount
3	Installation of Pile: Driving of Piles including bentonite	Rmt	69,300	4,816	33,37,48,800
4	Reinforced Cement Concrete in Foundation excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade foundation	Cum	1,13,981	6,294	71,73,94,400
5	Reinforced Cement Concrete in Substructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Substructure	Cum	2,07,525	6,591	1,36,77,95,891
6	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Superstructure	Cum	3,480	7,678	2,67,19,440
7	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M45 grade Superstructure	Cum	13,340	8,066	10,75,99,230
8	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M55 grade Superstructure	Cum	25,585	9,975	25,52,09,976
9	Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring	Rmt	2,505	4,225	1,05,82,780

S.No	Description of work	Unit	Quantity	Rate	Amount
	compliance to the manufacturer's instructions for installation.)				
10	Providing and laying wearing Coat of 65mm thick with Mastic Asphalt 25mm & Bituminous Concrete 40mm with paving grade bitumen meeting the requirements given in table 500-29, prepared by using mastic cooker and laid to required level and slope.	Cum	-	5,615	-
11	PCC Wearing coat over deck slab of M15 Grade for Railway Bridge	Cum	261	5,902	15,42,547
12	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as MORTH Technical Specification Section 1600. (Fe 500 Grade)	MT	49,403	1,18,239	5,84,13,78,461
13	Elastomeric Bearing	Cum	60	5,20,000	3,14,49,600
14	Pin Bearing	Nos	400	60,000	2,40,00,000
15	Metallic Guided Bearing	Nos	400	60,000	2,40,00,000
16	High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as MORTH Technical Specifications	MT	2,112	1,66,847	35,24,47,603
Total Amount (Rs.)					**9,11,52,47,167**

Table 2.166: Costing for Roadway Bridge (Left MCW + Right MCW + Crest Road) across flood regulator portion - Superstructure & Substructure

S.No	Description of work	Unit	Quantity	Rate	Amount

S.No	Description of work	Unit	Quantity	Rate	Amount
1	Excavation for Structures (Earth work in excavation of foundation of structures as per MoRTH technical specification, including setting out, construction of shoring and bracing, removal of stumps and other deleterious matter, dressing of sides and bottom and backfilling with approved material.)	Cum	1,12,580	85	95,69,329
2	Plain Cement Concrete in levelling course excluding reinforcement complete as per drawings and Technical Specifications Sections1500, 1700 and 2100. M15 grade	Cum	7,342	5,902	4,33,33,643
3	Installation of Pile: Driving of Piles including bentonite	Rmt	1,80,180	4,816	86,77,46,880
4	Reinforced Cement Concrete in Foundation excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade foundation	Cum	2,91,886	6,294	1,83,71,28,344
5	Reinforced Cement Concrete in Substructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Substructure	Cum	5,15,305	6,591	3,39,63,74,596
6	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Superstructure	Cum	72,874	7,678	55,95,27,800
7	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M45 grade Superstructure	Cum	56,893	8,066	45,88,95,550
8	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M55 grade Superstructure	Cum	-	9,975	-

S.No	Description of work	Unit	Quantity	Rate	Amount
9	Strip Seal Expansion Joint (Providing and laying of a strip seal expansion joint catering to maximum horizontal movement upto 70 mm, complete as per approved drawings and standard specifications to be installed by the manufacturer/supplier or their authorised representative ensuring compliance to the manufacturer's instructions for installation.)	Rmt	9,747	4,225	4,11,78,963
10	Providing and laying wearing Coat of 65mm thick with Mastic Asphalt 25mm & Bituminous Concrete 40mm with paving grade bitumen meeting the requirements given in table 500-29, prepared by using mastic cooker and laid to required level and slope.	Cum	627	5,615	35,22,250
11	PCC Wearing coat over deck slab of M15 Grade for Railway Bridge	Cum	-	5,902	-
12	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as MORTH Technical Specification Section 1600. (Fe 500 Grade)	MT	1,24,828	1,18,239	14,75,95,29,095
13	Elastomeric Bearing	Cum	125	5,20,000	6,48,54,400
14	Pin Bearing	Nos	-	60,000	-
15	Metallic Guided Bearing	Nos	-	60,000	-
16	High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as MORTH Technical Specifications	MT	2,724	1,66,847	45,44,52,853
Total Amount (Rs.)					**22,49,61,13,704**

