Brihanmumbai Municipal Corporation (BMC)

Consultancy Services for Construction of 45m Wide Elevated Road from Link Road at Dahisar (West) in MCGM Limit to Bhayander (West) in MBMC Limit

Stage-2
Part-D - Draft Feasibility Report

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1 INTRODUCTION

1.1 GENERAL

Mumbai is considered as the financial capital of India. It houses a population of 12.87 Million with a large floating population within in a small area of 437 sq.km. It is surrounded by sea on three sides and hence has no place to expand. The constraints of the geography and the inability of the city to expand have already made the city one of the densest Metropolis of the World. Mumbai city has seen an increase in the number of vehicles during the last 20 years which has resulted in extreme traffic congestion everywhere. This has led to more commuting time and a serious impact on the productivity in the city as well as the quality of life of its citizens.

The economic activity in the Mumbai Metropolitan Region is interconnected with the economic activity in the Greater Mumbai Region. Mira Bhayandar Municipal Corporation is one of the fastest growing satellite cities in Mumbai Metropolitan Region (MMR). As a result thereof, there is constant and continuous movement of people between the two cities and it is estimated that almost 10 lakhs people commute from Mumbai to Mira Bhayandar and vice-versa, every day.

At the moment, there are only two modes of connectivity to the Mira Bhayandar Municipal Corporation with the Greater Mumbai Region. The Western Express Highway (NH-8) and Western Railway lines, both serve as the primary connectivity's through road and rail respectively. As a result of this, the primary development of Mira-Bhayandar Municipal Corporation is concentrated around these two arteries of connectivity.

As per the Development Plan of MBMC, the western part of Mira Road and Bhayandar is entirely under Residential Zone. Due to lack of connectivity the entire western part of MBMC is undeveloped. Therefore it is imperative that additional arterial connectivity by road needs to be created between Greater Mumbai and Mira Bhayandar Municipal Corporation on its western part. Recognizing this lack of connectivity, MMRDA in its Regional Plan has proposed a link road from the proposed Coastal Road in its limits from Mumbai City. This road is proposed to form a link from Dahisar West to Mira Road West and onwards to Virar. The alignment of proposed road as per BMC with RoW of 45m is shown in the Figure 1.1. A Google map (Refer Figure 1.2) shows the connectivity from Dahisar Link Road to Mira Bhayandar West.

FIGURE 1-1: ALIGNMENT FOR PROPOSED DP ROAD WITH ROW

1.2 PROJECT ROAD

In Mira Bhayandar, currently the only mode of connectivity by road from Mumbai to Bhayandar and Mira road west is through the Western Express Highway via Kashimira Road to the Maxus Mall in Bhayandar West. It is pertinent to note that the WEH connects the Mira Bhayandar City only on the Eastern side of the railways. Therefore, the people residing in Bhayandar West and

Mira Road West have to rely upon a railway over bridge connecting Bhayandar East to Bhayandar West.

This passes over the Western Railway line. In the event of disaster, the entire population staying in Mira Road West and Bhayandar West will therefore be stranded and there will be no motorable road from Mumbai to Bhayandar (West)/Mira Road (W) and the only means of travel for the public will be with the help of the Western Railways Lines which are already very crowded owing to large population travelling to and from Virar to Churchgate and such a situation is certainly not desirable. In order to ensure that Mira Road (West) and Bhayandar (West) remain connected with the rest of Mumbai /Maharashtra State, the MMRDA in its Regional Plan has proposed a road from the existing link road to Bhayandar (West), Mira Road (West) and onwards to Virar.

The commuting distance and travel time by road from Link Road at Dahisar West up to the Maxus Mall in Bhayandar West presently is 9.7kms and about 50 mins to 1 hour respectively. Once the proposed Dahisar Link Road is constructed, commuting distance will reduce to about 5 Kms and travel time by road between Dahisar West and the Bhayandar West would only be 3-5 mins.

It is therefore necessary that an alternative route is planned which connects Bhayandar West and Mira Road West to Mumbai by proposing an extension to the link road at Dahisar West.

It is therefore necessary that the construction of this missing link between the two cities be taken up at the earliest so as to mitigate the hardships faced by the people of the two cities and also to improve the development of the undeveloped areas in Mira Bhayandar West as well as those areas in Dahisar West.

Hence, BMC appointed M/s Tandon Urban Solutions Private Limited as Consultant to assess the Feasibility.

FIGURE 1-2: PICTORIAL REPRESENTATION OF DAHISAR (W) – MIRA BHAYANDAR (W) DP LINK ROAD

1.3 OBJECTIVES

The objective of this assignment is to give feasible solution for smooth traffic dispersal and reduce the congestion of traffic on WEH (NH-8) by connecting a link road from Dahisar West to Mira Road (West).

1.4 REPORT STRUCTURE

In view of the above, Consultant has completed the study of alignment and obtained approval in principle from the authority. Thereafter, we as Consultants have collected various data, carried out various investigations and studied various available reports and on the basis of which the Feasibility is prepared for submission to BMC.

The DPR contains the following documents:

- Volume I: Main Report.
- Volume II: Design Report.
    1. Alignment Report
    2. Pavement Report
    3. Bridge Report
    4. Construction Methodology Report
- Volume – III: Materials Report
- Volume IV: Engineering Report.
    1. Geo-Technical Report
    2. Topography & Bathymetry Survey Report
- Volume V: Drainage Design Report
- Volume VI: Cost Estimate & Rate Analysis
- Volume VII: Drawings

2 REGIONAL/STATE SOCIO-ECONOMIC PROFILE

2.1 GENERAL

Mumbai is the capital of Maharashtra state. This chapter presents Socio-Economic profile of the State of Maharashtra, as the growth of Mumbai is largely dependent on it.

2.2 MAHARASHTRA STATE GEOGRAPHY

2.2.1 GEOGRAPHY

The dominant physical trait of the State is its plateau character. Maharashtra is a plateau of plateaus, its western upturned rims rising form the Sahyadri Range parallel to the sea-coast and its slopes gently descending towards the East and South-east. Satpuda ranges cover the Northern part of the State, while Ajanta and Satmala ranges run through Central part of the State.

Arabian Sea guards the western boundary of Maharashtra while Gujarat and Madhya Pradesh are on its northern side. The State receives its rainfall mainly from south-west monsoon.

Running north to south, throughout its length are the steeply rising Western Ghats. The foothills of the ghats sometimes approach the seashore and sometimes withdraw 40 or 50 km away. Nestling in these mountains at an altitude of 2000 meters are the hill stations of Maharashtra. These towns offer clean, calm and a thoroughly refreshing alternative to city life. Mumbai, India's commercial capital, and easily the most accessible city in this country, is the perfect gateway to Maharashtra's hill country, with convenient and comfortable links by road, rail, and air.

2.2.2 GEOLOGY

Except around Mumbai, and along the eastern limits, the State of Maharashtra presents a monotonously uniform, flat-topped skyline. This topography of the state is the outcome of its geological structure. The state area, barring the extreme eastern Vidarbha region, Parts of Kolhapur and Sindhudurg, is practically co-terminus with the Deccan Traps. Roughly 60 to 90 million years ago, the outpouring of Basic Lava, through fissures formed horizontally bedded basalt over large areas. Variations in their composition and structure have resulted in massive,

well –jointed steel-gray cliff faces alternating with structural benches of vesicular amygdaloidal lava and ash layers, all of which contribute to the pyramid-shaped hills and crest – level plateau or mesas. Earth sculpturing under the tropical climate completed the panorama – sharply defining the landform features in the semi – arid conditions, and rounding the hilltops under wetter condition.

2.2.3 DEMOGRAPHICAL FEATURES

2.2.3.1 POPULATION

As per the population Census 2011, Maharashtra's population was 11.23 crores, which was 9.28 % of India's population. Maharashtra is the second largest State in India in respect of population after Uttar Pradesh. During the decade 1991-2001, the population of the State increased by 15.99%. The corresponding growth during the earlier decade was 22.57 %. The decadal growth rate in 2001-2011 was more by 6.6%. As per Census, the population of India was 1,119,477.

2.2.3.2 POPULATION DENSITY

As per 2001 Population Census the density of population in the State was 322.5. During 2001-2011 there was an addition of 42.5 people per 1sq.km. As per Population Census 2011, the density of population of the State is 365 per sq.km. as compared to that of India (382). Mumbai has become the most populated city and world's fifth. In 2011, Mumbai's average density was 30,000 persons per sq.km.

Urban Population

According to 2011 Population Census, 45.23 %(42.4% in 2001) of the State's population was in urban areas as against 27.8% at All-India level. Thus, the proportion in the state is substantially higher than that for India.

2.2.3.3 STATE OF THE ECONOMY

Maharashtra state has highest Gross State Domestic product (GSDP) in India. The statistical data is presented in Table 2.1 below at current prices and constant prices.

TABLE 2-1: GROSS DOMESTIC PRODUCT OF MAHARASHTRA STATE

Year	Gross Domestic Product (Rs. in Crores)	
	Current Prices	Constant Prices
2006 - 2007	5,81,725	5,40,750
2007 - 2008	6,79,004	5,99,062
2008 - 2009	7,56,334	6,19,291
2009 - 2010	9,01,330	7,01,550
2010 - 2011	10,29,621	7,75,020
2011 - 2012	87,36,329	87,36,329
2012 - 2013	99,44,013	92,13,017
2013 - 2014	1,12,33,522	98,01,370
2014 - 2015	1,24,67,959	1,05,27,674
2015 - 2016	1,37,64,037	1,13,86,145
2016 - 2017	1,52,53,714	1,21,96,006

(As per Economy Survey of Maharashtra 2017-2018)

2.2.3.4 GROSS STATE DOMESTIC PRODUCT (GSDP)

The advance estimates of the real Gross State Domestic Product (GSDP) i.e. 'at constant (2011-12) prices' for 2017-18 is expected to be 19,59,920 crore with growth of 7.3 per cent over 2016-17. The advance estimates of the nominal GSDP i.e. 'GSDP at current prices' is expected to be ` 24,96,505 crore.

As compared to 2016-17, the State witnessed less rains during 2017-18. In comparison with the bumper crop in 2016-17, the production is expected to decrease substantially in 2017-18 leading to expected growth of (-)14.4 per cent in the real Gross State Value Added (GSVA) of 'Crops'. With 5.8 per cent, 1.5 per cent and 5.9 per cent growth in 'Livestock', 'Forestry & Logging' and 'Fisheries & Aquaculture' respectively, the 'Agriculture & allied activities' sector is expected to grow at (-) 8.3 per cent in 2017-18. With expected growth of 7.6 per cent in the 'Manufacturing' sector and 4.5 per cent in the 'Construction' sector, the 'Industry' sector is expected to grow at 6.5 per cent over the previous year. The Services sector, which is identified as the key driver of the economy, is expected to grow at 9.7 per cent.

TABLE 2-2: SECTOR WISE GSDP FOR MAHARASHTRA

Year	Sector Wise GSDP for Maharashtra (At Current Prices)			
	Primary	Secondary	Tertiary	Total
2006 - 2007	70515	183640	330342	584497
2007 - 2008	84556	217684	382577	684817

Year	Sector Wise GSDP for Maharashtra (At Current Prices)			
	Primary	Secondary	Tertiary	Total
2008 - 2009	81001	230921	442048	753970
2009 - 2010	93988	249698	512065	855751
2010 - 2011	132449	290766	611870	1035085
2011 - 2012	206520	353389	584509	1280369
2012 - 2013	221838	371853	633244	1357942
2013 - 2014	240604	400166	684504	1451601
2014 - 2015	230976	425352	747964	1543211
2015 - 2016	242172	455224	807869	1660387
2016 - 2017	302329	486281	885649	1826296

(As per Economy Survey of Maharashtra 2017-2018)

2.2.3.5 STATE PER CAPITA INCOME

Per Capita Income is 1,80,596 Rs. Cr during 2017-18 as against 1,65,491 Rs. Cr during 2016-17. The Per Capita State Income is estimated at ` 1,93,121 during 2020-21 whereas it was ` 1,96,100 during 2019-20. In Per Capita Income Maharashtra is leading state amongst major states. Per Capita Income of Maharashtra State for 2016-17 as compared to 2015-16 increased by 12.1 per cent.

TABLE 2-3PCI FOR MAHARASHTRA

Year	Per Capita Income (Rs in Crores)	
	Current Prices	Constant Prices
2006 - 2007	49,568	46,158
2007 - 2008	57,218	50,532
2008 - 2009	62,454	51,053
2009 - 2010	74,027	57,458
2010 - 2011	83,471	62,729
2011 - 2012	99,564	74,823
2012 - 2013	1,11,980	84,154
2013 - 2014	1,25,039	93,968
2014 - 2015	1,32,611	99,658
2015 - 2016	1,47,610	1,10,930
2016 - 2017	1,65,491	1,24,368
2017- 2018	1,72,663	1,24,368
2018- 2019	1,86,074	1,22,226
2019- 2020	1,96,100	1,28,812
2020- 2021	1,93,121	1,26,855

As per Economy Survey of Maharashtra 2021-2022)

2.2.4 ECONOMIC SECTORS

Since the early nineties, the Government of India has initiated a number of reforms measures in various sectors to liberalise the economy and make it conduct to rapid growth. As a result of liberalization, the economy is on the high growth path reflected by low inflation rate and growing foreign exchange reserve.

- **Agriculture**

About 61% of the total population in the State depends on agriculture and allied activities. Net irrigated area is about 39.47lakh hectare in 2016-2017. Principle crops grown in the State are rice, jawar, bajra, wheat, tur, mung, udid, gram and other pulses. The State is a major producer of oilseeds, groundnut, sunflower, soyabean are major oil seed crops. Important cash crops are cotton, sugarcane, turmeric and vegetables.

Sorgham, millet, and pulses dominate the cropped area. Rice grows where rainfall exceeds 40 inches, and wheat is a winter crop in fields that retain moisture. Cotton, tobacco and peanuts are major crops in areas having 24-39 inches of rainfall. Irrigation dams in rain-shadow areas have resulted in a rich sugarcane yield. The State has also a large area under horticulture and has an area of 10.91 lakh hectares under various fruit crops like mango, banana, orange, grape, cashewnut, etc.

- **Forest Cover**

As per the 'State of forest Report 2001' published by forest Survey of India, Dehradun, the forest cover of Maharashtra is 47482 sq. km. being open forests with crown density falling between 10 to 40 percent. The forest cover in the state has been showing increasing trends in the 1997, 1999, and 2001 assessments. In the 2001 assessment, the increase in forest cover in the State has been recorded as 810 sq.km over the 1999 assessment.

- **Minerals**

Maharashtra is richly endowed within various minerals of industrial importance like manganese, coal, iron ore, limestone, copper, bauxite, silica sand, and common salt. These minerals are found in substantial quantities in the eastern districts with some deposits in the west. Bituminous coal are found in the district of Bhandara, Nagpur and Chandrapur. Undersea oil deposits were discovered in and near Mumbai in the 1970s. The mountainous region of the state is a virtual repository of rich timber reserves.

- **Irrigation and Power**

By the end of June 1998, 33 major, 177 medium and about 1.835 state sector minor irrigation projects have been completed. Another 27 major, 86 medium and 263 minor irrigation projects were under construction. The gross irrigated area at the end of June 1998 was nearly 1997-98.

- **Tourist Centre**

The important Tourist Centres in the state include Ajanta, Ellora, Elephanta, Kanheri and Karla caves, Mahabaleshwar, Matheran and Panchgani, Jawhar, Malshejghat, Amboli, chikaldara, Panhala hill Stations and religious places at Pandharpur, Nasik, Nanded, Audhanagnath. Trimbakeshwar, Tuljapur, Ganpatipule, Bhimashankar, Harihareshwar and Shegaon.

- **Social and Community Services**

Social development in Maharashtra has attained satisfactory level of success. Successive government of the state has followed a development strategy by consciously investing in social development sector like education, medical and public health. The social security measures introduced by the state government were directed towards reducing income disparities and uplifting weaker segments.

2.2.5 TRANSPORT INFRASTRUCTURE

The transport system promotes the development of backward regions and integrating them with the main stream economy by opening their opportunities to trade and investment; acquire new knowledge, awareness and contributing their share of intellectual and financial wealth to the national development.

TABLE 2-4: CATEGORY WISE ROAD LENGTHS

Year	National Highways	Major State Highways	State Highways	Major District Roads	Other District Roads	Village Roads	All Roads
2011-12	4,376	--	34,157	50,256	47,529	1,06,601	2,42,919
2012-13	4,376	6,694	27,528	50,256	47,573	1,06,745	2,43,172
2013-14	5,858	6,337	33,963	50,232	52,761	1,14,557	2,63,708
2014-15	4,766	6,163	33,860	50,585	58,115	1,45,879	2,99,368
2015-16	7,438	5,180	33,330	50,844	58,116	1,45,881	3,00,789
2016-17	12,275	3,861	30,589	52,637	58,116	1,45,881	3,03,359

(Source - Public Works Department, GoM)

Maharashtra state has seen rapid growth in vehicle population in all categories due to rapid economic growth. Numbers of vehicles registered in the state are presented in table below.

TABLE 2-5: CATEGORY WISE VEHICLES

Vehicle Type	1971	1981	1991	2001	2011	2016	2017	2018*
Motor-cycles, scooters Motor Cars,	83,930	3,46,826	16,96,157	44,09,906	1,20,60,990	1,98,81,499	2,13,90,304	2,30,08,695
Jeeps	1,22,508	2,24,752	4,23,505	9,01,278	23,82,789	38,50,530	41,75,878	45,14,929
Taxi Cabs	17,806	31,302	43,168	86,438	1,82,676	2,24,308	2,70,160	2,95,321
Auto	3,049	29,474	1,26,049	4,07,660	6,44,037	7,26,120	7,20,439	7,47,337
Stage	10,250	13,789	18,203	27,286	34,061	38,318	35,682	35,706
Contract	--	1,498	3,980	13,975	31,459	43,985	36,407	43,233
Lorries -	34,987	87,079	1,80,883	3,41,344	8,78,239	13,88,231	14,09,749	15,13,678
Lorries -	21,791	18,005	13,774	57,317	77,189	28,563	9,427	9,255
Other -	--	--	--	N.A.	N.A.	5,979	57,691	59,833
Ambulances	441	925	2,233	4,025	9,600	14,315	12,689	14,974
School Bus	491	594	1,025	1,714	6,117	21,541	22,051	22,828
Private Service Vehicles	810	2,171	4,622	5,815	9,421	11,629	26,942	26,963
Trailers	7,075	23,173	60,858	1,67,856	2,84,696	3,84,482	3,48,619	4,09,365
Tractors	7,821	24,079	61,088	1,72,578	3,58,556	6,03,632	6,16,160	6,51,069
Others	810	1,319	5,040	9,872	29,829	46,997	53,670	61,805
Total	**3,11,769**	**8,04,986**	**26,40,585**	**66,07,064**	**1,69,89,659**	**2,72,70,129**	**2,91,85,868**	**3,14,14,991**

(Source - Office of the Transport Commissioner, GoM)

- **Railways**

Railway is the major mass transport system. Freight and passenger traffic are the two major segments of the railways. The railway route length in the State as on 31st March, 2017 was 6,165 km (including 381 km of Konkan railway), which is 9.2 per cent of the total railway route length (67,368 km) of India. The work of doubling of the route length of 35 km between Panvel & Pen is completed. The status of on-going railway works in the State is given in table 2.6.

TABLE 2-6: STATUS OF ONGOING RAILWAY PROJECTS IN MAHARASHTRA

Name of the Route (As on 30th June, 2017)	Route Length (Kms)	Project Cost (Rs. Crore)	Physical Progress (%)
Pen-Roha (doubling)	40	163	95
Baramati-Lonand (New Line)	64	736.44	50
Belapur-Seawood-Uran (New Line)	27	1,781.98	48
Ahmednagar-Narayandoh-Beed-Parli-Vaijnath	261	2,271.00	40
Bhusawal-Jalgaon 3rd line (doubling)	24	199.12	31
Wardha-Sewagram-Nagpur 3rd line (doubling)	76	540.02	16
Teegaon-Chichonda 3rd line (doubling)	17	175.66	13
Kalyan-Kasara 3rd line (doubling)	68	792.89	9
Wardha-Nanded via Yavatmal-Pusad (New Line)	284	2,491.43	8

(Source - South Eastern, Central, South Central & Western Railway and Konkan Railway Corporation)

- **Air Transport**

Maharashtra has a total of twenty-four Air fields/Airports. Out of these 17 are under the control of the state Government, four are managed and controlled by the International Airport Authority / Airport Authority of India and the remaining three are manned and managed by the Ministry of Defence.

Airports Authority of India (AAI) along with Mumbai International Airport Ltd. has built the new integrated Terminal T2 with a capacity to handle 40 million passengers per annum at Chhatrapati Shivaji International Airport, Mumbai. There are three international and 13 domestic airports functioning in the State. The passenger and cargo traffice handled at Baramati, Kolhapur,Soalpur, Nanded, Osmanabad, Latur and Yavatmal is meagre. Ojhar airport, Nashik carried about1,73,151 MT and 1,01,783 MT cargo during 2016-17 and 2017-18 (upto December) respectively.Operational statistics of passenger and cargo traffic of selected

airports in the State. However numbers of airports available for commercial operations are limited and traffic handled by these is presented in Table 2.7.