Table 2.167: Costing for Railway Bridges in approaches

S.No	Description of work	Unit	Quantity	Rate	Amount
1	Reinforced Cement Concrete in Foundation & Substructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700	Cum	1,92,622	6,591	1,26,95,68,966

	and 2200. M35 grade foundation & Substructure				
2	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Superstructure	Cum	-	7,678	-
3	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M45 grade Superstructure	Cum	-	8,066	-
4	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M55 grade Superstructure	Cum	11,522	9,975	11,49,28,758
5	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as MORTH Technical Specification Section 1600. (Fe 500 Grade)	MT	26,969	1,18,239	3,18,88,25,412
6	Elastomeric Bearing	Cum	5	5,20,000	25,15,968
7	Pin Bearing	Nos	64	60,000	38,40,000
8	Metallic Guided Bearing	Nos	64	60,000	38,40,000
9	Spherical Bearing	Nos	32	1,30,000	41,60,000
10	High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as MORTH Technical Specifications	MT	396	1,66,847	6,60,39,377
11	Structural Steel of grade E350 including fabrication for Superstructure	MT	10,960	1,31,736	1,44,38,26,560
			Total Amount (Rs.)		**6,09,75,45,041**

Note: Above quantification and costing is a block cost estimate done based only on the data of No. of Bridges and tentative span of the bridges in approaches.

Table 2.168: Costing for Roadway Bridges in approaches

S.No	Description of work	Unit	Quantity	Rate	Amount
1	Reinforced Cement Concrete in Foundation & Substructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade foundation & Substructure	Cum	5,01,476	6,591	3,30,52,25,021
2	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M35 grade Superstructure	Cum	-	7,678	-
3	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M45 grade Superstructure	Cum	54,128	8,066	43,65,92,818
4	Reinforced Cement Concrete in Superstructure excluding reinforcement complete as per MoRTH Technical Specifications Sections 1500, 1700 and 2200. M55 grade Superstructure	Cum	-	9,975	-
5	Providing, cutting, bending and fixing TMT/HYSD bar reinforcement in reinforced concrete structures complete as MORTH Technical Specification Section 1600. (Fe 500 Grade)	MT	74,833	1,18,239	8,84,82,16,003
6	Elastomeric Bearing	Cum	19	5,20,000	97,69,032
7	Pin Bearing	Nos	31	60,000	18,60,000
8	Metallic Guided Bearing	Nos	31	60,000	18,60,000
9	Spherical Bearing	Nos	80	1,30,000	1,04,00,000
10	High tensile steel wires/strands including all accessories for stressing, stressing operations and grouting complete as MORTH Technical Specifications	MT	2,264	1,66,847	37,77,71,640
11	Structural Steel of grade E350 including fabrication for	MT	-	1,31,736	-

S.No	Description of work	Unit	Quantity	Rate	Amount
	Superstructure				
			Total Amount (Rs.)		**12,99,16,94,514**

Note: Above quantification and costing is a block cost estimate done based only on the data of No. of Bridges and tentative span of the bridges in approaches.

Table 2.169: Overall Summary of Block Costs of Bridge Structures

For Flood regulator portion:	**Amount (Rs.)**
Railway	9,11,52,47,167
Roadway	22,49,61,13,704
For Approach portion:	
Railway	6,09,75,45,041
Roadway	12,99,16,94,514
Total Railway (Flood regulator + approach)	15,21,27,92,208
Total Roadway (Flood regulator + approach)	35,48,78,08,218
Total Bridges cost	**50,70,06,00,426**

- **Summary of Block cost estimates**

Block cost estimates for road and rail components have been estimated for dyke section and approach road sections. Road cost is estimated based on prevailing SOR rates in Gujarat. Road costing is estimated under the following heads:
(1) Civil; and
(2) ITS

Delhi schedule of rates were used for deriving the block cost estimates for Rail components Railway costing is estimated under the following heads:
(1) Civil;
(2) Electrical;
(3) Mechanical; and
(4) Signalling & Telecommunication

The summary of block cost estimates for dyke section and approach road section is given in **Table 2.171.** The above cost does not include the land acquisition cost.

Table 2.170: Summary of block cost estimates (road and rail)

S.No.	Description-total	Total Amount	Total Amount in Rs. Crore
Road Cost			
1	Highway Civil Cost	56,60,24,00,121	5,660.24
2	Road Structural Cost	35,48,78,08,218	3,548.78
3	Intelligent Transport System (ITS) Cost	75,73,60,040	75.74
4	Environmental Charges due to Road @ 1% of civil cost	56,60,24,001	56.60
	Sub-Total - Road	**93,41,35,92,380**	**9,341.36**

S.No.	Description-total	Total Amount	Total Amount in Rs. Crore
	Rail Cost		
5	Rail Civil Cost	44,24,83,63,294	4,424.84
6	Rail Signalling, Telecommunication and Electrification Cost	12,21,67,89,216	1,221.68
7	Rail Mechanical Cost	1,15,83,608	1.16
8	Rail Structural Cost	17,54,86,68,995	1,754.87
9	Environmental Charges due to Rail @ 1% of civil cost	44,24,83,633	44.25
	Sub-Total - Rail	**74,46,78,88,746**	**7,446.79**
	Total Cost (Road & Rail)	**1,67,88,14,81,126**	**16,788.15**

Table 2.171: Summary of block cost estimates (road and rail)-Dyke Section

S.No.	Description-Waterway	Total Amount	Total Amount in Rs. Crore
	Road Cost		
1	Highway Civil Cost	29,44,52,44,800	2,944.52
2	Road Structural Cost	22,49,61,13,704	2,249.61
3	Intelligent Transport System (ITS) Cost	43,15,44,182	43.15
4	Environmental Charges due to Road @ 1% of civil cost	29,44,52,448.00	29.45
	Sub-Total - Road	**52,66,73,55,134**	**5,266.74**
	Rail Cost		
5	Rail Civil Cost	14,18,24,03,830	1,418.24
6	Rail Signalling, Telecommunication and Electrification Cost	4,82,94,27,715	482.94
7	Rail Mechanical Cost	62,24,179	0.62
8	Rail Structural Cost	9,11,52,47,167	911.52
9	Environmental Charges due to Rail @ 1% of civil cost	14,18,24,038.30	14.18
	Sub-Total - Rail	**28,27,51,26,929**	**2,827.51**
	Total Cost (Road & Rail)	**80,94,24,82,063**	**8,094.25**

Table 2.172: Summary of block cost estimates (road and rail)-Approach Road Section

S.No.	Description-Approaches	Total Amount	Total Amount in Rs. Crore
Road Cost			
1	Highway Civil Cost	27,15,71,55,321	2,715.72
2	Road Structural Cost	12,99,16,94,514	1,299.17
3	Intelligent Transport System (ITS) Cost	32,58,15,858	32.58
4	Environmental Charges due to Road @ 1% of civil cost	27,15,71,553.21	27.16

S.No.	Description-Approaches	Total Amount	Total Amount in Rs. Crore
Sub-Total - Road		**40,74,62,37,246**	**4,074.62**
Rail Cost			
5	Rail Civil Cost	30,06,59,59,464	3,006.60
6	Rail Signalling, Telecommunication and Electrification Cost	7,38,73,61,501	738.74
7	Rail Mechanical Cost	53,59,430	0.54
8	Rail Structural Cost	8,43,34,21,828	843.34
9	Environmental Charges due to Rail @ 1% of civil cost	30,06,59,595	30.07
Sub-Total - Rail		**46,19,27,61,818**	**4,619.28**
Total Cost (Road & Rail)		**86,93,89,99,063**	**8,693.90**

2.3.15Conclusion

Block cost estimates for road component is estimated based on prevailing SOR rates in Gujarat. Whereas block cost estimates for rail components is estimated using Delhi schedule of rates. Total cost of various components such as civil works, electrical, mechanical and ITS facilities for both dyke section and approach road section is **Rs. 16,788.15 Cr**, while the total cost for road component alone is **Rs. 9,341.36 Cr** and the total cost for rail component alone is **Rs. 7,446.79 Cr**.