TABLE 2-7: AIRPORTS

Airport	Passengers (Lakh)			Cargo (MT)		
	2016	2017	Per cent change	2016	2017	Per cent change
A) Domestic	**372.16**	**415.05**	**11.5**	**2,48,513**	**2,78,096**	**11.9**
Mumbai	300.46	327.12	8.9	2,09,003	2,34,917	12.4
Pune	51.76	65.12	25.8	31,765	34,645	9.1
Nagpur	15.21	17.82	17.2	5,958	6,726	12.9
Aurangabad	2.99	3.24	8.4	1,406	1,436	2.1
Juhu	1.74	1.75	0.6	381	372	(-)2.4
B) International	**119.38**	**128.91**	**8.0**	**4,96,679**	**5,47,791**	**10.3**
Mumbai	116.24	124.42	7.0	4,96,246	5,47,372	10.3
Pune	2.40	2.57	7.1	0	0	--
Nagpur	0.74	1.92	159.5	433	419	(-)3.2
Total (A + B)	**491.54**	**543.96**	**10.7**	**7,45,192**	**8,25,887**	**10.8**

(Source –Airport Authority of India)

- **Sea Ports**

The State has two major ports, operated by Mumbai Port Trust (MbPT) and Jawaharlal Nehru Port Trust (JNPT). During 2016-17, MbPT and JNPT handled 630.48 lakh MT and 621.51 lakh MT cargo traffic respectively. Operational statistics of major ports is given in Table 2.8.

TABLE 2-8: MAJOR PORTS IN MAHARASHTRA

Item	MbPT			JNPT		
	2015-16	2016-17	Per cent change	2015-16	2016-17	Per cent Change
Total cargo capacity (lakh MT)	**502.50**	**502.50**	0.0	**793.70**	**893.70**	12.6
Employees (no.)	10,166	9,445	(-)7.1	1,638	1,615	(-)1.4
Cargo traffic handled (lakh MT)	**611.10**	**630.48**	3.2	**640.27**	**621.51**	(-)2.9
Of which a) Import	412.94	427.25	3.5	350.75	347.56	(-)0.9
b) Export	198.16	203.23	2.6	289.52	273.95	(-)5.4
Passenger traffic handled ('000)	3.18	17.44	448.4	NA	NA	NA
Vessels handled (no.)	5,169	5,427	5.0	2,780	2,720	(-)2.2
Operating income (₹ Crore)	1,478.18	1,477.80	0.0	1,665.10	1700.97	2.2
Operating expenditure (₹ Crore)	1,075.69	1,111.67	3.3	693.12	804.97	16.1
Operating surplus/profit (₹ Crore)	402.49	366.13	(-)9.0	971.98	896.00	(-)7.8

(Source – MbPT and JNPT)

Maharashtra Maritime Board (MMB) has undertaken development of six non major ports Dhamankhol-Jaigad, Dighi and Lavgan-Jaigad (Angre port) ports are commissioned. Pre-construction activities are in progress for Rewas-Aware, Vijaydurg and Redi ports. Apart from these ports, there are number of captive and multi-purpose jetties set up within the limits of non-major ports, which also undertake cargo handling. Operational statistics of non-major ports is given in Table 2.9.

TABLE 2-9: CARGO HANDLING BY NON MAJOR PORTS

Particulars	2015-16	2016-17	2017-18+
Cargo traffic handled (lakh MT)	**288.49**	**348.94**	**227.92**
Of which a) Import	244.74	290.09	194.33
b) Export	43.75	58.85	33.59
Passenger traffic handled (lakh)	**180.72**	**182.82**	**118.37**
Of which a) By mechanised vessels	169.80	173.18	114.60
b) By non- mechanised vessels	10.92	9.64	3.77

3 SOCIO-ECONOMIC PROFILE OF THE PROJECT INFLUENCE AREA

3.1 MUMBAI METRO CITY

Mumbai, the capital of Maharashtra, is considered the financial capital of India with the headquarters of almost all major banks, financial institutions, insurance companies and mutual funds being based in the city. India's largest stock exchange Bombay Stock Exchange, the oldest in Asia, is also located in the city. More than 41% of the S&P CNX 500 conglomerates have corporate 1 office in Maharashtra. Mumbai (formerly known as Bombay) is located on the western seacoast of India on the Arabian Sea at 180 53' N to 190 16' N latitude and 720 E to 720 59' E longitude.

Mumbai was originally a cluster of seven islands inhabited by fishermen, which were later joined to form the present city. Mumbai was ruled by various Hindu dynasties till 1348 when the Muslims took over. In 1534 Mumbai was handed over to the Portuguese who offered the city as dowry to Charles II of England in May 1664. In 1668, the East India Company took over Mumbai and started developing it as a firm base of their commercial activities. Land reclamation was started.

It is well known that Mumbai city is comprised of seven islands till 1857. Gradually with invasion the islands were merged by the invaders and now the entire city is one big island. The island city has a rich heritage of natural resources like the forests, lakes mangroves, etc. Greater Mumbai Region consists of 7 islands in the city area and 4 islands in the suburbs. The present day city is divided into two revenue districts, Mumbai City District, i.e., the island city in the South and Mumbai Suburban District comprising the Western and Eastern suburbs. Mumbai occupies an area of 468 square kilometers (sq. km.) and its width is 17 km. east to west and 42 km. north to south. The entire region encompasses rich natural heritage, such as, hills, lakes, coastal water, forests, and mangroves, alongside built areas. The coastline of Mumbai has been reclaimed for development purposes; e.g., areas like Cuff Parade and Mahim creek were wetlands, later reclaimed for residential and commercial uses.

The residents drew water from wells and tanks which were, before long, inadequate for the growing needs. In the absence of Perennial River, harnessing of surface water was the only feasible solution. Search for a suitable site for impounding the monsoon runs-offs was started in 1845.

FIGURE 3-1: MAP OF MUMBAI

3.2 BMC

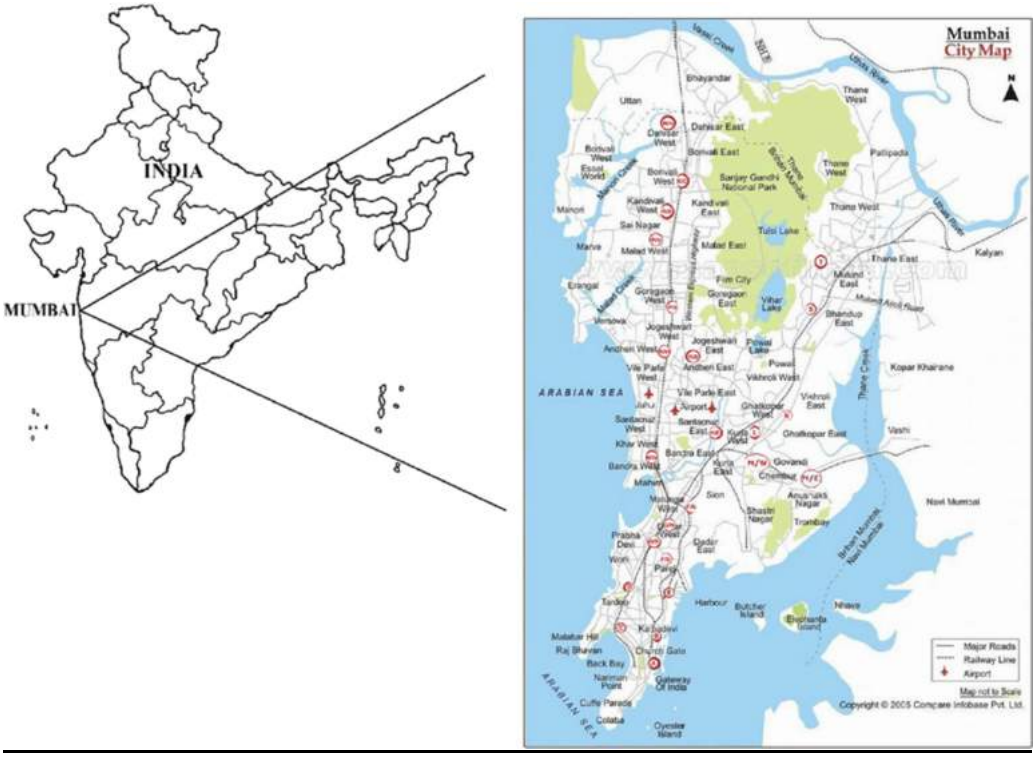


FIGURE 3-2: LOCATION OF BMC

Brihan Mumbai Municipal Corporation was formed way back in the year 1865 as Mumbai's civic body. The BMC is variably the cradle of Local Self Government of India. It embodies the principle of democracy of "Governance of the People, by the people, for the people".

Through the multifarious civic and recreational services that it provides, the BMC has always been committed to improve the quality of life of Mumbai. BMC covers an area over 437.71 square Kilometres, catering to the civic needs of over 1.25 crores Citizens. The Corporation operates an annual utilization outlay of more than Rs. 9,000/- crores. Most of the functions carried out by this Corporation are service oriented. The service offered includes Sanitation, Health (Public Health Care and Secondary Health Care Services through its Hospitals, Maternity, Child Health Care Units, Dispensaries and Field Services) Water, Community service, Primary Education and Town Planning etc.

3.2.1 HISTORY OF MUMBAI

The Koli, an indigenous tribe of fishermen, were the city's first recorded occupants, while Paleolithic stone tools discovered in Greater Mumbai's Kandivli district suggest that people had lived there for hundreds of thousands of years. In 1000 BCE, the city served as a major port for marine trade between Persia and Egypt. In the second century CE, Ptolemy, an ancient Egyptian astronomer and geographer of Greek heritage, referred to it as Heptanesia. It was a part of Ashoka's empire in the third century BCE.

The Chalukyas, who dominated the city between the sixth and eighth centuries, left their mark on Elephanta Island (Gharapuri). The Walkeswar Temple at Malabar Point was most likely constructed between the ninth and thirteenth centuries, under the control of Shilahara lords from the Konkan coast. The town of Mahikavati (Mahim) on Mumbai Island was established by the Yadavas of Devagiri (later Daulatabad; 1187–1318) in reaction to incursions from the north by the Khalji kingdom of Hindustan in 1294. Present-day Mumbai is home to Yadava descendants, and the majority of the place names on the island originate from that time period.

The island was taken over by Muslim invaders in 1348 and incorporated into the Gujarati kingdom. Mahim was unsuccessfully invaded by the Portuguese in 1507, but Sultan Bahdur Shah, the governor of Gujarat, gave the island to them in 1534. As a result of the marriage agreement between King Charles II of England and Catherine of Braganza, the Portuguese monarch's sister, it came under British rule in 1661. In 1668, the East India Company received a cession from the crown.

In contrast to Calcutta (now Kolkata) and Madras (now Chennai), Bombay, as it was known to the British, did not initially prove to be a valuable asset to the East India company; rather, it served to preserve a foothold on the west coast. On the mainland, the Marathas (led by the legendary leader Chhatrapati Shivaji) were more powerful than the territorial rulers in Gujarat to the northwest, the Mughals in the north, and the Marathas in the territory around and extending from Bombay. The Mughals, Marathas, Portuguese, and Dutch, who all had interests in the area, were stronger than even British naval strength. But at the start of the 19th century, outside factors had influenced the city's expansion.

The decline of Mughal control in Delhi, Mughal-Maratha conflicts, and Gujarat's instability forced craftsmen and traders to the islands for refuge, and Mumbai began to flourish. With the fall of Maratha rule, commerce and links to the mainland were restored, existing ties to Europe were expanded, and Mumbai began to develop.

The first spinning and weaving mill was founded in 1857, and by 1860, the city had grown to become India's largest cotton market. The American Civil War (1861-65) and the subsequent limitation of cotton supply to Britain resulted in a significant economic boom in Mumbai. Cotton prices plummeted after the Civil War, and the bubble burst. However, at that time, the hinterland had been opened, and Mumbai had established itself as a major centre of import commerce. The Suez Canal, which opened in 1869 and substantially improved trade with Britain and continental Europe, also contributed to Mumbai's success.

However, as the population grew, messy, overcrowded, and unclean circumstances became more common. In 1896, for example, the plague came out. In response to these issues, the City Improvement Trust was formed to open additional areas for settlement and to build homes for the artisan classes. An ambitious plan to build a seawall in Back Bay to reclaim 1,300 acres (525 hectares) of land was proposed in 1918, but it was not completed until the completion of Netaji Subhas Chandra Bose Road (Marine Drive) from Nariman Point to Malabar Point—first India's two-way highway—after World War II (1939-45).

After the world war II, the building of residential quarters in suburban regions began, and the administration of Mumbai city was extended to the suburbs of Greater Mumbai via a municipal corporation.

From 1956 to 1960, Mumbai was the site of severe Maratha protests over the state's two-language (Marathi-Gujarati) constitution (of which Mumbai remained the capital), a relic of British imperialism. These protests resulted in the state's separation into the present states of Gujarat and Maharashtra in 1960, with Mumbai designated as Maharashtra's capital that year.

Mumbai grew and prospered throughout the twenty-first century, owing to technological breakthroughs. Greater Mumbai's population had surpassed 20 million by the second decade of the twentieth century. The city's infrastructure has been significantly enhanced with the building of new highways and bridges, the development of port facilities, and the launch of new public-transit systems. However, overcrowding, traffic congestion, pollution, and pervasive poverty were serious ongoing issues.

FIGURE 3-3: MAP OF MUMBAI, 1900 CENTURY

Source: 10th edition of Encyclopedia Britannica

3.2.2 TOPOGRAPHY

Many parts of the city lie just above sea level, with elevations ranging from 10 meters (33 feet) to 15 meters (49 feet). The city has an average elevation of 14 meters (46 feet). Northern Mumbai (Salsette) has a hilly while the rest of the city is low lying and flat. The highest point in the city is 450 meters (1,476 feet) located in Salsette north of Mumbai in the Powai-Kanheri ranges. (Mumbai on the net, 2010).

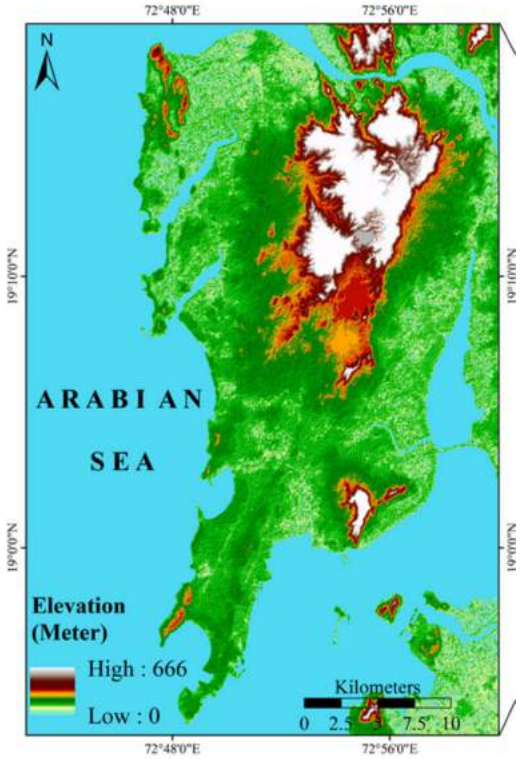


FIGURE 3-4: CONTOUR MAP OF MUMBAI

Source: Sahana, M., Dutta, S., & Sajjad, H. (2019). Assessing land transformation and its relation with land surface temperature in Mumbai city, India using geospatial techniques. International Journal of Urban Sciences, 23(2), 205-225.

3.2.3 SOIL

The soil cover in the city is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy. The underlying rock of the region is composed of black Deccan basalt flows, and their acidic and basic variants dating back to the late Cretaceous and early Eocene eras. Mumbai sits on a seismically active zone owing to the presence of 23 fault lines in the vicinity. The area is classified as a Seismic Zone III region, which means an earthquake of up to magnitude 6.5 on the Richter-scale.

3.2.4 LAND AREA

Greater Mumbai, the area under the administration of Brihanmumbai Municipal Corporation (BMC), spans a total area of 437.71 square kilometres (169 square miles). Mumbai Island City located at the southern tip of Mumbai covers 67.79 square kilometres (26 square miles) of land territory while the suburban district located north of the Island City covers 369 square kilometres (142.47 square miles) of land. Greater Mumbai accounts for most of Mumbai's

territory. Mumbai, as an urban entity however, spans a bigger total area of 603.4 square kilometres (233 square miles) including some regions such as Defence lands, Mumbai Port Trust lands, and the Borivali National Park area, which are outside the administrative jurisdiction of MCGM. The bigger Mumbai Metropolitan Region covers an extensive area of about 4,355 square kilometres (1,681 square miles) (Mumbai on the net, 2010).

3.2.5 CLIMATE OF MUMBAI

Mumbai has a tropical climate, specifically a tropical wet and dry climate (Aw) under the Köppen climate classification. It varies between a dry period extending from October to May and a wet period peaking in June. The cooler season from December to February is followed by the hotter season from March to May. The period from June to about the end of September constitutes the south west monsoon season, and October and November form the post-monsoon season.

Flooding during monsoon is a major problem for Mumbai. Between June and September, the south west monsoon rains lash the city. Pre-monsoon showers are received in May. Occasionally, north-east monsoon showers occur in October and November. The maximum annual rainfall ever recorded was 3,452 mm (136 in) for 1954. The highest rainfall recorded in a single day was 944 mm (37 in) on 26 July 2005. The average total annual rainfall is 2,146.6 mm (85 in) for the Island City, and 2,457 mm (97 in) for the suburbs.

The average annual temperature is 27°C (81°F), and the average annual precipitation is 2,167 mm (85 in). In the Island City, the average maximum temperature is 31°C (88°F), while the average minimum temperature is 24°C (75°F). In the suburbs, the daily mean maximum temperature ranges from 29°C (84°F) to 33°C (91°F), while the daily mean minimum temperature ranges from 16°C (61°F) to 26°C (79°F). The record high is 42.2°C (108 °F) set on 14 April 1952, and the record low is 7.4°C (45°F) set on 27 January 1962.

Tropical Cyclones are rare in the city, the worst Cyclone to ever impact Mumbai was the 1948 Mumbai Cyclone where gusts reached 151 km/h (94 mph) in Juhu, the storm left 38 people dead and 47 missing, the storm reportedly impacted Mumbai for 20 hours and left the city devastated.

3.2.6 POPULATION

Mumbai's urban population is estimated to be over 22 million, and the densely populated city is the largest in India in terms of population, trade activity and business. The metropolitan area has experienced an rapid in growth over the past 20 years, a common occurrence with metropolitan areas in India. The rapid population growth is attributed to migration from other regions in the country, with migrants seeking business and employment opportunities.

The number of people living in slums is estimated at 9 million, which is up from 6 million just a decade ago. That means about 62% of all Mumbaikar's live in slums. Dharavi, the second largest slum in Asia, is located in central Mumbai and is home to 800,000 to 1 million people in just 2.39 square kilometers (or 0.92 square miles). This makes it one of the most densely populated areas on the planet with a density of a minimum of 334,728 people per square kilometer. It's also the most literate slum in India with a literacy rate of 69%.

Because land is at such a premium, residents of Mumbai frequently live in cheap, cramped housing far from work, so there are usually long commutes necessary on its busy mass transit system.

TABLE 3-1: MUMBAI POPULATION AS PER CENSUS OF INDIA 2011

Mumbai Metropolitan	Total	Male	Female
Population	18,394, 912	98,72,271	85,22,641
Literates	1,48,54,433	82,42,697	66,11,736
Children (0-6)	18,49,849	9,68,584	8,81,310
Average Literacy (%)	89.78	92.58	86.53
Sex Ratio	863		
Child Sex Ratio	910		

TABLE 3-2: MIRA - BHAYANDAR POPULATION AS PER CENSUS OF INDIA 2011

Mumbai metropolitan	Total	Male	Female
Population	809,378	429,260	380,118
Literates	656,293	356,434	299,859
Children (0-6)	88,01	46,375	41,640
Average Literacy (%)	90.98	93.09	88.59
Sex Ratio	886		
Child Sex Ratio	898		

TABLE 3-3 THANE POPULATION AS PER CENSUS OF INDIA 2011

Mumbai Metropolitan	Total	Male	Female
Population	18,41,488	9,75,399	8,66,089
Literates	14,58,796	7,97,342	6,61,454
Children (0-6)	2,09,879	1,10,004	99,875
Average Literacy (%)	89.41	92.14	86.33
Sex Ratio	888		
Child Sex Ratio	908		

3.2.7 DEMOGRAPHICS

According to the 2011 census, the population of Mumbai city was 12,479,608. The population density is estimated to be about 20,482 persons per square kilometre. The living space is 4.5 square meters per person. Mumbai Metropolitan Region was home to 20,748,395 people by 2011. Greater Mumbai, the area under the administration of the MCGM, has a literacy rate of 94.7%, higher than the national average of 86.7%. The number of slum-dwellers in the Mumbai Metropolitan Region is estimated to be 90 lakh (9 million), up from 60 lakh (6 million) in 2001 which constitutes approximately 41.8% of the region.