The Total cost in dyke section alone is **Rs. 8,094.25 Cr**, while the total cost for road component alone is **Rs. 5,266.74 Cr** and the total cost for rail component alone is **Rs. 2,827.51 Cr**. The above cost does not include the land acquisition cost.

3.4 Economic viability

The Economic Viability Analysis (also known Social-Cost Benefit analysis) of transportation link over the Kalpasar Dyke has been assessed within the broad framework of Cost-Benefit Analysis, generally used for appraisal of public infrastructure projects. The main objective of the analysis is to identify all the direct and indirect benefits and to compare them over the economic life of the project to justify its implementation based on benefits/profits to the economy/Society. This necessitates consideration of different streams of cost and benefits over time.

In the present economic analysis, the economic costs and benefits of the project over the life of the project have been identified under "with" and "without" the project conditions and are expressed in terms of Economic Internal Rate of Return (EIRR). The EIRR indicates the return, which the society would derive from the investment for the proposed Dyke. The EIRR is compared with the accounting rate of return of 12% considered as the cut-off point for judicious investment decision, by the Government of India and International funding agencies like the World Bank and the Asian Development Bank (ADB).

The main steps followed in the economic evaluation are:
(1) Estimation of economic cost of the project, both capital as well as annual operating and maintenance costs;
(2) Identification of direct and indirect benefits to the users, non-users and economy/ community and quantifying the benefits to the extent possible;
(3) Comparison of annual streams of costs and benefits and estimation of EIRR on the basis of Discounted Cash Flow (DCF) technique; and
(4) The project is further subjected to sensitivity analysis by assessing the effects of adverse changes in the key variables on the base EIRR. This helps in identifying critical parameters of the project and gauges the economic strength of the project to withstand future risks and uncertainties.

- **Economic Costs**

- **Capital Cost**

The project cost consists of two main component viz. capital cost and operating & Maintenance (O & M) cost. These costs for the project are estimated in financial terms at base year price level of 2022. For the purpose of present analysis, road and rail components of project cost are considered as given below.

- **Road components**

Followings are the road components:
(1) Pavement over dyke with construction of median and footpaths;
(2) Construction of embankments on either side of dyke;
(3) Two interchanges at start and end of Kalpasar road;
(4) Road structural cost;
(5) Highway civil cost;
(6) ITS components;
(7) Toll plaza;
(8) Road furniture; and
(9) Environmental charges due to road

- **Rail components**

Followings are the road components:

(1) Railway civil cost;
(2) Railway electrical cost;
(3) Railway signal & telecommunication cost;
(4) Railway mechanical cost;
(5) Railway structural cost; and
(6) Environmental charges due to rail.

The estimated cost of road, rail and bridge structural component works out to be Rs. 1,67,881.48 million at 2022 prices. The breakup of cost estimate is presented in **Table 2.173**.

Table 2.173: Breakup of cost estimate

S.No.	Description-total	Total Amount in Rs. (Million)
	Road Cost	
1	Highway Civil Cost	56,602.40
2	Road Structural Cost	35,487.81
3	Intelligent Transport System (ITS) Cost	757.36
4	Environmental Charges due to Road @ 1% of civil cost	566.02
	Sub-Total - Road	**93,413.59**
	Maintenance cost for Road	**28,621.60**
	Rail Cost	
5	Rail Civil Cost	44,248.36
6	Rail Signalling, Telecommunication and Electrification Cost	12,216.79
7	Rail Mechanical Cost	11.58
8	Rail Structural Cost	17,548.67
9	Environmental Charges due to Rail @ 1% of civil cost	442.48
	Sub-Total - Rail	**74,467.89**
	Maintenance cost for Rail	**61,795.10**
	Total Cost (Road & Rail) in Million (Excluding Maintenance Cost)	**1,67,881.48**
	Total Maintenance Cost in Rs. Million	**90,416.70**

The construction period of the project is taken as 6 years i.e. 2026 to 2031. Capital expenditure cost is taken from the year 2024 till 2031 and the cost incurred has been split uniformly. Economic viability analysis was carried out for 48 years period from 2024 to 2071. Table 2.174 shows the assumptions made for activities leading operation of Kalpasar project development.