The sex ratio in 2011 was 838 females per 1,000 males in the island city, 857 in the suburbs, and 848 as a whole in Greater Mumbai, all numbers lower than the national average of 914 females per 1,000 males. The low sex ratio is partly because of the large number of male migrants who come to the city to work

"*Parsis of Bombay*", a wood engraving, *ca.* 1878. Mumbai is home to the largest population of Parsis in the world.

Residents of Mumbai call themselves *Mumbaikar*, *Mumbaiite*, *Bombayite* or *Bombaiite*.

Mumbai suffers from the same major urbanization problems seen in many fast growing cities in developing countries: poverty and unemployment. With available land at a premium, Mumbai residents often reside in cramped, relatively expensive housing, usually far from workplaces, and therefore requiring long commutes on crowded mass transit, or clogged roadways. Many of them live in close proximity to bus or train stations although suburban residents spend significant time travelling southward to the main commercial district. Dharavi, Asia's second largest slum (if Karachi's Orangi Town is counted as a single slum) is located in central Mumbai and houses between 800,000 and 10 lakh (one million) people in 2.39 square kilometres

(0.92 sq. mi), making it one of the most densely populated areas on Earth with a population density of at least 334,728 persons per square kilometre.

The number of migrants to Mumbai from outside Maharashtra during the 1991–2001 decade was 11.2 lakh (1.12 million), which amounted to 54.8% of the net addition to the population of Mumbai

The number of households in Mumbai is forecast to rise from 42 lakh (4.2 million) in 2008 to 66 lakh (6.6 million) in 2020. The number of households with annual incomes of 20 lakh (2 million) rupees will increase from 4% to 10% by 2020, amounting to 660,000 families. The number of households with incomes from 10-20 lakh (1–2 million) rupees is also estimated to increase from 4% to 15% by 2020. According to the 2016 report of the Central Pollution Control Board, Mumbai is the noisiest city in India, ahead of Lucknow, Hyderabad and Delhi.

3.2.8 COASTAL REGION AND IMPORTANCE OF MANGROVES

The Mumbai city boasts a 149-kilometer coastline and almost 16 kilometres of beaches running from Colaba in the south to Madh and Marve in the north. The zone between sea and land is quite an inhospitable place for life to thrive. The water is salty, substratum is anoxic and the soil is alternately exposed and submerged due to tidal action. The only species of trees that can thrive in this volatile environment are the mangroves, which have developed special adaptation for this purpose. Every mangrove tree is an ecosystem in itself. Its roots act as substrate for sessile organisms like oysters and barnacles, its crown a rookery for swamp birds and the flowers are a good source of honey. The leaves are raw material for ants engaged in nest building and when they fall, they form the basis of food chain in the surrounding waters.

Mangroves confer a variety of benefits to mankind. They are natural barriers against sea intrusion, as demonstrated well during the Tsunami that hit our coast in 2004. By breaking up large storm surges and strong tidal currents they protect sea coast from erosion. They are important land builders which filter sediments from land and expand the extent of land towards sea. The enormous productivity of mangrove swamps enables them to support a rich faunal diversity. The unique habitat act as nursery grounds for many species of fish and shell fish and offer protection to many juveniles against predators. This way, the lives of millions of fishermen in our country are linked directly to the existence of healthy mangroves. Scientific studies prove that the ability of mangrove forest to absorb carbon dioxide from atmosphere and bury it in the soil is six times that of Amazon rain forest. This shows how important mangroves are in our to fight climate change and sea level rise.

According to forest survey of India, the total extent of mangroves in Maharashtra is 186 sq.km distributed along its six coastal districts. The thickly populated city of Mumbai alone has about 6000 hectares of mangroves, which is perhaps the largest extend of mangroves for any metropolitan city in the world. Mangroves are the green lungs for the city, which ensures abundant supply of oxygen to us. They also maintain the stability of the shoreline and prevent release of toxic wastes into the waters around Mumbai, thus playing a silent life supporting role. Their ability to absorb large volumes of water is a great boon to a city, which is prone to heavy rains and flooding from time to time. The rate of reduction in mangrove cover is a matter of great concern and the alarm bells are loud and clear.

On 6th October 2005, the High Court of Bombay issued a landmark to save the mangroves of Maharashtra coast. This judgment mandated that on government land be declared as Protected Forests and those on private lands as “Forests". The Hon'ble High Court prohibited any construction within 50 m from the boundary of the mangroves and also put a ban on dumping of debris in the mangrove areas. Following this order, 5469 hectares of mangroves in government land in Mumbai was notified as Protected Forest under Sec 29 of the Indian Forest Act. To improve the protection status of mangroves on government land, the state has decided to notify all such areas as Reserve Forest. Accordingly, 3998 hectares of mangroves in Mumbai has been declared as Reserved Forests.

In order to protect, conserve and manage the mangroves of the State, a "Mangrove Cell" was created by the government. The Cell is headed by a Chief Conservator of forest and is functioning from its office in Bandra, Mumbai. To give further fillip to the mangrove conservation efforts in Mumbai region a 'Mumbai Mangrove Conservation Unit' (MMCU) has been created on 17th May 2013.

3.2.9 SOCIAL INFRASTRUCTURE

Until the advent of mechanized transport, the size of a town was usually limited by how far people could walk to / from work, shops and in many larger towns, this leads to high residential densities and unhealthy living conditions. With the advent of increasing affluence and urban transport in the mid-19th century, people began to spread themselves and residential densities began to fall, although the towns continued to grow due to the migration from countryside.

In a developing region, economic development essentially means production and distribution of finished goods and also the availability of raw materials. Adequate transport facilities are

therefore one of the essential initial triggers for economic development and is accordingly considered as the infrastructure needed for any development.

The Municipal Corporation would need to make reservations for the additional facilities required for the projected population. The construction and management of primary health and education, entertainment & other social facilities is the responsibility of the Municipal Corporation.

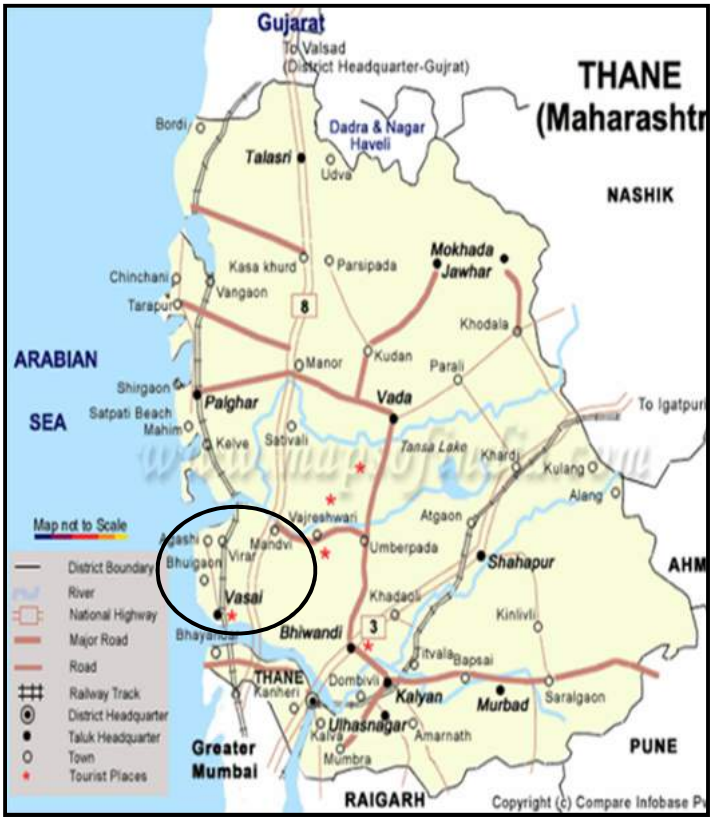
3.2.10 HOUSING

The population of Mumbai is more than 12 million, out of which 60% of the population resides in the hutments. It creates burden on environment and many health problems. Mumbai Slum Improvement Board provides amenities in various slums in Mumbai city and suburbs. Majority of the people residing in the hutments are from economically and socially weaker stratum. Span of slum redevelopment plan of State Government is extended to provide permanent residence and civic amenities. The main purpose of this project is to provide residence, basic amenities and other related civic amenities.

Mumbai Slum Development Board has planned construction program regarding basic amenities for the year 2015-16 as given below.

- Construction of protection wall.
- Improvement plan for civic backward colony.
- Development plan for slum area.
- Plan for beautification.
- Development plan for crematorium.
- To provide facilities to citizens in area under MCGM.
- Member of parliament/MLA/Apposite party members.
- Development of tourist places.
- New plans/ Ladies saving group/ Water tank protection/ Bore well.

3.3 INTRODUCTION TO MIRA BHAYANDER



Mira-Bhainder is a city, in the district of Thane with an area 79 sq. km., in the western state of Maharashtra, in India, located around 20 kms to the north of Mumbai on the Mumbai-Ahmedabad highway. It extends between 18º42' N to 20º20' N latitude and 0º25' E to 73º44' E.

Mira-Bhainder area is situated at the northern threshold of Brihan Mumbai Metropolis and has been identified as one of the growth centers. Mira-Bhainder has gradually developed into an important residential locality due to its proximity to Mumbai and lower cost of living. Earlier Bhainder was administrated by the Gram Panchayat system of local government. However subsequently in accordance with recommendations of MMRDA Mira Bhainder Municipal Corporation (MBMC) has been constituted for this area on 12th June 1985. Khari, Ghoddeo, Ghodbunder, Pen-pada, Mira, Kashi, Navghar, Bhainder and Mahajan wadi are the nine villages under its jurisdiction. Adjoining villages of the limits of Municipal Corporation are also showing trend of urbanization. Therefore govt. under its notification extended the limits of MBMC by including following 10 villages: Chene, Varsave, Rai murdhe, Murdhe, Morva, Uttan, Dongri, Tarodi Pali Chowk.

Bhainder is divided into two parts by the Mumbai suburban rail line - East and West. The West was traditionally residential, and the East was predominantly an industrial area. Recent population growth and a flurry of construction have blurred the boundaries between Bhainder and neighbouring Mira Road on the East side of the rail tracks, turning it into a populous suburb.

3.3.1 HISTORY OF MIRA BHAYANDER

Mira Bhainder is a city which has its own Historic value. It was an important port for business during past. This port has seen some most important Historic Legends right from Alexander to Peshwas and some great kings who have travelled through this port. The city is surrounded by big mountains on both the side boundaries along with Arabian Sea guarding the west side of the city. The North side of the city is surrounded by Vasai (Basin) Creek. So is the city of Bhainder Situated at the Heart of the Nature.

As we all know that India was governed by British. British also came to Bhainder but it was far time after as Bhainder and Vasai were governed by Portuguese. Portuguese were the first one to rule on this part. But British also ruled over Bhainder for quite some time. The example of British existence can be seen by the Railway Bridge over Vasai (Basin) Creek.

A large estate of 3688 acres, exclusive of salt marsh was granted by deed dated 1870 to Ramchandra Laxmanji of Bombay, on a lease of 999 years, in the village of Ghodbunder, Bhainder and Mira. The condition attaching to this grant were that the lessee should pay a yearly rent of Rs. 6790/-; that he should keep the embankments, dams, and sluic s in repair; that he should demand no rent from Inamdars; that he should demand only survey rates for Suti and Varkas lands; that he should keep boundary marks in repair; that he should pay Patil's and hereditary officers' claims and allowances; that he should not interfere with the rights of way; that he should surrender land free of cost for the Bhainder Railway Station; that he should give the Notice for the assignment of the lands; that he should not assign lands without leave; and that the salt marsh lands were liable for resumption if not reclaimed within twenty years. This estate has been the cause of much litigation, owing to an attempt of the leaseholder to levy from the yearly tenants one-half instead of one-third of the produce. The District court and the High Court on appeal (appeal 292 and 1880) have decided that the leaseholder's claim to levy one-half is contrary to the custom of the country. (Source: Gazetteer Of The Bombay Presidency, Volume XIII, Part II, Chapter VIII).

The Devnar Estate includes five villages: Devnar, Borla, Kirol, Chene and Varsava Borbhat. It was granted in perpetual lease to Mr. Dhakji Dadaji in 1809 on a rental of Rs. 5180. In addition to this a sum of Rs. 390/- is paid for lands held by husbandmen direct from Government. Only two of the villages Chene and Varsava Borbhat remain in the family of the original grantee. The other three have been sold to different buyers. (Source: Gazetteer of The Bombay Presidency, Volume XIII, Part II, Chapter VIII).

Formation of Mira Bhainder as a City:

Being a neighbouring city of Mumbai, the growth of the city is tremendous still the city has managed to keep its originality like small scale industries, farming, fishing, sand and salt cultivation as its major business. The small scale industry situated in Bhainder (E) rank Third in Asia. Agri and Koli are the original residents of this city, but there are people of all other Religion and casts.

On 12th June 1985, five Grampanchayats naming Bhainder, Kashi, Mira, Navghar and Ghodbunder were integrated to form Mira Bhainder Municipal Council. In 1990 the Council got extended by including 4 other Grampanchayats naming Chena, Varsova, Rai – Murdhe, Dongri – Uttan. Thus this corporation is made up of 9 Grampanchayats, hence the Mira Bhainder Logo has 9 stars on it.

In 1990 the Council conducted its first election. Mr. Gilbert John Mendonsa was the first President. On 28th February 2002 the Council was declared as Corporation on the basis of its population. On 11th August 2002 the Corporation conducted its first election which gave 79 elected and 5 Cops members. Mrs. Mayra Gilbert Mendonsa was the first Female Mayor of the city.

3.3.2 TOPOGRAPHY

It is located in the northern part of the Konkan region to the west of sahyadri hill ranges. The whole town is on a plain level land. The vasai creek surrounds the city from east to north, followed by the Arabian Sea, till the west. The Mumbai city is situated on the southwest. To the south is the Sanjay Gandhi national park and on the southeast thane city. Geographically the city falls in the Deccan lava terrain. Geologically the city falls in lava terrain. Uttan and Ghodbunder are hilly regions. The plain terrain forms a wide area of water logged and marshy land.

3.3.3 METEROLOGY

The climate in the month of October is wet and hot followed by cool and pleasant weather from December to February and dry and hot weather from March to June. The climate of Mira-Bhainder is typically coastal, sultry and not really hot. There are virtually two distinct seasons, namely Monsoon and dry season. The later covers both summer and winter.

TABLE 3-4: CLIMATIC CONDITION OF MIRA BHAINDER

Sr. No.	Season	Max. Temperature (ºC)	Min. Temperature (ºC)
1	Summer	34.57	32.37
2	Winter	20.5	17.6

3.3.4 RAINFALL

The rainy season starts at the beginning of June and ends in the last week of September. Annual mean rainfall of 2400 mm. the maximum rainfall is in the month of July averaging to 800 mm.

3.3.5 HUMUDITY

The humidity ranges from 49% to 87% with the highest humidity in the month of July.

3.3.6 DEMOGRAPHY

DISTRIBUTION OF POPULATION:

In year 2008-2009 the population of Mira-Bhainder has been recorded app. 9,00,000. The total male population is 55% of the total population i.e. 4,95,000 and the total female population is 4,05,000 (45%) of total population. In Mira-Bhainder 1,17,000 population is under 6 years of age i.e. 13% of total population.

LITERACY LEVEL:

Mira-Bhainder has an average literacy rate of 81% which is higher than the national average of 59.5%. In this region, male literacy is found to be 81% of total male population i.e. 4,00,950 and female literacy is 74% i.e. 6,66,000 of total female population.

3.3.7 LAND USE PATTERN

The Mira- Bhainder Municipal Corporation area is 79.40sq.km. It was incurred in the previous BMRDA development plan. The independent development of the plan was sanctioned by the State Government as per the government rule dated 14th May 1990. The planning was as follows;

TABLE 3-5: LAND USE DETAILS OF STUDY AREA

Sr. No.	Land Use	Area (Hectres)
I.	*Developed Area*	*2034.36*
1	Residential Area	1157.75
2	Industrial Area	138.29
3	Commercial Area	53.91
4	Public Utility	251.49
5	Transportation	254.17
6	Open Spaces (playgrounds & gardens)	175.05
7	Graveyard	3.70
II.	*Undeveloped Area*	*4554.77*
1	Barren Land & Salt Pans	139.33
2	Forest & Mountain Area	1064.96
3	Water Logged Area	3350.48

- Residential area: In last few years Mira-Bhainder has emerged as the fastest growing suburb of the Mumbai City. Due to the increasing population pressure on Mumbai and easy communication facilities for commuters going to and coming from Mumbai from Mira- Bhainder, the population has shifted towards the Mira-Bhainder region. As a result large housing complex have come up in this area. This has also lead to the development of slum pockets in the area. At present, 13,182 no. of slum household have been recorded in the area of which only 10,261 no. are authorized and 2,921 nos. are unauthorized.
- Commercial area: Residential growth of the area has lead to the massive commercial establishment. Earlier the commercial activities were limited mainly on Bhainder Uttan road form Bhainder station (W) upto Municipal Corporation office and on east of Bhainder railway station activity was concentrated to Balaram Patil road. In last year the area around Mira Bhainder road and Mira – Bhainder Bridge has emerged as the largest commercial development of the region. Maxus Mall, Reliance Fresh, Spinach bank, Restaurants, showrooms of famous brands like Reebok, Woodland, Vijay sales etc. have come up here. Further, many banks such as, SBI, Corporation Bank etc. had also open their branches in this region.

- Industrial area: This user covers around 1.59% of the total area. As per the latest records of MBMC there are around 383 industrial estates with around 5000 industrial galas are existing in the area. It is estimated that around 20,000 workers are working in this industrial area.
- Land under Public and Semi public Use : This category includes areas occupied by Educational institutions such primary and secondary schools, Religious places such as temple, church, mosque etc, Government and semi-government offices. It covers nearly 0.151% of the total area.
- Land under open spaces: Mira-Bhainder is bounded by natural water tanks scattered in various parts of the town. The municipal corporation has developed three lakes enriched with proper landscaping viz. MBMC Main Office Lake, Goddeo lake and Shivar lake wherein boating activity is also available for citizens. The open spaces and recreational grounds are lungs of the town and they cater active and passive recreation needs of the city.
- There are several salt pans in Mira-Bhainder region. These Salt pans are shallow manmade ponds designed to produce salt from sea water. The seawater is fed into large pans and water is drawn out through natural evaporation which allows the salt to be subsequently harvested.

3.3.8 ACCESSIBILITY

3.3.8.1 RAIL

The Western Railway of the Mumbai Suburban Railway is the lifeline of the western and extended suburbs of Mumbai. Mira Road & Bhainder are the railway stations on this line. Mira Road is one station after Dahisar. After Bhainder is the Vasai (Bassein) Creek bridge followed by Naigaon. Slow and fast trains between Churchgate, Dadar, Andheri & Borivali and Vasai Road/Virar operate from Mira Road & Bhainder stations. Bhainder is also a terminal for a few trains, a convenience to residents here. Number of trains starting from Bhainder has been considerably increased in recent times after the deployment of 4 railway tracks between Borivali and Virar. This has been a crucial step to make train journeys safer and comfortable for the residents of Mira-Bhainder and the rapidly increasing population of Bhainder.

3.3.8.2 ROAD NETWORK

The Western Express Highway, as termed in Mumbai leaves the city as the NH 8 (National Highway) linking Mumbai with the west and north-west of India. Important cities covered on

the NH 8 are Vapi (for Daman & Silvassa), Surat, Baroda, Ahmedabad, Udaipur, Ajmer, Jaipur and Delhi. On the NH 8, just beyond the Ghodbunder area is the Virar-Vasai area. Ghodbunder is also linked to Thane by a highway.

Kashimira is a point falling between Dahisar Check Naka and Ghodbunder, from which a main road arise that leads to Mira Road, Bhainder & the coastal villages of Uttan, Gorai, Manori & the heavily marketed Amusement Parks – Essel World & Water Kingdom.

3.3.8.3 BUS SERVICES

The BEST Undertaking has been the longest provider of services to the area with services to Mira Road Station, Shrusti Complex, Bhainder Railway Station (East), Kashimira & Ghodbunder from points in Borivali, Kandivali, Marol, Mulund, Santacruz, Mahim & Sion. Several Western and central suburbs are thus conveniently connected. The BEST operates these buses under the 700 number series.

BEST have introduced AC Express Bus services from MIRA ROAD RAILWAY STATION EAST to NEHRU PLANETARIUM (A-70EXP) via S.K. Stone Police Chowkey. This route is operated between Mira Road Station (East), and Nehru Planetarium. The itinerary of this route is via Mira-Bhainder Road, Kashimira, Western Express Highway through all the Flyover Bridges, and also through Bandra-Worli Sea Link. BEST AC services AS 458 and AS 700 to Thane pass through Mira road.

BEST has also introduced AC Bus service from GOLDEN NEST Bhainder East (Fatak) to SANTACRUZ DEPOT (AS707) via Mindspace and Juhu. Now it's extended up to MAXUS MALL. BHAINDER (WEST)

BEST has also introduced the Corridor (Express) bus Service from Mira Road to Mahim (C-71), Mira Road to Mulund Check naka (C-61) and Bhainder to Sion (C-72), this buses offers rapid connectivity to Mumbai and Thane. C-71 & C-72 passes through important commercial locations of Mumbai on Western Express highway, like Borivali, Andheri, Bandra and so on while C-61 offers great connectivity to Thane & Mulund areas.

MSRTC operates frequent services from Bhainder Station W to Thane Railway Station West ST Stand via Kashimira, Ghodbunder Road, Owale & Eastern Express Highway. A few services now commence from Bhainder Station E. Frequency of the buses is quite good from Bhainder W with buses running every 15th minute between Bhainder and Thane during rush hours.

The Thane Municipal Transport (TMT) operates the very popular routes 57, 58 & 75 between Thane Railway Station West & Mira Road Railway Station. TMT AC 65 service passes through Mira Road.

The Navi Mumbai Municipal Transport (NMMT) has introduced its new service route from Vashi to Bhainder (East). The new route no. 70 will travel from Bhainder (East) to Vashi Depot, and there will be 23 bus services during the day with a frequency of one approximately every 30 minutes.

The Mira-Bhainder Municipal Transport (MBMT) has local bus services connecting interconnecting various places in the Mira-Bhainder area.

MBMT bus services are available from Mira Road Stn E, Bhainder Railway Stn E, Bhainder Railway Stn W & Dahisar Check Naka parts of this city. Recently they have also started the new bus between Western Park (Kashimira) to Behram Baugh (Jegeshwari). These buses are run on contract basis by MBMC.

Apart from this government transportation, Private vehicles (Call Center Vehicles) are also easily available from Mira-Bhainder Road for Andheri and Thane at very cheap rates as low as Rs. 40; office going people during morning peak hours easily gets these vehicles popularly from Golden Nest Circle and other important Bus Stops through Mira Bhainder Road.

3.4 SOCIO ECONOMIC PROFILE OF MMR

MMR is highly urbanized area with more than 90% of the total population of 11.9 million as per 2001 census and 12.4 million as per 2011 census is concentrated in cities and towns. The urban population is however confined to 8 Municipal Corporations, 11 Municipal Councils and 10 Non Municipal Towns. Total area under these urban units is about 1,500 sq. km. In the rest of the region, about 1 million population is spread over 950 village settlements. The demographic census gives population and worker details according to 88 census sections in Greater Mumbai, for suitably defined wards in other urban centres and for village as a whole in MMR.

3.5 MMR PLAN

The sanctioned Regional Plan for MMR 1996-2011, specifies the land-use for different parts of the region. In this plan, urban development is categorized under two classes namely, U1 and U2 zone. U1 zone, constituting 19% of the total land denotes intensive and high density urban

development, whereas, U2 zone, constituting 5% of the total envisages relatively low density urban development. U1 zone largely covers the existing Municipal Corporations, Municipal Councils and a few Non Municipal Towns. U2 zone is generally showing the possible outgrowth of the cities and towns. Further, 3% of the land is placed under Industrial Zone, 1% under Port and Airport and 6% under Recreation & Tourism Development Zone and National Park. The rest of the 66% of land-use is distributed among Forest Zone (23%), Green Zone (39%), Coastal Wetland (3%) and Water body (1%). The Regional Plan also provides estimates of population and its distribution in different parts of MMR for the year 2011. Corresponding projections for the year 2021 and 2031 are also made by MMRDA.

Under the notification dated 4th February, 2003, Matheran Municipal Council area and the surrounding region are declared as Eco-Sensitive Zone (ESZ) imposing restriction on industries and development activities in the said zone. The ESZ covers an area of 215 sq. Km. area and its Zonal Master Plan is to be prepared to guide the development.

Dronagiri Node in Navi Mumbai developed by CIDCO is designated as a Special Economic Zones (SEZ) and its plan is currently under preparation. There is a proposal to establish domestic/international airport near Panvel town in Navi Mumbai.

The Region has a fairly well developed rail and road network. The rail network consists of suburban and main line sections. The rail network connects most of the important urban areas. The road network comprises Expressways, National Highways, State Highways, Major District Roads, other District Roads and Village Roads. The village settlements are largely served by the road network and state road bus transport services.

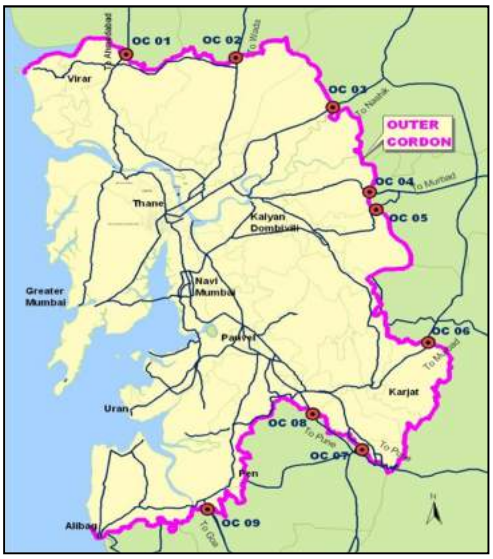
3.5.1 COMPREHENSIVE TRAFFIC & TRANSPORT STUDY (CTTS)

MMRDA with technical assistance from World Bank under Mumbai Urban Transport Project embarked on the Comprehensive Transportation Study for MMR with prime objective of identifying travel pattern of residents in MMR and recommending long term comprehensive transportation strategy for MMR up to 2031. The Comprehensive Transportation Study for the Mumbai Metropolitan Region carried out by M/s Lea & Associates is given the acronym TRANSFORM or Transportation Study for Mumbai. Mira Bhainder region being part of MMR was covered under this study.

The Comprehensive Transport Study for MMR was conducted in 2008 with objective to ensure adequate levels of accessibility in the expanding urban areas and to assist the economic

development of the region. The transit and highway networks for horizon year 2031 and beyond has been defined and assessed keeping in view the goals & objectives set for the future MMR. The networks build on the strengths and functions of the existing transport networks and planned, or committed, highway, suburban rail and metro corridors proposed by various planning organizations. The concept plans extend the both road and rail networks into the mainland Greenfield areas and improving the connectivity to the many expanding existing urban clusters of the region. The key ingredient of the plans is regional inter-connectivity since currently and in the future the whole of the MMR will largely function as an economically integrated region. While planning strategies in other large metropolitan regions across the world have attempted to contain the growth of the 'Mother City" and develop largely autominous peripheral cities.

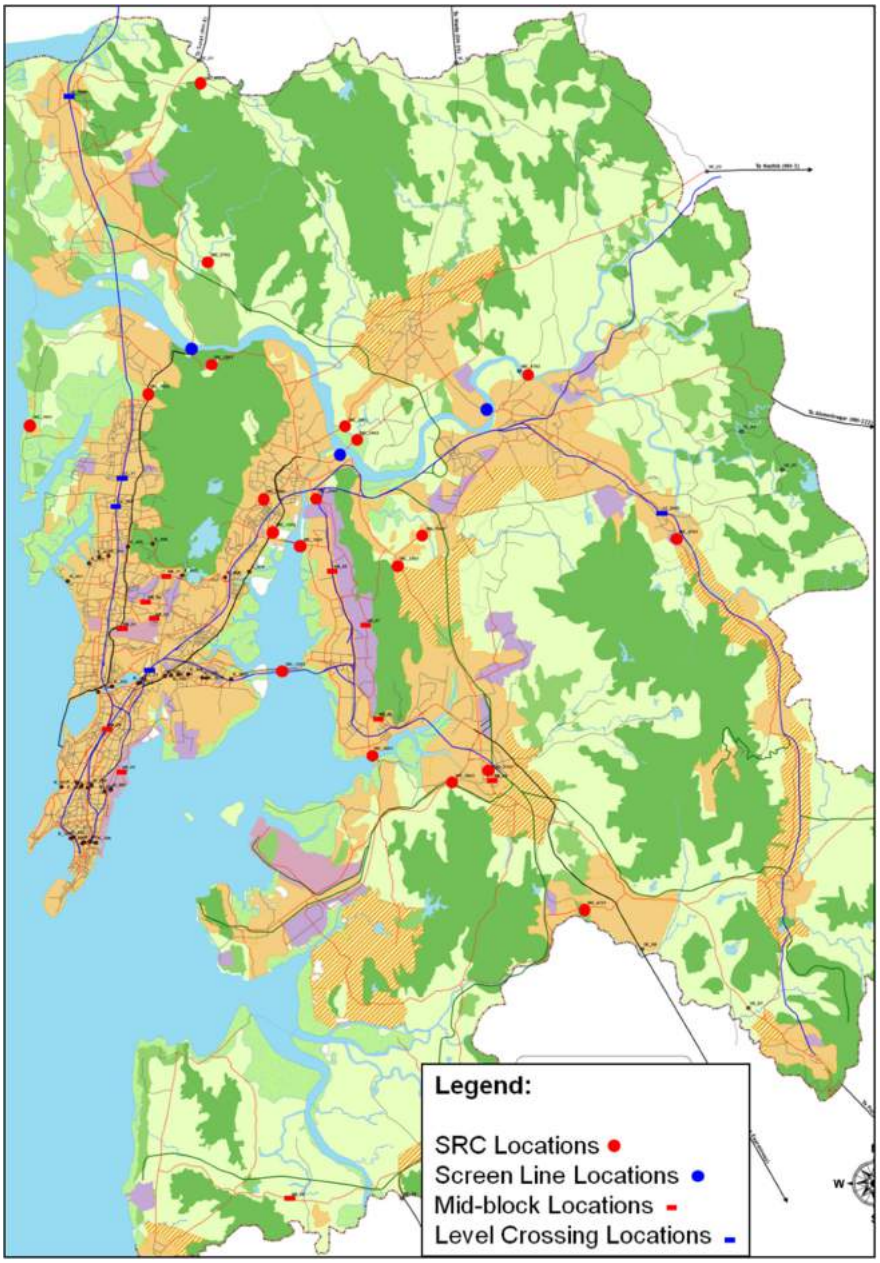
Classified volume count at outer cordon locations: The external travel for the base year (2005) has been assessed from the classified traffic count survey, occupancy survey and OD survey carried out at 9 outer cordon locations for 24 hours. It was found that About 48,000 vehicles enter Mumbai every day and almost same number leaves. About 90% of this traffic is from north and south side of the region with very little from the east side. Out of total MMR traffic, the traffic moving in the northern direction is around 40,000 vehicles, eastern direction 8,600 vehicles and southern direction is 45,200 vehicles. The major traffic handling corridors are NH8 (29.7%), Mumbai-Pune Expressway (20.2%), NH17 (13.5%) and NH4 (11.6%).



Classified volume count at sub regional cordon locations: Traffic counts at sub-regional cordons, inner cordons and screen lines were undertaken for validation of the travel demand models and matrices assessed from HIS analysis. In addition, classified traffic volume counts

were carried out at mid-block and level crossing locations. The survey locations are presented in below.

Description	24 hours		16 hours		Total survey points
	Traffic Count points	RSI points	Traffic count points	RSI points	
Sub-Regional Cordon	20	20	-	-	**20**
Screen Line	3		-	-	**3**
Inner Cordon	6		27	3	**33**
Other roads			11		**11**
Level Crossing			**5**		**5**



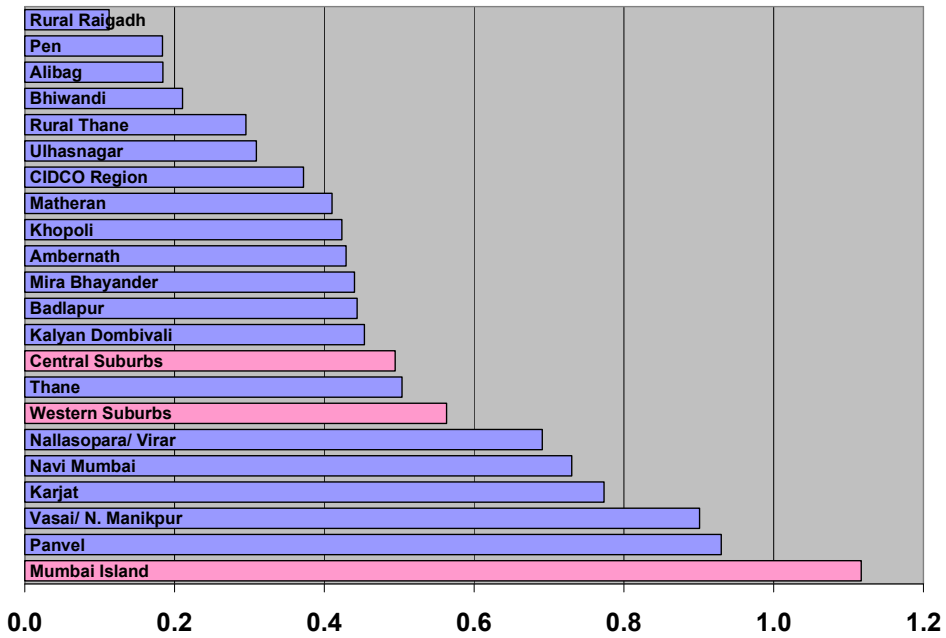
The internal travel pattern within MMR is quantified through analysis of various primary surveys, which includes home interview surveys, classified traffic volume count and origin-destination studies at inner cordon/sub-regional cordon locations, classified traffic volume count surveys at mid-block/level crossings and sub-urban rail passenger surveys. Besides, to understand the speed profiles on various major corridors of the study area, Journey Speed studies have been carried out. For developing volume-delay functions and turn penalty functions which form an important input for network analysis, separate studies were carried out.

It is estimated1 that 20.8 million people in the MMR perform nearly 34.3 million trips every day for all types of purposes and by modes recorded in the survey. This equals to an average Per Capita Trip Rate (PCTR) of about 1.65 per day. In terms of person-km, this amounts to total travel of about 250 million-km per day;

By excluding the walk trips which are generally short trip length, the PCTR is estimated to be 0.65 per day; and

The demand for mechanized travel varies across the MMR. Some of the smaller but highly urbanized municipalities, including Island City, show higher than average trip rate. In Mira Bhainder per capita trip rate is 0.45 per day against average per capita trip rate of MMR region, i.e. 0.65 per day.

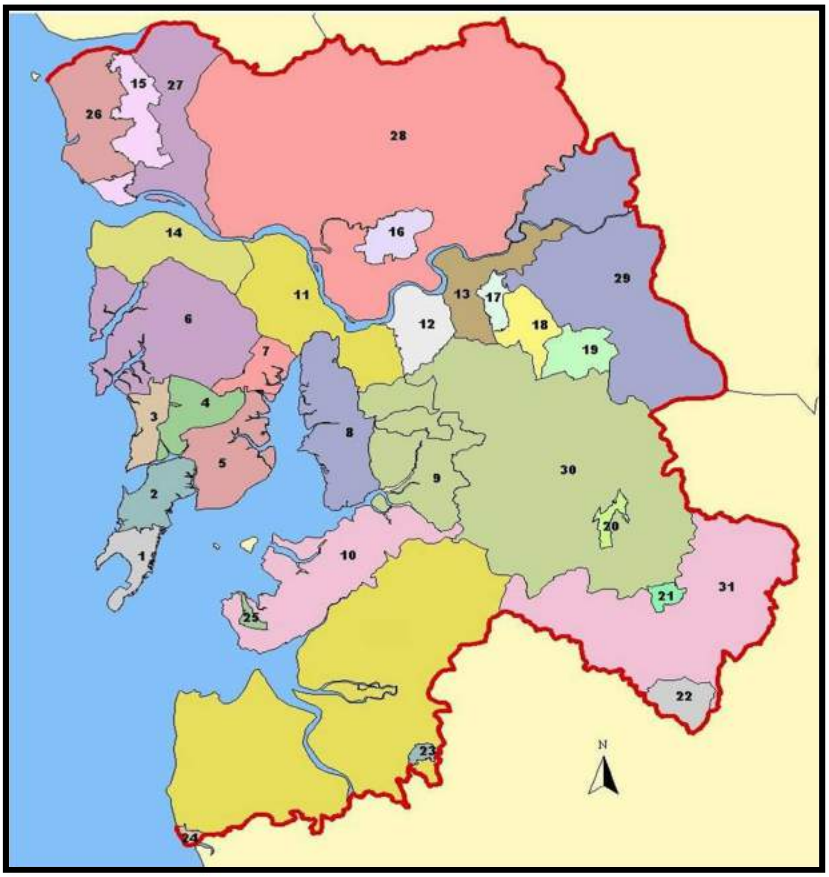
On the other hand, predominanty rural parts of the MMR have relatively less average trip rates.



External demand i.e. passenger and goods vehicle travel from the study area to outside the study area (internal to external), from outside to inside of the study area (external to internal) and outside of the study area to outside (external to external) play crucial role, especially traffic flows on corridors connecting the study area with rest of the study area (i.e. NHs and SHs), sub-regional corridors connecting the sub-regions (i.e. Vashi Creek Bridge, Airoli Bridge, Western Express Highway (WEH), Eastern Express Highway (EEH), Sion-Panvel Highway, Thane-Ghodbunder Road, etc.), corridors connecting the ports (Wadala Truck Terminal Road, Rafi Ahmed Kidwai Road, P D'Mello Road, NH4B, SH54, etc.).

The external travel for the base year has been assessed from the classified traffic count survey, occupancy survey and OD survey carried out at 9 outer cordon locations for 24 hours.

For external travel demand analysis, a coarse zoning system of 40 super-zones for MMR is adopted and the zoning system is presented below. Due care is taken of socio economic, demographic and land use pattern before finalising these groups. The external zoning systems within the state of Maharashtra and across the country are also presented below.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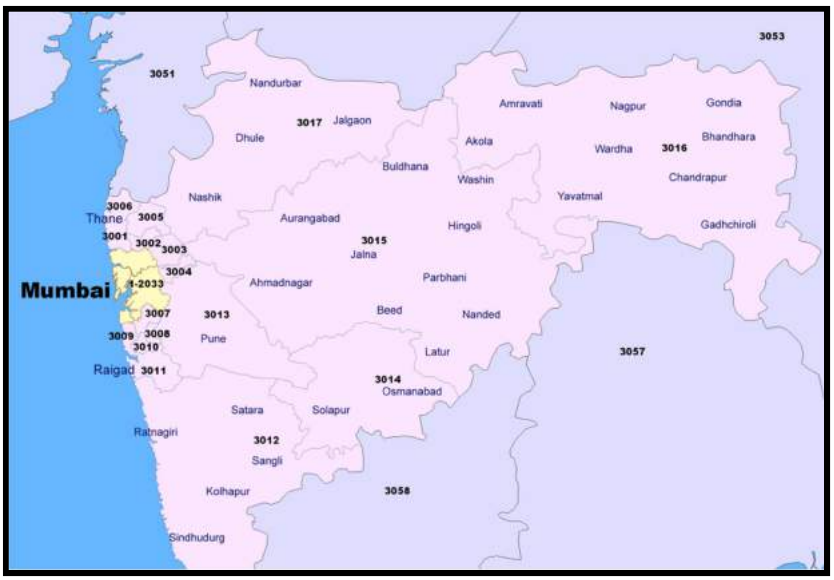
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Osmanabad
Satara
Solapur
Ratnagiri
Sangli
Kolhapur
Sindhudurg
Buldhana
Akola
Washin
Amravati
Wardha
Nagpur
Gondia
Bhandhara
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Nearly 63% of total traffic (in vehicles) moving out of the region originates from Greater Mumbai, the mother city of the region (refer below). O-D characteristics specific to major urban areas of MMR is presented below. Greater Mumbai has the highest number of trips with a share of 50.5% and 57.5% of the total traffic attracted and produced. The major trip generators are Greater Mumbai, Kalyan, Navi Mumbai and Thane and others are with moderate shares varying from 5 to 10%.