Table 2.174: Activities leading Operation of Kalpasar Project Development

Period	Activities leading Operation of Kalpasar Project Development
2022	Preparation of DPR
2023	Approval of DPR

Period	Activities leading Operation of Kalpasar Project Development
2024	Funding, Establishment of SPV for Development of Project, Preparation of Contract Documents
2025	Tendering Process and Award of Work to Contractors
2026-2031	6-year Construction Period
2032	Operation of the Kalpasar Project

The economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections, Government policies and regulations. In the present study, the estimated financial costs have been converted into economic cost by applying conversion factor of 0.9, so as to represent exclusion of taxes & duties, which are considered as transfer payments and cost relating to depreciation, interest charges.

- **Operating and Maintenance (O & M) cost**

The main items of O & M cost relate to maintenance of pavement & tracks, cost of operation of Toll Plaza and ITS etc.

Regular O & M cost of road & rail is taken as 1% of capital cost that to be incurred every year and periodic O & M cost for road is taken as 5% of the project cost to be incurred every 5 years. Periodic maintenance cost for rail is arrived based on following assumptions,
(a) Rails at every 10 years;
(b) Sleepers at every 20 years;
(c) Screenings / ballast at every 10 years; and
(d) Electrical and S&T: Every 20 years.

- **Economic Benefits**

The construction of the dyke cum road is expected to generate direct and indirect benefits. The direct economic benefits that will accrue because of the project include savings in vehicle operating costs and travel time costs to passengers. The following categories of benefits due to Kalpasar dyke have been quantified in monitory values:
(1) Savings in Vehicle Operation Costs (VOC);
(2) Savings in Value of Passenger Time (VOT); and
(3) Carbon credits

However, there are other social benefits, which will accrue due to Kalpasar project but not quantified. Those are listed below:
(1) Reduction of congestion and improvement of speeds on the existing roads; and
(2) Reduction in accidents on the existing roads.

- **Economic Viability and Sensitivity Analysis for Various Scenarios**

Economic viability analysis in terms of EIRR and NPV are estimated for following the scenarios listed below:
(1) Scenario-I : Optimistic;
(2) Scenario-II : Most likely; and
(3) Scenario-III : Pessimistic.

Sensitivity analysis of the project's economic viability has been carried out to consider various uncertainties pertaining to traffic forecast and critical parameters relating to cost and benefits. Those are:
(1) Sensitivity-I : Increase in project cost by 15%;

(2) Sensitivity-II : Decrease in benefits by 15%; and
(3) Sensitivity-III: Combined effect of increase in project cost by 15% and decrease in benefits by 15%.

The following **Table 2.175** gives the summary of EIRRs and NPVs for selected scenarios.

Table 2.175: Results of economic analysis

Scenario	Economic Parameter	Base Case	Sensitivity-I	Sensitivity-II	Sensitivity-III
Optimistic	EIRR	59.8%	57.2%	56.8%	54.2%
	NPV (in Million Rs)	3043837.0	3029603.1	2573027.6	2558793.7
Most Likely	EIRR	57.9%	55.3%	54.8%	52.3%
	NPV (in Million Rs)	2720685.8	2706452.0	2298349.1	2284115.2
Pessimistic	EIRR	55.9%	53.3%	52.9%	50.4%
	NPV (in Million Rs)	2436354.2	2422120.4	2056667.2	2042433.4

The NPV of the stream of net benefits have been computed using prevailing discount rate of 12%, which is cut off rate for the economically viable project. The details of cost & benefit streams for all the scenarios are given in **Annexure-2N**.

The project gives the EIRR of 59.8% for optimistic scenario and for base case. This indicates that the project is viable. The sensitivity analysis estimates the lowest EIRR at 50.4%. This indicates that the project is viable even under the worst condition of increase in project cost by 15% and decrease in benefits by 15% considering pessimistic scenario.