Distribution of Passenger Moving out of MMR by Place of Origin:

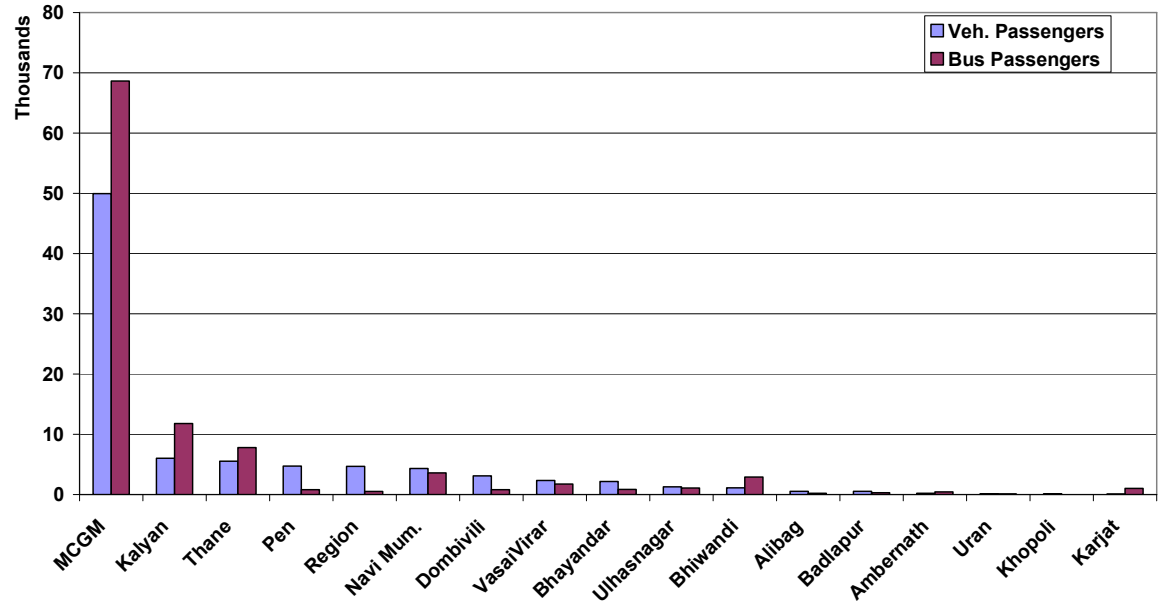


TABLE 3-6: PASSENGER O-D CHARACTERISTICS OF PASSENGERS WITH IN MMR (NO. OF PERSONS)

Sl. No.	Urban Zone	Productions	%	Attractions	%
1	Greater Mumbai	49950	57.50	43464	50.50
2	Navi Mumbai	4324	4.98	8681	10.09
3	Thane	5533	6.37	6480	7.53
4	Dombivali	3102	3.57	1513	1.76
5	Kalyan	6028	6.94	3960	4.60
6	**Mira Bhainder**	**2175**	**2.50**	**706**	**0.82**
7	Vasai-Virar Region	2339	2.69	2388	2.77
8	Bhiwandi	1110	1.28	1923	2.23
9	Ulhas Nagar	1288	1.48	1262	1.47
10	Ambernath	218	0.25	518	0.60
11	Badlapur	532	0.61	525	0.61
12	Matheran	0	0.00	311	0.36
13	Karjat	76	0.09	250	0.29
14	Khopoli	115	0.13	128	0.15
15	Pen	4726	5.44	8322	9.67
16	Alibaug	533	0.61	486	0.56
17	Uran	142	0.16	0	0.00
18	Rest of MMR	4674	5.38	5150	5.98
Total		**86865**	**100**	**86067**	**100**

For forecasting travel demand in the MMR, under various policy and transport infrastructure levels, models have been calibrated to simulate travel patterns. Transportation models

developed for the purpose of traffic forecast constitute the core support system for decision making. These models are developed on a GIS enabled transportation network using state-of-art software EMME/3 and ARCGIS. The models developed have been used for forecasting travel demand for the various horizon year periods up to 2031 for various growth scenarios. The outputs of these models will also provide inputs for social, environmental, economic and financial analysis of various transport network options. A standard four-step transport modelling approach has been followed with suitable modifications to capture the specific characteristics of Mumbai region.

Travel demand forecasting is further carried out to ascertain the travel demand and its loading on the existing and proposed transport network.

FIGURE 3-5: RECOMMENDED HIGHWAY NETWORK FOR THE HORIZON YEAR 2016

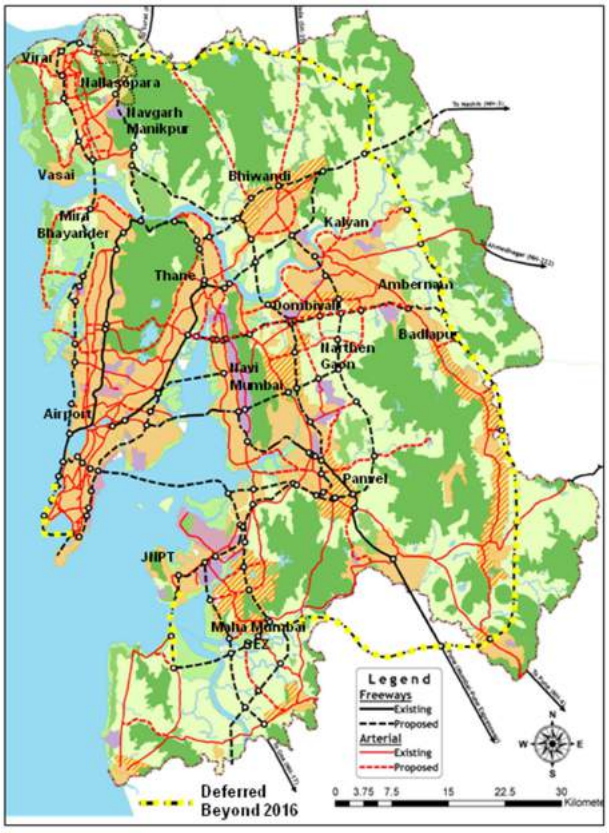


FIGURE 3-6: RECOMMENDED SUB-URBAN & METRO NETWORK FOR THE HORIZON YEAR 2016

FIGURE 3-7: RECOMMENDED HIGHWAY NETWORK FOR THE HORIZON YEAR 2021

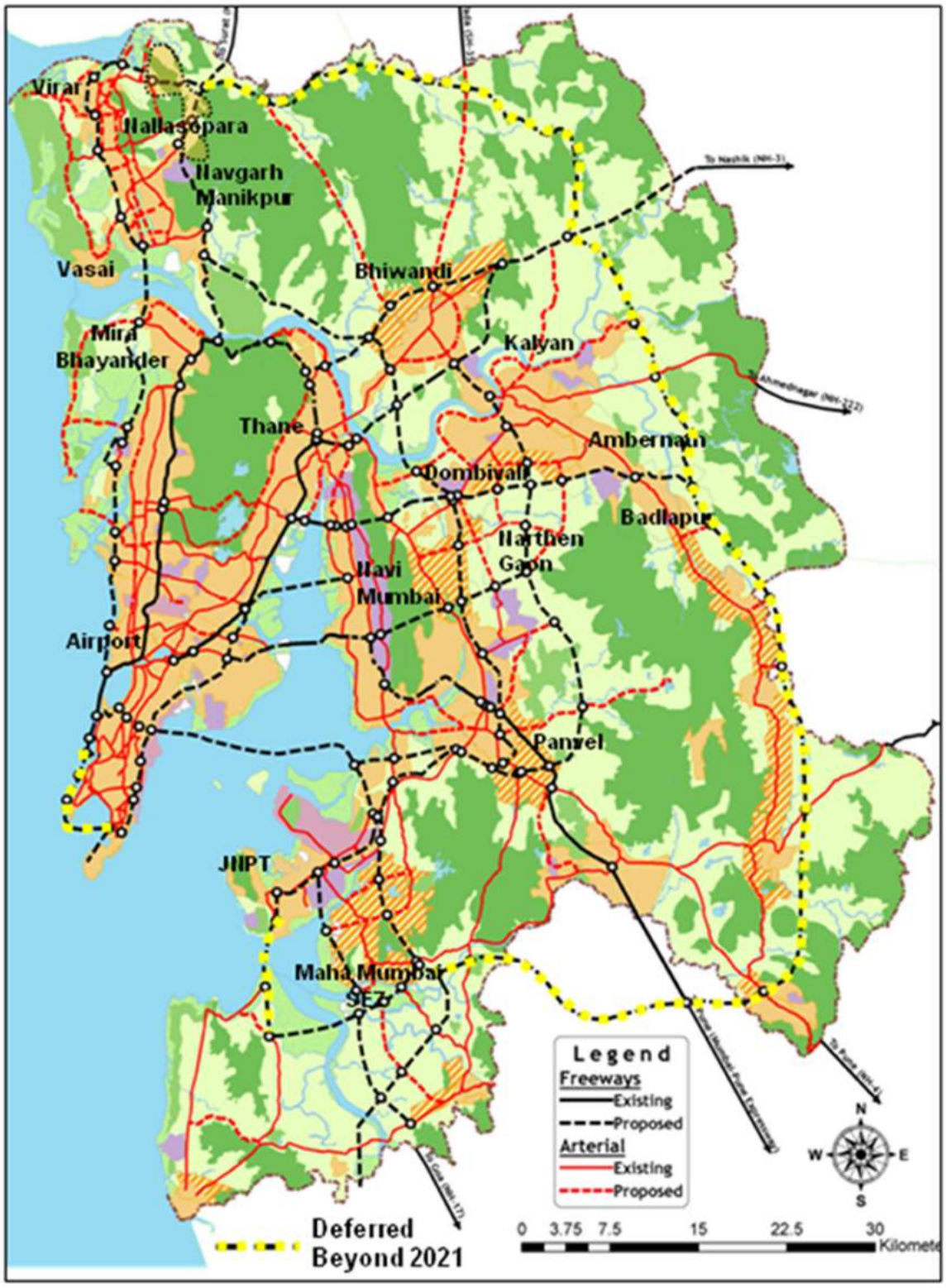


FIGURE 3-8: RECOMMENDED SUB-URBAN & METRO NETWORK FOR THE HORIZON YEAR 2021

TABLE 3-7: ULB WISE TRAFFIC ENGINEERING MEASURES ARE ALSO PROPOSED AND PRESENTED BELOW.

Components	Intersection Imp. (No.)	Flyovers/ Interchanges (No.)	FOBs (No.)	ROBs / RUBs (No.)	Ped. Subways (No.)	Parking Plazas (No.)	Footpath Imp. (2 to 3 m wide) (kms)
Greater Mumbai	250	30	75	25	50	50	1000
TMC	27	13	4	2	10	3	250
KDMC	14	8	5	5	6	5	200
NMMC	15	12	17	5	6	2	100
Mira Bhainder	**4**	**2**	**2**	**2**	**2**	**1**	**80**
Bhiwandi-Nizampur	5	2	2	2	1	1	80
Ulhasnagar	2	1	2	1	1		40
Ambernath	2	1	2	1	1		10
Kulgaon-Badlapur	1	1	2	1	1		10
Nallasopara	1	1	2	1	1		10
Vasai	1	1	2	1	1		10
Virar	2	1	2	1	1		10
Navghar-Manikpur	1	1	2	1	1		10
Alibaug	1	1	1	1	1		10
Karjat	1	1	2	1	1		10
Khopoli	1	1	2	1	1		10
Matheran	1	1	1	1	1		10
Panvel	3	1	3	1	1	1	20
Pen	1	1	1	1	1		10
Uran	1	1	1	1	1		10
Total	**334**	**81**	**130**	**55**	**89**	**63**	**1890**

3.5.2 INTRODUCTION TO UPDATION OF CTS FOR MMR STUDY

The quality and amount of transportation infrastructure provided often governs economic growth and spatial development. An inadequate transportation facility causes congestion, delays, and a higher carbon footprint, resulting in significant socioeconomic costs to society, whereas an unrestrained facility, although might not always economical, but often supports long-term spatial development strategies of settlements and regions. The key to planned development is an optimal degree of sustainable infrastructure provisioning. Under this overarching premise, MMRDA intends to develop an investment programme for augmenting and expanding the capacity of MMR's transportation infrastructure, generally in accordance with the recommendations presented in the MMR area's Comprehensive Transportation Study (CTS).

During the recent decade, MMRDA and other MMR partners began several transportation infrastructure projects, including metro, monorail, highway, and suburban rail projects. In addition, the MMRDA wants to improve the MMR transportation network. Furthermore, after the completion of CTS, MMR has seen significant land area expansion during the previous decade. As a result, it is deemed that the TRANSFORM: 2011-31 should be updated. (MMR Study CTS 2005-08). Hence there was need to carry out updation of CTS for MMR study.

The CTS study looked at the major elements that affect traveling, such as the changing economic and social circumstances in the region. The study also assessed the difficulties and opportunities that must be identified and handled. The study's findings will be valuable in developing suggestions for the MMRDA, CIDCO, MRVC, MSRDC, PWD, ULBS, and Municipal Transport divisions. The proposals will be valuable to the Traffic Police and other organisations involved in day-to-day traffic operations as well as future traffic and transportation infrastructure development within MMR.

3.5.2.1 OBJECTIVE OF UPDATION OF CTS FOR MMR STUDY

The MMRDA has launched Updating CTS for MMR Study with the following key goals

a) To update the CTS study (2005-08) and Travel Demand Model using recent census 2011, Economic Census, and major developments in MMR;
b) To assess the mode wise travel demand for metro rail, suburban rail, bus system, and road/highway corridors for horizon years 2021, 2031, and 2041;
c) To update and prioritise metro rail, suburban rail, and highway corridors for horizon years 2021, 2031, and 2041; and
d) To prepare phase wise investment plans for prioritised metro rail, suburban rail and highway.

3.5.2.2 TRAVEL DEMAND FOR MMR- BASE YEAR 2017

Updation CTS study also includes studying on traveling behaviour and pattern for base year of 2017 was carried. This study includes assessing the passenger travel demand and goods travel demand for morning peak period. The following table shows the estimated Passenger and goods travel demand for MMR- Base Year 2017.

TABLE 3-8: PASSENGER TRAVEL DEMAND FOR MMR- BASE YEAR 2017, MORNING PEAK PERIOD (6:00 TO 11:00HRS.)

Mode	Total (in Lakhs)	% share
Car	3,88,699	6.9%
Two-wheeler	6,24,932	11.1%
Auto Rickshaw	2,78,650	4.9%
Taxi	3,48,990	6.2%
Bus	10,08,417	17.9%
Train	28,84,431	51.1%
Metro/ Mono	1,13,786	2.0%
Total	56,47,906	100%

TABLE 3-9: GOODS TRAVEL DEMAND (IN VEHICLE TRIPS) FOR MMR- BASE YEAR 2017, MORNING PEAK PERIOD (6:00 TO 11:00HRS.)

Mode	Total
LCV	3,88,699
Trucks	6,24,932
Total	**56,47,906**

Also with this the movement of external vehicle were also studied under this study. The 2017 external travel volumes, consisting of the "Internal to External" (MMR to outside of MMR) the

"External to -Internal" (Outside of MMR to MMR) and the "External-External" (Outside of MMR to Outside of MMR) during the Morning Peak Period (6:00 to 11:00 hrs.) is summarized in below table.

TABLE 3-10: EXTERNAL TRAVEL IN VEHICLES (MMR - OUTSIDE OF MMR AND VICE VERSA) - BASE YEAR 2017, MORNING PEAK PERIOD (6:00 TO 11:00 HRS.)

Mode	Vehicles Trips
Car	20,054
Two-wheeler	14,191
Auto	580

Mode	Vehicles Trips
Taxi	2,443
Bus	1,822
Goods	13,340

This report calculated the estimated travel demand for future for horizon year 2041. While doing so different planning criteria were assessed for the MMR region over the base years and other horizon years which are given in following table. Using the planning criteria, travel demands for various horizon years were projected. As part of the CTS Updating project, updated travel demand models were created. Transportation assignments over various time periods from 2021 to 2041 was calculated. Further analysis had been carried out in order to establish the essential transport network requirements for the 2021 horizon, which included the short term (2026), midway (2031), and long term (2031).

TABLE 3-11: PLANNING CRITERIA FOR THE BASE AND HORIZON YEARS

Criteria	2021	2026	2031	2041
Population (in million)	26.52	27.76	29.32	32.17
Workforce Participation Rates (%)	42	43	44	46
Employment (in million)	11.13	11.97	12.99	14.91

Using those parameters, the future travel demand was projected according to that the following table shows the travelling demand for year 2021, 2026, 2031 and 2041.

TABLE 3-12: DAILY PASSENGER TRAVEL DEMAND WITHIN MMR- HORIZON PERIOD 2021-41, IN MILLION VEHICLE TYPE

Vehicle type	2017	2021	2026	2031	2041
Car	1.59	1.71	1.39	1.50	1.74
Two wheeler	2.43	2.62	1.95	2.11	2.43
Auto	0.95	0.98	1.03	1.03	1.09
Taxi	1.63	1.55	1.38	1.36	1.37
Bus	3.75	3.93	1.32	1.34	1.44
Suburban	8.11	7.48	5.40	5.81	6.51
Metro & Mono	0.41	2.35	9.62	10.62	12.37

Vehicle type	2017	2021	2026	2031	2041
Total	18.78	20.62	22.08	23.77	26.96
PV(car&2-wheeler)	3.94	4.33	3.33	3.63	4.17
IPT(Taxi & Auto)	2.58	2.53	2.41	2.39	2.46
PT(Bus, suburban, metro& mono)	12.27	13.76	16.34	17.76	20.32
Total	**18.78**	**20.62**	**22.08**	**23.77**	**6.96**

Similar to the study of passenger travel within the MMR region, an assessment of goods vehicle traffic within the MMR area was also conducted from horizon 2021 to 2041. Following table summarises the vehicle type and travel demand predicted by various goods vehicular modes inside the MMR during the morning peak period (6:00 AM to 11:00 AM).

TABLE 3-13: GOODS TRAVEL DEMAND (IN VEHICLE TRIPS) FOR MMR- HORIZON PERIOD 2021-41, MORNING PEAK PERIOD (6:00 TO 11:00 HRS.)

Vehicle type	2017	2021	2026	2031	2041
LCV	7,138	8,416	10,340	12,704	19,176
Truck	18,394	19,879	21,905	24,237	29,308
Total	25,532	28,295	32,245	36,841	48,484

The external travel volumes by various modes during the morning peak period i.e. 6:00 AM to 11:00 AM under various horizon periods until 2041 are presented in following table

TABLE 3-14: EXTERNAL TRAVEL IN PCUS (MMR TO OUTSIDE OF MMR AND VICE VERSA) - HORIZON PERIOD 2021-41, MORNING PEAK PERIOD (6:00 TO 11:00 HRS.)

Vehicle type	2017	2021	2026	2031	2041
Car	20,085	23,831	29,520	37,104	57,590
Two wheeler	14,190	16,846	20,785	25,798	39,147
Auto	781	946	1,181	1,493	2,297
Taxi	2,038	2,450	3,059	3,860	6,020
Bus	1,986	2,276	2,725	3,328	4,902
Goods	13,346	17,540	24,093	32,280	47,995

3.5.2.3 DAILY MODE SPLIT AND MODE SPLIT CHANGES FOR MMR

The assessment of daily travel demand for the base year 2017 was done using home interview survey data and analytical findings, the original CTS database, secondary data on ridership details in various public transportation systems, and so on. The following table summarises the daily mode split data for motorised vehicles in MMR

TABLE 3-15: DAILY MODE SPLIT, MUMBAI METROPOLITAN REGION

Vehicle type	2017 (CTS Updation)	
	Trips per day (million)	Motorized Mode split
Metro & Mono	0.41	2.2%
Suburban	8.11	43.2%
Bus	3.75	20.0%
Auto	0.95	5.1%
Taxi	1.63	8.7%
Two wheeler	2.43	12.5%
Car	1.59	8.5%
Total	**18.78**	**100%**
PV(car&2-wheeler)	3.94	20.9%
IPT(Taxi & Auto)	2.58	13.7%
PT(Bus, suburban,metro& mono)	12.27	65.3%
Total	**18.78**	**100%**

The following table summarises a comparison of mode-split within MMR assessed in 2005 (CTS for MMR Study) and that in 2017 (Update of CTS for MMR). It can be deduced that considerable mode split changes occurred over the previous decade, with public transportation's share decreasing from 78.1 percent to 65.3 percent, which is concerning. The main causes for the decrease in public transportation share might be attributed to a lack of speed in periodic capacity augmentations to the suburban rail system, delays in metro rail installation, increasing private car growth, increased journey time by the surface transportation system, and so on.

TABLE 3-16: DAILY MODE SPLIT, MUMBAI METROPOLITAN REGION COMPARISON: CTS FOR MMR STUDY (2005-08) AND CTS UPDATING STUDY (2017)2005 (CTS FOR MMR STUDY) CTS UPDATING STUDY (2017)

Vehicle type	2005 (CTS)		2017 (CTS Updation)	
	Trips per day (million)	Motorized Mode split	Trips per day (million)	Motorized Mode split
Metro & Mono			0.41	2.2%
Suburban	6.97	51.8%	8.11	43.2%
Bus	3.55	26.3%	3.75	20.0%
Auto	1.05	7.8%	0.95	5.1%
Taxi	0.22	1.7%	1.63	8.7%
Two wheeler	1.05	7.8%	2.43	12.5%
Car	0.62	4.6%	1.59	8.5%
Total	**13.447**	**100%**	**18.78**	**100%**
PV(car&2-wheeler)	1.67	12.4%	3.94	20.9%
IPT(Taxi & Auto)	1.27	9.5%	2.58	13.7%
PT(Bus, suburban,metro& mono)	10.52	78.1%	12.27	65.3%
Total	**13.475**	**100%**	**18.78**	**100%**

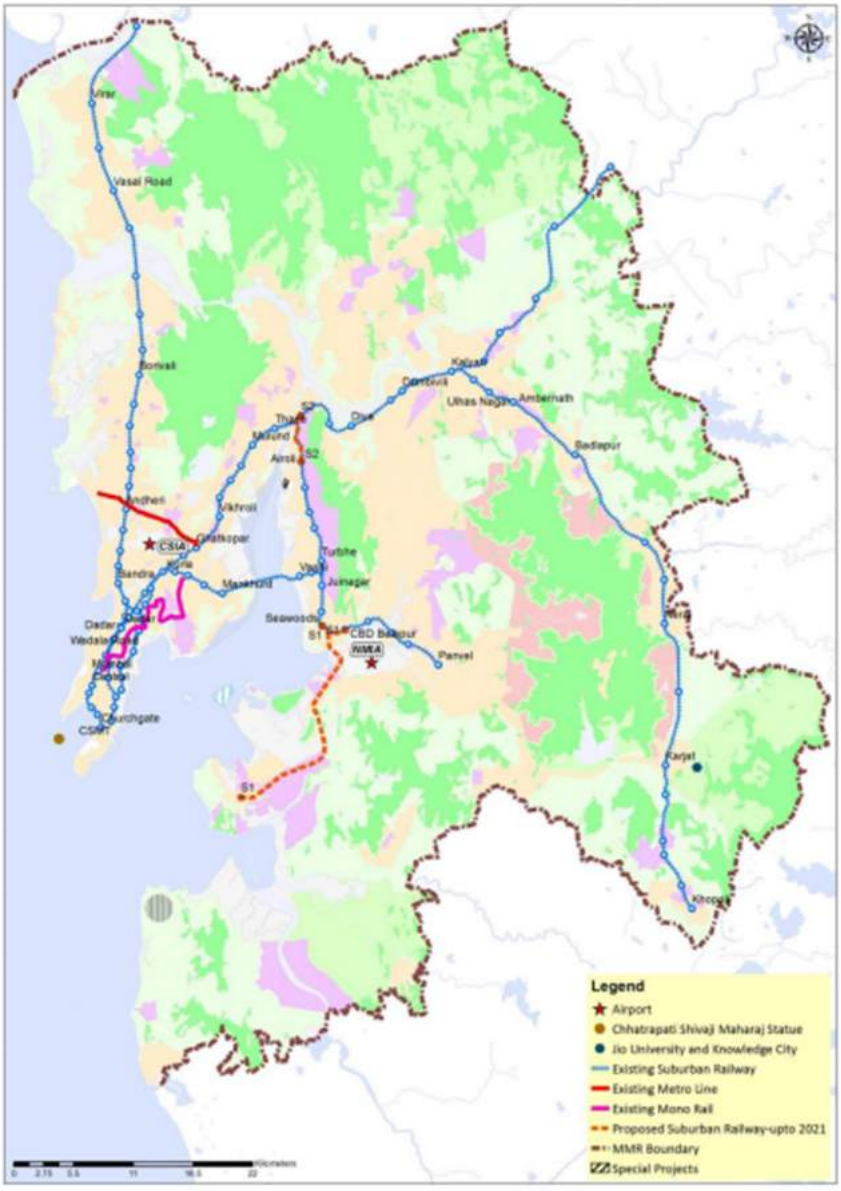
3.5.2.4 SUBURBAN NETWORK PLAN FOR MMR FOR THE HORIZON YEAR 2021

Suburban network (additional corridors) for the horizon year 2021 is shown in following table and figure. Total suburban network for 2021 is 28.9 km.

TABLE 3-17: SUBURBAN CORRIDORS IMPLEMENTATION FOR 2021

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	S-1	Seawoods to Uran	24.2	Under construction (Seawoods to Kharkopar:9km is already operational)	28.9 km
2	S-2	Airoli-Kalwa	4.7	Under Construct ion	

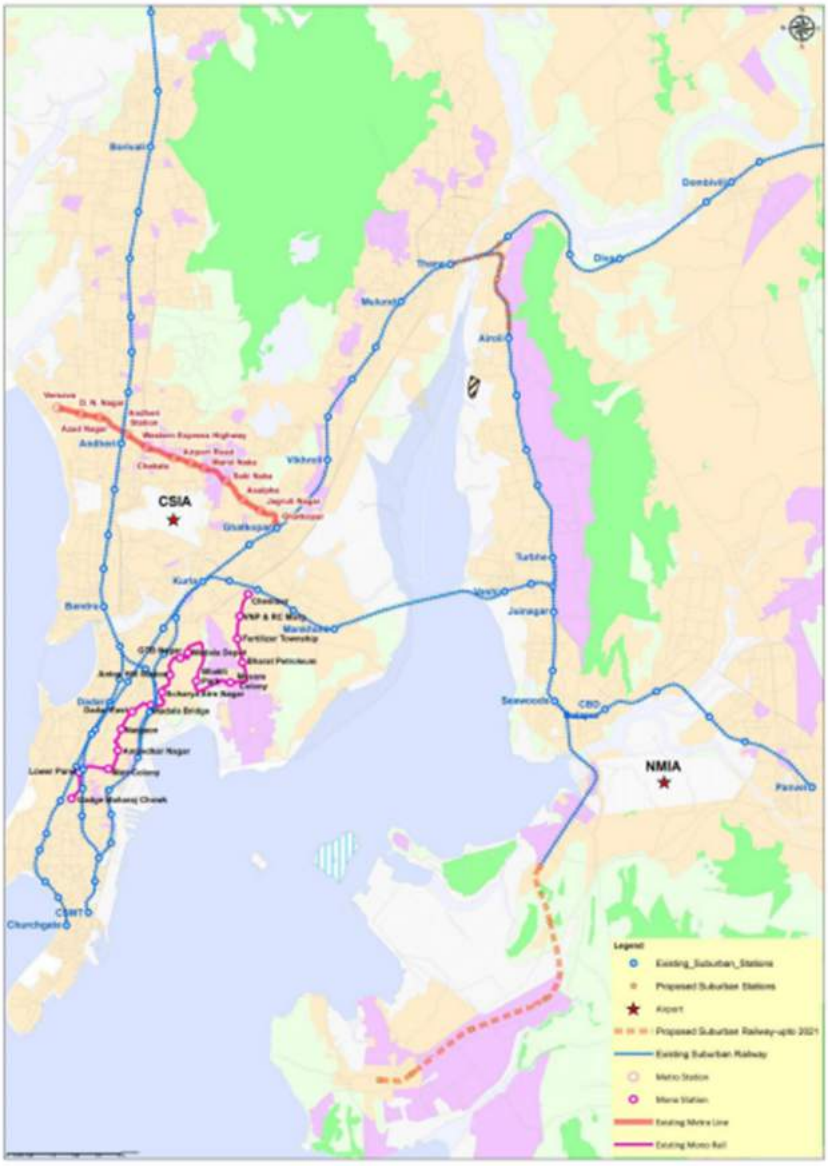
FIGURE 3-9: SUBURBAN CORRIDORS IMPLEMENTATION FOR 2021



3.5.2.5 MONORAIL CORRIDOR IMPLEMENTED BY 2021

The monorail corridor expansion from Wadala to Satrasta/Jacob Circle, is shown in the figure below, was completed and put into service in March 2019.

FIGURE 3-10: MONORAIL CORRIDORS IMPLEMENTATION FOR 2021



3.5.2.6 HIGHWAY NETWORK PLAN FOR MMR FOR HORIZON YEAR 2021

No major road/bridge projects have been begun in the recent 3 to 4 years, and construction work is still ongoing. However, flyovers, elevated roads, ROB/ Rub, and the expansion of several critical linkages have been built. Following tables and figure provide information on Flyovers, Elevated Roads, and Robs.

TABLE 3-18: FLYOVER IMPLEMENTED BY 2021

Sr.no.	ID	Name	Length(KM)
1	F-1	connector between Bandra Kurla Complex G Block and Eastern Express Highway including ROB at the level crossin on V.N. Purav Mar near Chunabhatti Station	1.69
2	F-2	2 lanes MeenataiThakary Chowk	1.37
3	F-3	A lmeida Chowk	0.75
4	F-4	SH-54	0.68
5	F-5	Mahatama Gandhi Road	0.54
6	F-6	Junction of SV road and GMLR	0.75
7	F-7	Junction of SV Road and Kora Kendra Road	0.54
8	F-8	6 lane divided Mankoli Flyover	1.14
9	F-9	Ranjoli Flyover	0.84
10	F-10	Bhiwandi Kalyan road (Rajiv Gandhi Chowk to Saibaba Temp le)	3.03
11	F-11	4 Lane Talavali Naka	1.61
12	F-12	Shilphata Mahape Road (SH-40) with four lane flyover at L&T Junction and Service Road.	0.67
13	F-13	Savita Chemicaljunction	0.72
14	F-14	AGLR Flyover	0.82
15	F-15	Uran Road	0.72
16	F-16	Bapne-Naigaon-Agashi Rd	0.21
17	F-17	Navade Phata and Kalamboli steelyard fly over	1.13

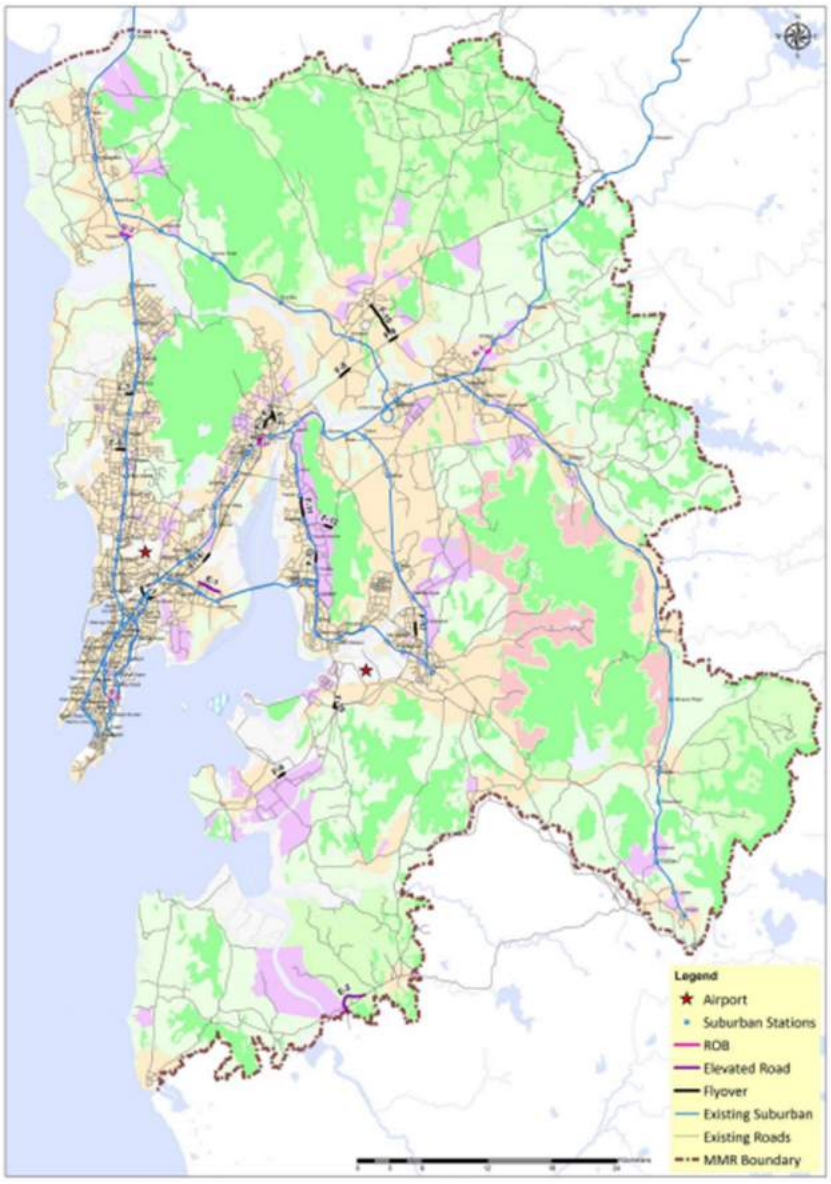
TABLE 3-19: ELEVATED ROADS IMPLEMENTED BY 2021

Sr.no.	ID	Name	Length(KM)
1	E-1	Ghatkopar Mankhurd Junction Shivaji Nagar Road	2.5
2	E-2	Alibag Khapoli Road to Mumbai Goa Road (Vadkhal Naka)	3.46

TABLE 3-20: ROBS IMPLEMENTED BY 2021

Sr.no.	ID	Name	Length(KM)
1	R-1	ROB at Titwala Amb ivaliJunction	0.48
2	R-2	6 lane divided Rail Over Bridge (ROB) at Kopari,Thane	0.48
3	R-3	4 lane Naigaon Railway stat ion and construction of Creek bridge I	1.33
4	R-4	Hancock Bridge	0.15

FIGURE 3-11: HIGHWAY NETWORK PLAN IMPLEMENTED BY 2021



3.5.2.7 METRO NETWORK PLAN FOR MMR FOR HORIZON YEAR 2026- SHORT TERM

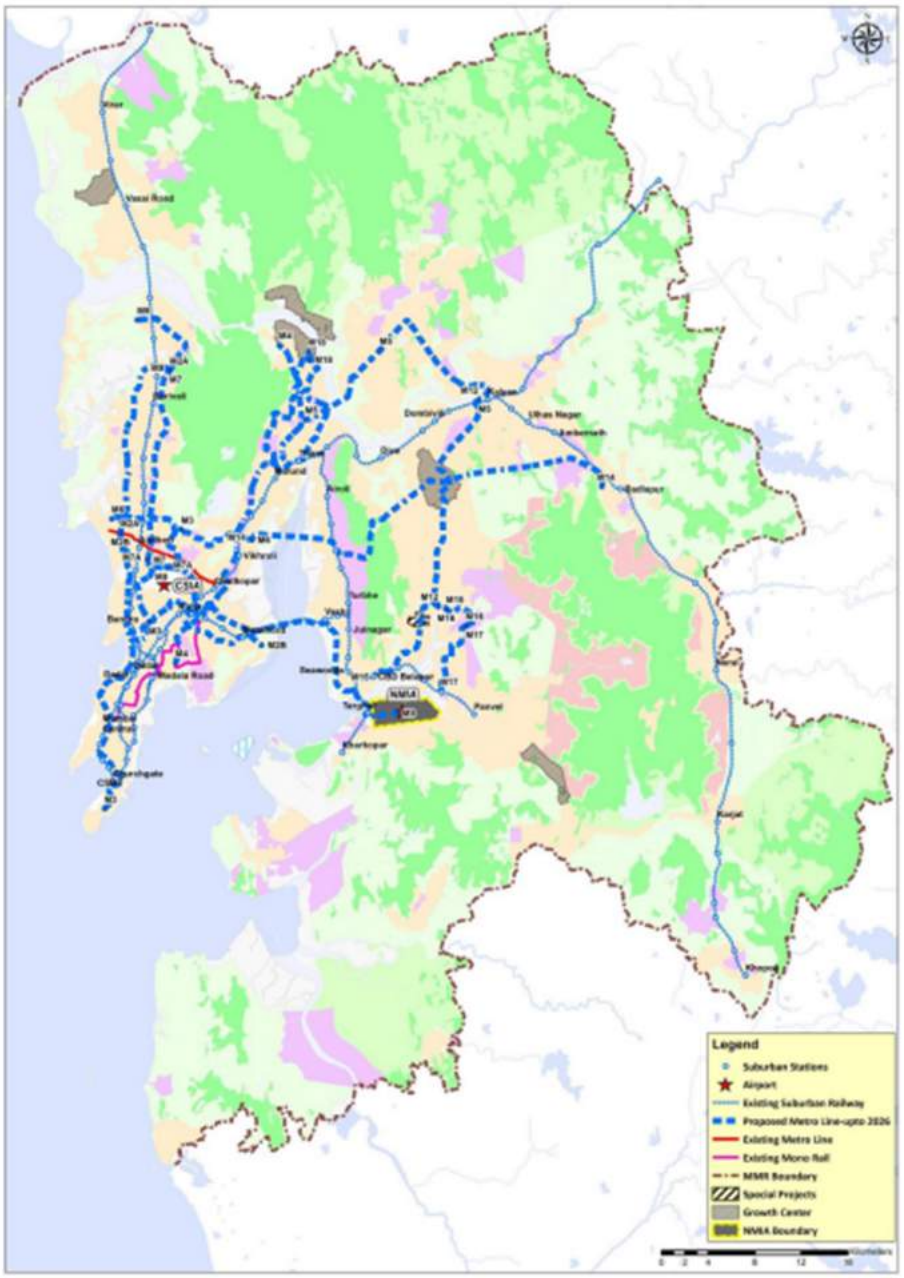
Metro network (additional corridors) for the horizon year 2026 is enlisted in following table and shown in the following figure. Total metro network length proposed for the year 2026 is 322.5 km.

TABLE 3-21: PROPOSED METRO CORRIDORS FOR HORIZON YEAR 2026

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	M-2A	Dahisar - ON Nagar - (UC)	18.6	Under construction	2022-2026 (322.5 km)
2	M-3	Colaba-Bandra - SEEPZ (UC)	33.2	Under construction	
3	M-2B	D.N. Nagar - Mandale - Cheeta Camp (UC)	23.6	Under construction	
4	M-4	Wadala -Kasarvadvali-Gaimukh - (UC)	35.0	Under construction	
5	M-5	Thane-Bhiwandi-Kalyan - (UC)	24.9	Under construction	
6	M-6	Swami Samarth Nagar - Vikhroli- (UC)	14.5	Under construction	
7	M-7	Dahisar (E) - Andheri (E) - (UC)	16.5	Under construction	
8	M-7A	Andheri East To CSIA Airport - (DPR C)	3.2	Under construction	
9	M-8	Airport Metro (CSIA - NMIA) (DPR UP)	35.0	DPR in progress	
10	M-9	Dahisar (E)- Mira Bhayandar - (UC)	10.3	Under construction	
11	M-12	Kalyan - Taloja (GA)	20.7	Govt. of Maharashtra Approved	
12	M-14	Kanjurmarg-Badlapur (DPR UP)	38.0	DPR in progress	
13	M-15	Belapur -Taloja- Pendhar - (UC)	11.1	Under construction	

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
14	M-16	Pendhar to MIDC - (UC)	2	Under construction	
15	M-17	MIDC- Khandeshwar - (DPR C)	7.2	DPR is completed	
16	M-18	Thane Ring Metro - (DPR C)	28.7	DPR is completed	

FIGURE 3-12: PROPOSED METRO CORRIDORS FOR HORIZON YEAR 2026



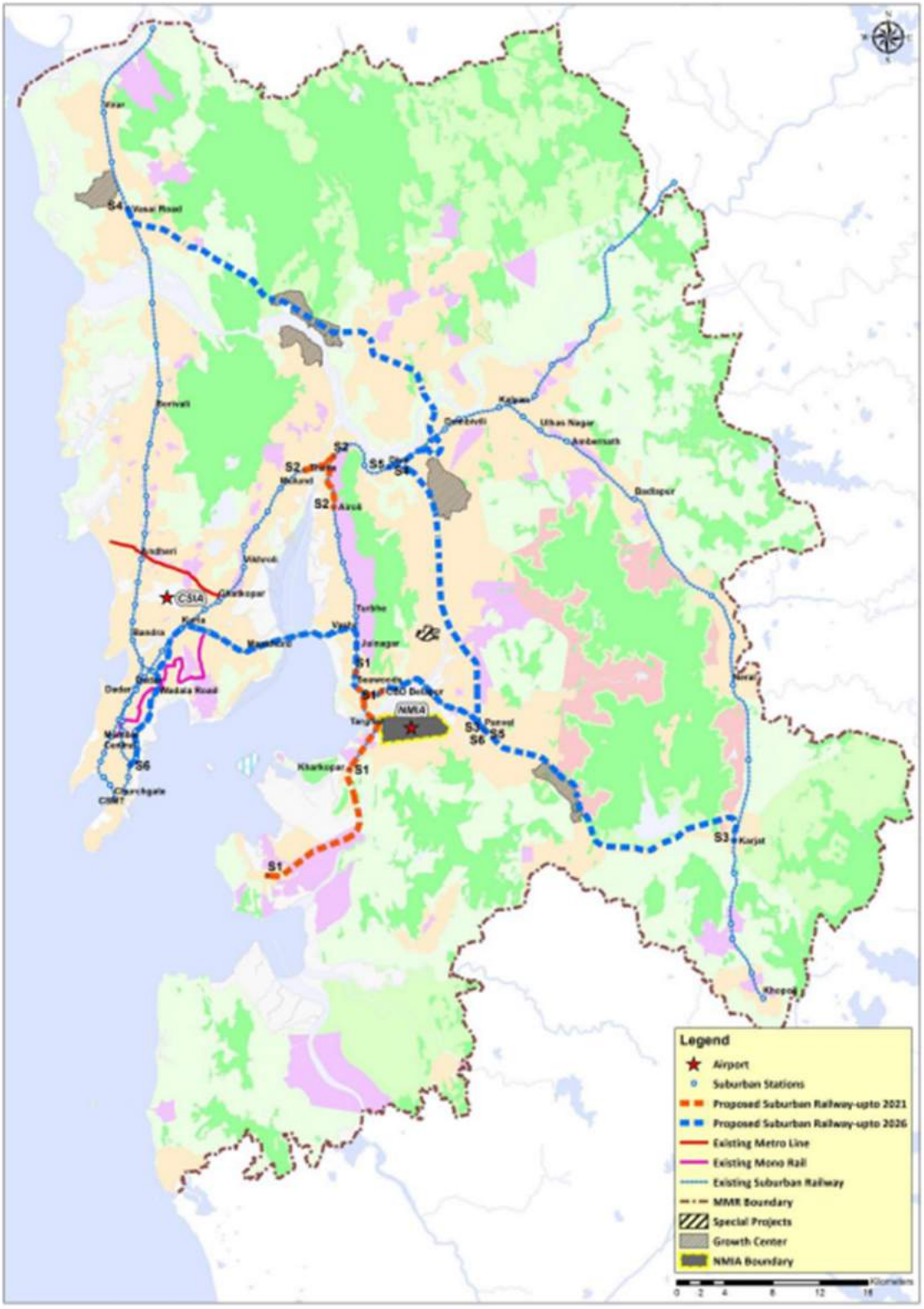
3.5.2.8 SUBURBAN NETWORK PLAN FOR MMR FOR HORIZON YEAR 2026- SHORT TERM

Suburban network (additional corridors) for the horizon year 2026 is enlisted in following table and shown in the following figure. Total proposed suburban network for the horizon year 2026 is 172.3 km.

TABLE 3-22: PROPOSED SUBURBAN CORRIDORS FOR HORIZON YEAR 2026

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	S-1	Seawoods to Uran	24.2	Under Construction (Seawoods to Kharko ar:9 km is alread under o eration)	Upto 2021 (28.9 km)
2	S-2	Airoli -Kalwa	4.7	Under Construction	
3	S-3	Panvel To Karjat	28.S	MRVC carried out DPR study and planned for implementation by 2025	2022-2026 (143.4 km)
4	S-4	Diva Vasai Road	41.5		
5	S-5	Diva Panvel	25.6		
6	S-6	CSMT to Panvel Fast Corridor	47.8	DPR is in progress	

FIGURE 3-13: PROPOSED SUBURBAN CORRIDORS FOR HORIZON YEAR 2026



3.5.2.9 HIGHWAY NETWORK PLAN FOR MMR FOR HORIZON YEAR 2026- SHORT TERM

The following figure represents the suggested highway/road network (additional corridors) for the year 2026. The projected road network for the horizon year 2026 is approximately 546.1 km, as shown in the table below. These planned highway/road routes are in addition to those considered for the Horizon Year 2021, such as highway/road widening, flyovers, elevated roads, and ROBs/ RUBs.

TABLE 3-23: PROPOSED HIGHWAYS/ ROAD CORRIDORS FOR HORIZON YEAR 2026

Sr.no.	ID	Name	Length(KM)	Status as on Sep 2021	Period
1	H1	Elevated Link (Sewri-Worli Sea Link)	5.0	Feasibility Completed	2022-2026 (546.1 km)
2	H2	MTHL	23.0	Under Construction	
3	H3	Multimodal Corridor (Virar to Alibag)	127.3	DPR in progress	
4	H4	Radial 3 (Mumbai Nashik Exp. NH3)	40.7	Proposed in CTSU	
5	H5	Radial-4 (Nahur-Airoli-Nilaj e-Badlapur)	35.2	Under Construction	
6	H6	Radial-S(Turbhe-Taloja-Usata ne)	17.1	DPR completed by CIDCO for (Turbhe to Taloj a)	
7	H7a	Mumbai-Vadodara Spur in MMR	84.8	Under Construction	
8	H7b	Mumbai-Vadodara Spur in MMR (Virar to Mira Road)	26.1	Under Construction	
9	H8	Thane-Ghodbunder	4.4	Proposed in CTSU	
10	H9	Western Sea Link North Extn (Bandra-Versova)	12.3	DPR completed by MSRDC	
11	H10	Coastal Road to Ambivali(MMC)	17.6	Proposed in CTSU	
12	H11	Goregaon Mulund Link Road	16.1	DPR completed by MCGM	
13	H12	Khopolito Pen	31.9	Proposed in RP	
14	H13	CIDCO Coastal Road	10.0	DPR completed by CIDCO	
15	H14	Mankhurd to NMIA	18.4	Proposed in CTSU	
16	H15	Kalyan Ring Road	30.9	Under Construction	

Sr.no.	ID	Name	Length(KM)	Status as on Sep 2021	Period
17	H16	Thane Coastal Road (Gaimukh to Saket)	11.0	DPR completed by TMC	
18	H17	Panvel Matheran Road	10.2	Proposed in CTSU	
19	H18	Nariman Point to Colaba	1.3	Feasibility is in progress	
20	H19	Anand Nagar Toll Naka (Kopri) to Saket Road	6.3	Proposed in TIA Thane	
21	H20	Kalyan to Bapgaon	2.4	Proposed in TIA Thane	

FIGURE 3-14: PROPOSED HIGHWAYS/ ROAD CORRIDORS FOR HORIZON YEAR 2026

3.5.2.10 METRO NETWORK PLAN FOR MMR FOR HORIZON YEAR 2031- - MEDIUM TERM

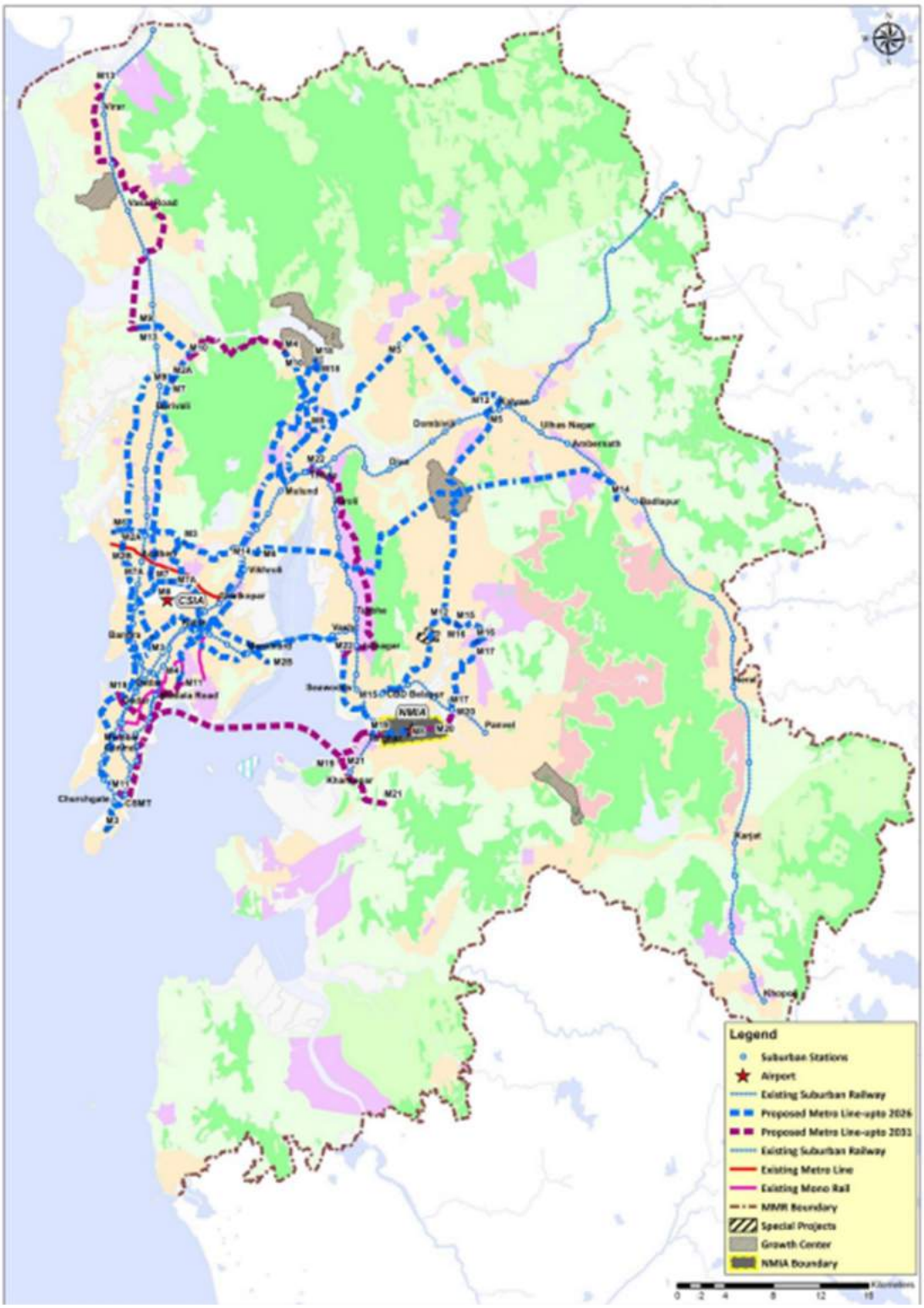
Metro network (additional corridors) for the horizon year 2032 is enlisted in following table and shown in the following figure. Total metro network length proposed for the year 2031 is 423.2 km.

TABLE 3-24: PROPOSED METRO CORRIDORS FOR HORIZON YEAR 2031

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	M-2A	Dahisar - ON Nagar - (UC)	18.6	Under construction	2022-2026 (322.S km)
2	M-3	Colaba-Bandra - SEEPZ (UC)	33.2	Under construction	
3	M-2B	D.N. Nagar - Mandale - Cheeta Camp (UC)	23.6	Under construction	
4	M-4	Wadala - Kasarvadva li-Gaimukh - (UC)	35.0	Under construction	
5	M-5	Thane-Bhiwandi-Kalyan - (UC)	24.9	Under construction	
6	M-6	Swami Samarth Nagar - Vikhroli - (UC)	14.S	Under construction	
7	M-7	Dahisar (E) - Andher i (E) - (UC)	16.S	Under construction	
8	M-7A	Andher i East To CSIA Airport - (DPR C)	3.2	Under construction	
9	M-8	Airport Metro (CSIA - NMIA) (DPR UP)	35.0	DPR in progress	
10	M-9	Dahisar (E)- Mira Bhayandar - (UC)	10.3	Under construction	

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
11	M-12	Kalyan - Taloja (GA)	20.7	Govt. of Maharashtra Approved	
12	M-14	Kanjurmarg-Badlapur (DPR UP)	38.0	DPR in progress	
13	M-15	Belapur -Taloja-Pendhar - (UC)	11.1	Under construction	
14	M-16	Pendhar to MIDC - (UC)	2	Under construction	
15	M-17	MIDC-Khandeshwar - (DPR C)	7.2	DPR is completed	
16	M-18	Thane Ring Metro - (DPR C)	28.7	DPR is completed	
17	M-11(M 4 Ext)	Wadala-CSMT - (GA)	12.7	Govt. of Maharashtra Approved	2027-2031 (100.7 km)
18	M-19	Prabhadevi-Sewri - NMIA (MTHL) - (DPR C)	26.S	DPR is completed	
19	M-13	Shivaji Chowk (Mira Road) - Virar (DPR UP)	23.0	DPR in progress	
20	M-10	Gaimukh to Shivaji Chowk (Mira Road) - (GA)	9.2	Govt. of Maharashtra Approved	
21	M-20	Khandeshwar to NMIA - (DPR C)	3.7	DPR is completed	
22	M-21	MTHL Spur to Jambhulpada - (DPR C)	5.0	DPR is completed	
23	M-22	Thane to Juinagar	20.6	Proposed in CTSU	

FIGURE 3-15: PROPOSED METRO CORRIDORS FOR HORIZON YEAR 2031



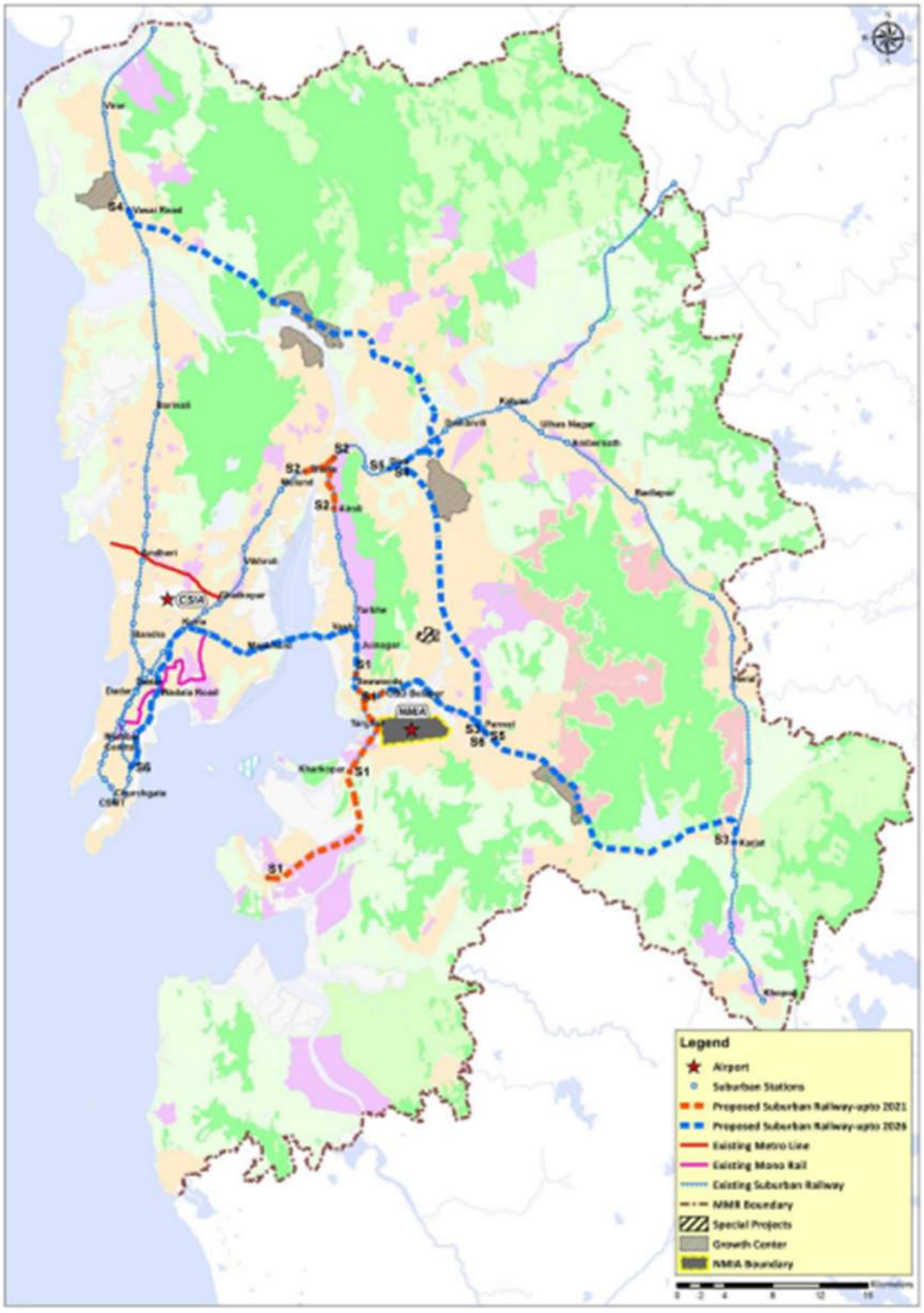
3.5.2.11 SUBURBAN NETWORK PLAN FOR MMR FOR HORIZON YEAR 2031- MEDIUM TERM

Suburban network (additional corridors) for the horizon year 2031 is enlisted in following table and shown in the following figure. Total proposed suburban network for the horizon year 2031 is 172.3 km.

TABLE 3-25: PROPOSED SUBURBAN CORRIDORS FOR HORIZON YEAR 2031

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	S-1	Seawoods to Uran	24.2	Under Construction (Seawoods to Kharkopar: 9 km is already under operation)	"Upto 2021 (28.9 km)"
2	S-2	Airoli -Kalwa	4.7	DPR completed	
3	S-3	Panvel To Karjat	28.S	MRVC carried out DPR study and planned for implementation by 2025	"2022-2026 (143.4 km)"
4	S-4	Diva Vasai Road	41.S		
5	S-5	Diva Panvel	25.6		
6	S-6	CSMT to Panvel Fast Corridor	47.8	DPR is in progress	

FIGURE 3-16: PROPOSED SUBURBAN CORRIDORS FOR HORIZON YEAR 2031



3.5.2.12 METRO NETWORK PLAN FOR MMR FOR HORIZON YEAR 2041- - LONG TERM

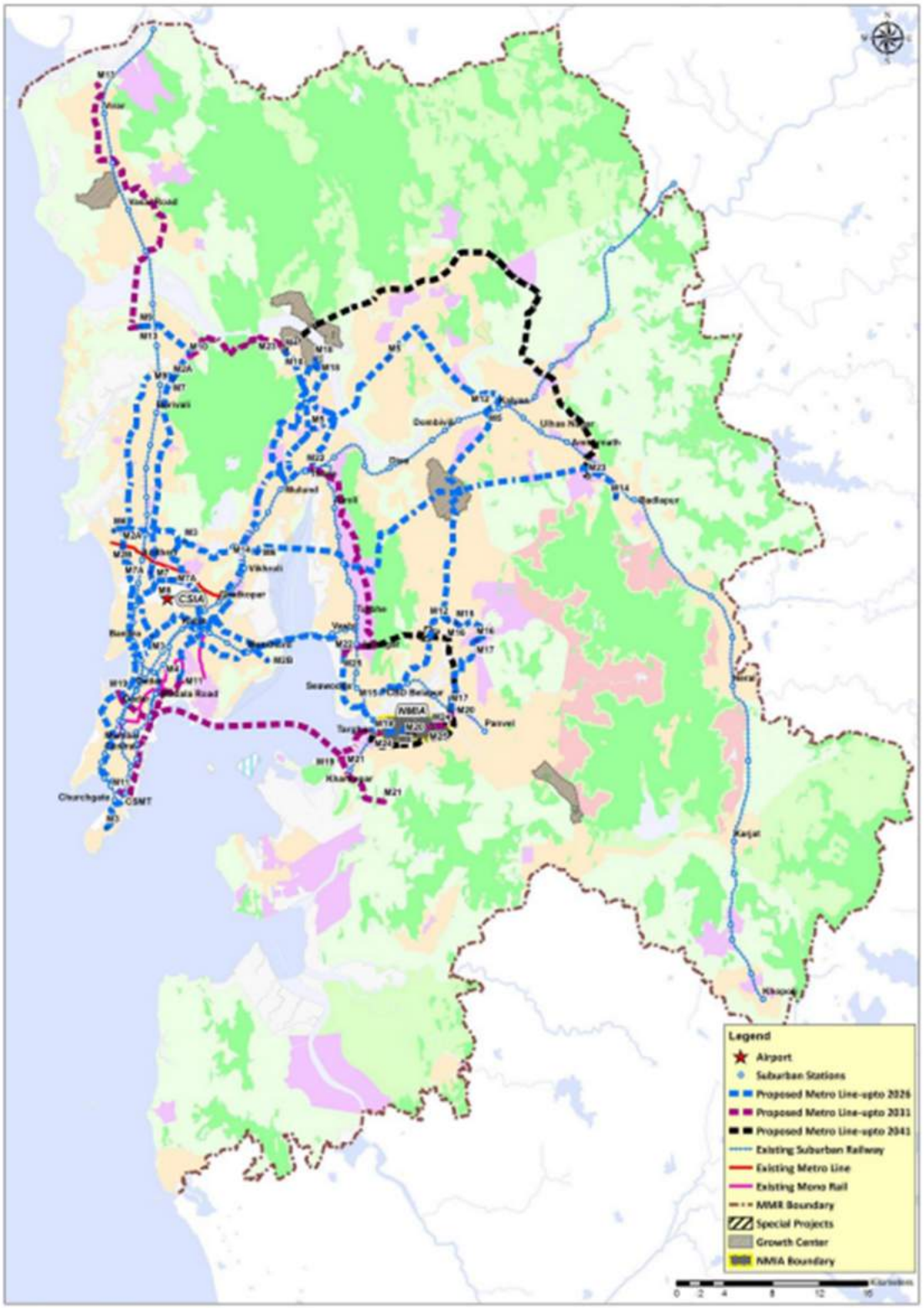
Metro network (additional corridors) for the horizon year 2032 is enlisted in following table and shown in the following figure. Total metro network length proposed for the year 2031 is 487.3 km.

TABLE 3-26: PROPOSED METRO CORRIDORS FOR HORIZON YEAR 2041

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	M-2A	Dahisar - DN Nagar - (UC)	18.6	Under construction	2022-2026 (322.5 km)
2	M-3	Colaba-Bandra - SEEPZ (UC)	33.2	Under construction	
3	M-2B	D.N. Nagar - Mandale - Cheeta camp (UC)	23.6	Under construction	
4	M-4	Wada la -Kasarvadvali-Gaimukh - (UC)	35.0	Under construction	
5	M-5	Thane-Bhiwandi - Kalyan - (UC)	24.9	Under construction	
6	M-6	Swami Samarth Nagar - Vikhroli - (UC)	14.5	Under construction	
7	M-7	Dahisar (E) - Andheri(E) - (UC)	16.5	Under construction	
8	M-7A	Andher iEast To CSIA Airport - (DPR CJ	3.2	Under construction	
9	M-8	Airport Metro (CSIA - NMIA) (DPR UP)	35.0	DPR in progress	
10	M-9	Dahisar (E)- Mira Bhayandar - (UC)	10.3	Under construction	
11	M-12	Kalyan - Taloja (GA)	20.7	Govt. of Maharashtra Approved	
12	M-14	Kanjurmarg-Badlapur (DPR UP)	38.0	DPR in progress	
13	M-15	Belapur - Taloja-Pendhar - (UC)	11.1	Under construction	

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
14	M-16	Pendhar to MIDC - (UC)	2	Under construction	
15	M-17	MIDC- Khandeshwa r - (DPR CJ	7.2	DPR is completed	
16	M-18	Thane Ring Metro - (DPR CJ	28.7	DPR is completed	
17	M-11 (M 4 Ext)	Wada la-CSMT - (GA)	12.7	Govt. of Maharashtra Approved	2027-2031 (100.7 km)
18	M-19	Prabhadev i-Sewri-NMIA (MTHL) - (DPR CJ	26.5	DPR is completed	
19	M-13	Shivaji Chowk (Mira Road) - Virar (DPR UP)	23.0	DPR in progress	
20	M-10	Gaimukh to Shivaji Chowk (Mira Road) - (GA)	9.2	Govt. of Maharashtra Approved	
21	M-20	Khandeshwa r to NMIA - (DPR CJ	3.7	DPR is completed	
22	M-21	MTHL Spur to Jambhulpada - (DPR CJ	5.0	DPR is completed	
23	M-22	Thane to Juinagar	20.6	Proposed in CTSU	
24	M-23	Kasarvadaval i-Ambernath	41.4	Proposed in CTSU	2032-2041 (64.1km)
25	M-24	Khandeshwar-Aerocity-Targhar	9.9	Proposed in Aeroc ity CIDCO	
26	M-25	Juinagar- NMIA Eastern Entry via ICP	12.8	Proposed in Aeroc ity CIDCO	

FIGURE 3-17: PROPOSED METRO CORRIDORS FOR HORIZON YEAR 2041



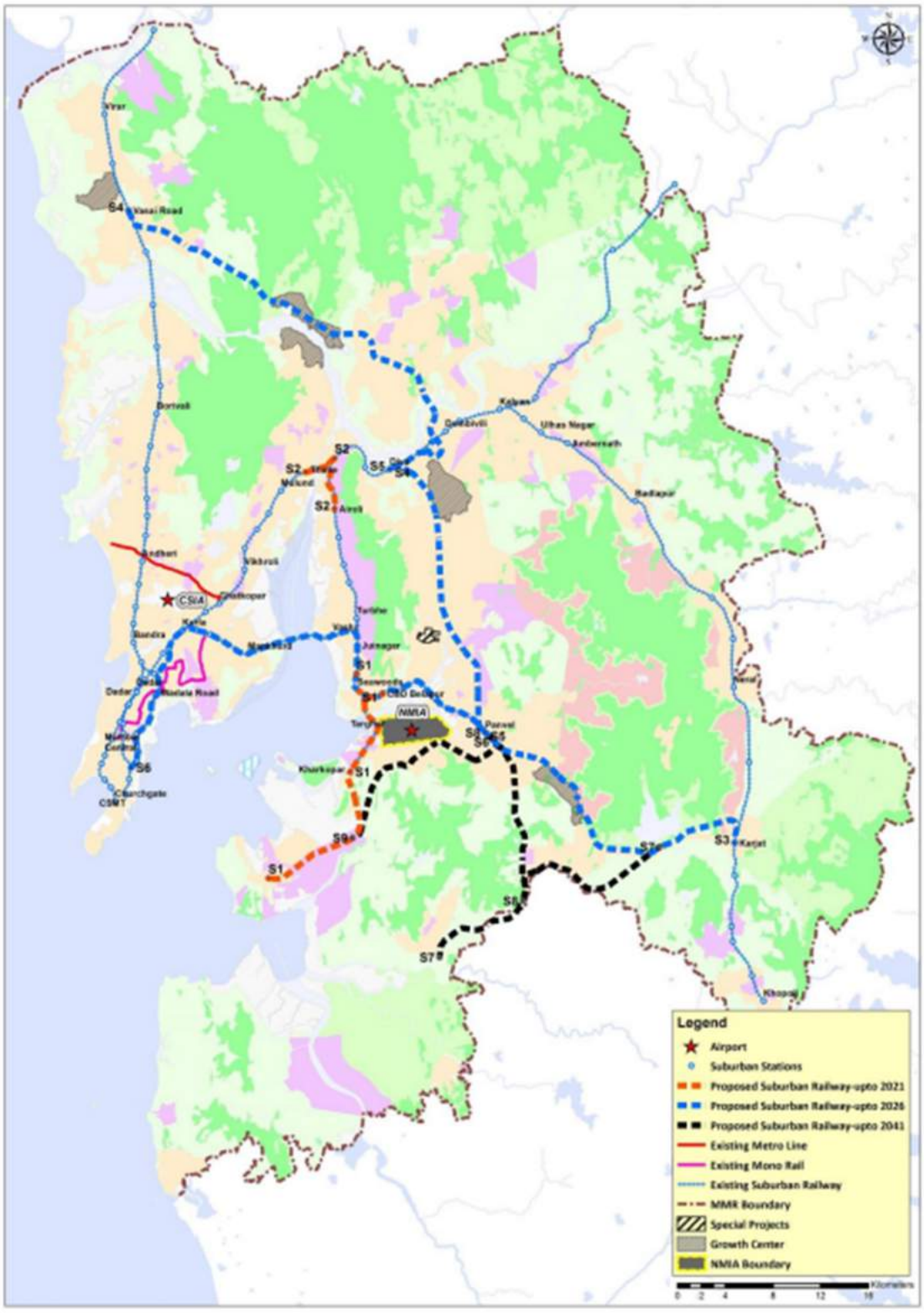
3.5.2.13 SUBURBAN NETWORK PLAN FOR MMR FOR HORIZON YEAR 2041- LONG TERM

Suburban network (additional corridors) for the horizon year 2041 is enlisted in following table and shown in the following figure. Total proposed suburban network for the horizon year 2041 is 232 km.

TABLE 3-27: PROPOSED SUBURBAN CORRIDORS FOR HORIZON YEAR 2041

Sr.no.	ID	Name	Length(KM)	Status as on Sep. 2021	Total Length
1	S-1	Seawoods to Uran	24.2	Under Construction (Seawoods to Kharkopar : 9 km is already under operation)	Upto 2021 (28.9 km)
2	S-2	Airoli -Kalwa	4.7	Under Construction	
3	S-3	Panvel To Karjat	28.5	MRVC carried out DPR study and planned for implementation by 2025	2022-2026 (143.4 km)
4	S-4	Diva Vasai Road	41.5		
5	S-5	Diva Panvel	25.6		
6	S-6	CSMT to Panvel Fast Corridor	47.8	DPR is in progress	
7	S-7	Chowk To Jite	25.1	Proposed in CTSU	2031-2041 (59.5 km)
8	S-8	Panvel To Apte	15.3	Proposed in CTSU	
9	S-9	Panvel To Ranjanpada	19.1	Proposed in CTSU	

FIGURE 3-18: PROPOSED SUBURBAN CORRIDORS FOR HORIZON YEAR 2031



3.5.2.14 HIGHWAY NETWORK PLAN FOR MMR FOR HORIZON YEAR 2031- MEDIUM TERM

The anticipated road network for the year 2031 is approximately 714.2 km, as shown in following table 6-22. These planned highway/road routes are in addition to those considered for the Horizon Year 2021, such as highway/road widening, flyovers, elevated roads, and ROBs/ RUBs. Following figure depicts the suggested Highway Network for the year 2031.

TABLE 3-28: PROPOSED HIGHWAYS/ ROAD CORRIDORS FOR HORIZON YEAR 2031

Sr.no.	ID	Name	Length(KM)	Status as on Sep 2021	Period
1	H1	Elevated Link (Sewri-WorliSea link)	5	Feasibility Completed	2022-2026 (546. km)
2	H2	MTHL	23.0	Under Construction	
3	H3	Multimodal Corridor (Virar to Alibag)	127.3	DPR in progress	
4	H4	Radial 3 Mumbai Nashik Ex .NH3	40.7	Pro osed in CTSU	
5	HS	Radial-4 (Nahur-Airoli-Nilaje-Badlapur)	35.2	Under Construction	
6	H6	Radial-S(Turbhe-Taloja-Usatane)	17.1	DPR completed by CIDCO for (Turbhe to Taloja}	
7	H7a	Mumbai-Vadodara Spur in MMR	84.8	Under Construction	
8	H7b	Mumbai-Vadodara Spur in MMR (Virar to Mira Road}	26.1	Under Construction	
9	H8	Thane-Ghodbunder	4.4	Proposed in CTSU	
10	H9	Western Sea link North Extn (Bandra-Versova)	12.3	DPR completed by MSRDC	
11	H1O	Coastal Road to Ambivali (MMC)	17.6	Proposed in CTSU	
12	H11	Goregaon Mulund link Road	16.1	DPR completed by MCGM	
13	H12	Kho olito Pen	31.9	Pro osed in RP	
14	H13	CIDCO Coastal Road	10.0	DPR completed by CIDCO	
15	H14	Mankhurd to NMIA	18.4	Proposed in CTSU	
16	H15	Kalyan Ring Road	30.9	Under Construction	

Sr.no.	ID	Name	Length(KM)	Status as on Sep 2021	Period
17	H16	Thane Coastal Road (Gaimukh to Saket)	11.0	DPR completed by TMC	
18	H17	Panvel Matheran Road	10.2	Proposed in CTSU	
19	H18	Nariman Point to Colaba	1.3	Feasibility is in progress	
20	H19	Anand Nagar Toll Naka (Kopri) to Saket Road	6.3	Proposed in TIA Thane	
21	H20	Kalyan to Bapgaon	2.4	Proposed in TIA Thane	
22	H21	Hindu Hurudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg	14.1	Under Construction	
23	H22	Kan·urmar - Ko arkairane Creek Brid e	7.7	Proposed in RP	2027-31 (168. km)
24	H23	Western Sea link South Extn (Worli-Marine Lines)	10.4	Under Construction	
25	H24	Coastal Road (Thane to Sanpada}	20.2	Proposed in CTSU	
26	H25	Spine Corridor in NAINA	43.1	Proposed in NAINA DP	
27	H26	Coastal Road-Marve to Ghodbunder	29.7	Proposed in RP	
28	H27	Western Sea link North Extn (Versova-Kandivali)	9.6	Proposed in CTSU	
29	H28	Radial-2 (Part of NH-3) Ghodbunder to Vadape	20.5	Proposed in RP	
30	H29	Extension of Eastern freeway (Chedda Nagar to Kopri)	14.0	Proposed in TIA Thane	
31	H30	Kolshet to Kalher Bhiwandi	2.4	Proposed in TIA Thane	
32	H31	BorivaliThane Tunnel	10.5	DPR in progress	

FIGURE 3-19: PROPOSED HIGHWAYS/ ROAD CORRIDORS FOR HORIZON YEAR 2031

3.5.2.15 HIGHWAY NETWORK PLAN FOR MMR FOR HORIZON YEAR 2041- LONG TERM

The anticipated road network for the year 2041 is approximately 818.9 km, as shown in following table 6-22. These planned highway/road routes are in addition to those considered for the Horizon Year 2021, such as highway/road widening, flyovers, elevated roads, and ROBs/ RUBs. Following figure depicts the suggested Highway Network for the year 2031.

TABLE 3-29: PROPOSED HIGHWAYS/ ROAD CORRIDORS FOR HORIZON YEAR 2041

Sr.no.	ID	Name	Length(KM)	Status as on Sep 2021	Period
1	H1	Elevated Link (Sewri - Worli Sea Link}	5.0	Feasibility Completed	2022-2026 (546.1 km)
2	H2	MTHL	23.0	Under Construction	
3	H3	Multimodal Corridor (Virar to Alibag)	127.3	DPR In progress	
4	H4	Radial3 (Mumbai Nashik Exo.NH3}	40.7	Proposed in CTSU	
5	HS	Radial-4 (Nahur-Alroli-Nilaje-Badlapur}	35.2	Under Construction	
6	HG	Radial-5(Turbhe-Taloja-Usatane)	17.1	DPR completed by CIDCO for (Turbhe to Taloja)	
7	H7a	Mumbai-Vadodara Spur in MMR	&4.8	Under Construction	
8	H7b	Mumbai-Vadodara Spur in MMR (Virar to Mira Rd.)	26.1	Under Construction	
9	H8	Thane-Ghodbunder	4.4	Proposed In CTSU	
10	H9	Western Sea Link North Extn (Bandra-Versova)	12.3	DPR completed by MSRDC	
11	H10	Coastal Road to Ambivali (MMC)	17.6	Proposed In CTSU	
12	H11	Goregaon Mulund Link Road	16.1	DPR completed by MCGM	
13	H12	Khopoli to Pen	31.9	Proposed In RP	
14	H13	CIDCO Coastal Road	10.0	DPR completed by CIDCO	
15	H14	Mankhurd to NMIA	18.4	Proposed In CTSU	
16	H15	Kalyan Ring Road	30.9	Under Construction	
17	H16	Thane Coastal Road (Gaimukh to Saket)	11.0	DPR completed by TMC	
18	H17	Panvel Matheran Road	10.2	Proposed In CTSU	

Sr.no.	ID	Name	Length(KM)	Status as on Sep 2021	Period
19	H18	Nariman Point to Colaba	1.3	Feasibility Is In progress	
20	H19	Anand NaRar Toll Naka (Kopri) to Saket Road	6.3	Proposed in TIA Thane	
21	H20	Kalyan to Bapgaon	2.4	Proposed in TIA Thane	
22	H21	Hindu Hurudaysamrat Balasaheb Thackeray Maharashtra Samruddhi Mahamarg	14.1	Under Construction	
23	H22	Kanjurmarg - Koparkairane Creek Bridge	7.7	Proposed in RP	
24	H23	Western Sea Link South Extn (Worli-Marine Lines)	10.4	Under Construction	
25	H24	Coastal Road (Thane to Sanpada}	20.2	Proposed in CTSU	
26	H25	Spine Corridor in NAINA	43.l	Proposed In NAINA DP	
27	H26	Coastal Road-Marve to Ghodbunder	29.7	Proposed in RP	
28					2027-31(168.1 km)
29	H27	Western Sea Link North Extn (Versova-Kandivali}	9.6	Proposed In CTSU	
30					
31	H28	Radial-2 (Part of NH-3} Ghodbunder to Vadape	20.5	Proposed in RP	
32	H29	Extension of Eastern freewav (Chedda Nagar to Kopri)	14.0	Proposed in TIA Thane	
33	H30	Kolshet to Kalher Bhiwandi	2.4	Proposed in TIA Thane	
34	H31	Borivali Thane Tunnel	10.5	DPR in progress	
35	H32	Radial-1(NH-8}	28.4	Proposed in CTSU	
36	H33	Belapur to MMC (Taloja MIDC)	17.2	Proposed in CTSU	
37	H34	Vichumbe(Panvel) To MMC	11.4	Proposed in NAINA DP	
38	H35	Dahisar-Virar	36.8	Proposed in RP	2032-41 (104.7 km)
39	H36	Extension of Coastal Road from Old Agra Road to Mulund toll naka	7.8	Proposed in TIA Thane	
40	H37	Kopari Patni Bridge	3.1	Proposed in TIA Thane	

FIGURE 3-20: PROPOSED HIGHWAYS/ ROAD CORRIDORS FOR HORIZON YEAR 2041

4 METHODOLOGY ADOPTED FOR STUDY

4.1 GENERAL

Alignment selection methodology is based on the five aspects, viz. Engineering, Environment, Social, Traffic and Road Usability.

4.1.1 COLLECTION AND REVIEW OF SECONDARY DATA

The secondary data required for the development of study was collected from various sources primarily from MMRDA. The secondary data includes:

- CTS & CTS UPDATION for MMR,
- Details of Proposed/Ongoing Infrastructure Projects in and around the project corridor. The data collected was reviewed to understand the project and the project influenced areas.

4.1.2 RECONNAISSANCE SURVEY

The detailed ground reconnaissance was undertaken by TUSPL's team and BMC's officers. Identified alignment was visited to carry out ground reconnaissance survey. The data collected from the reconnaissance survey has been done for planning and programming the detailed surveys and investigations. All field studies were undertaken on the basis of information derived from the reconnaissance surveys.

4.1.3 FIELD INVESTIGATIONS

The field investigations were conducted on the approved alignment. Following surveys have been conducted in the area:

- Stage 1:
    i. Topography Survey,
    ii. Bathymetry Survey,
    iii. Geo-technical investigation,

Various permits necessary for carrying out Engineering surveys and investigations were obtained. The process of obtaining such permissions was taken up immediately after project inception.

4.1.4 DESIGN STANDARDS AND METHODOLOGY

Primary objective is to design the project road as per the recommendations provided in the Indian Road Congress (IRC) guidelines and International best practices. Proposed design standards for the project road were presented at inception stage of the project and approved from BMC.

5 DESIGN STANDARDS AND SPECIFICATIONS

5.1 GENERAL

This section describes the design standards and principles based on which the various designs are carried out at this stage and will be done in the DPR stage. These proposed standards are consistent with the parameters recommended in the relevant standards of the Indian Roads Congress (IRC). The aim of this chapter is to evolve Design Standards and Material Specifications for the study primarily based on IRC publications and MoRTH circulars and relevant recommendations from the international standards and to recommend the same for concurrence/approval of MoRTH.

5.2 DESIGN SPEED

Design speed is the basic parameter, which governs the geometric characteristics of the road. The design speed for different terrain categories given in Table 5.1 as per IRC: 86-2018 are as follows:

TABLE 5-1: DESIGN SPEED AS PER IRC-86-2018

Class of Urban Road	Plain Terrain	Rolling Terrain
Urban Expressway	80	70
Arterial Road	60	50
Sub-arterial Road	60	50
Collector Street	40	40
Local Street	30	30

As the project road is urban expressway, design speed is proposed as 80 kmph.

The design speed for loop/ramps varies between 40-50 kmph and it is reduced to 30 kmph with respect to site constraints.

5.3 RIGHT - OF – WAY (ROW)

The recommended minimum right of way in Plain and Rolling terrain for urban expressway as per IRC: 86-2018 are as follows.

TABLE 5-2: RIGHT OF WAY IN PLAIN / ROLLING TERRAIN

Section	Right of Way Width*(ROW)
Plain	45 - 75
Rolling	35 - 60

For this project, proposed RoW is as below:

RoW of 45.0m is as proposed by BMC. Additional land for junction improvement locations shall be acquired as per design. No service roads shall be provided with in the ROW of the expressway.

5.4 LANE WIDTH OF CARRIAGEWAY

The standard lane width shall be 3.50m as per IRC: 86-2018.

5.5 MEDIAN

Absolute minimum width of median in urban areas is 1.2 m; a desirable minimum width is 5 m is recommended as per IRC: 86-2018. In Bridge section, width of median is increased to 9.0m.

5.5.1 SIDE STRIPS

Side strips on both sides of the main carriageway with flexible pavement is proposed. The proposed with of side strips shall be as per drawings.

5.5.2 CROSS FALL

The cross fall or camber for carriageway shall be as per IRC: 86-2018 as given below. Each carriageway shall have unidirectional cross fall.

TABLE 5-3: CROSSFALL ON DIFFERENT SURFACES

Cross-Sectional Element	Camber	
	Light Rainfall Area	Heavy Rainfall Area
Thin Bituminous Surfacing	2.0 percent	2.5 percent
Heavy Bituminous Surfacing or cement concrete surfacing	1.7-2.0 percent	2.0-2.5 percent

Proposed camber for project road is 2.5%. The cross fall for earthen/granular shoulders on straight portions shall be at least 0.5 percent steeper than the values given in Table 5.3. On super elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse cross fall so that the earth does not drain on the carriageway and the storm water drain out with minimum travel path.

5.6 HORIZONTAL ALIGNMENT

Alignment shall be fluent and blend with the topography. The horizontal curves shall be designed to have largest practical radius and shall consist of circular portion flanked by spiral transitions at both ends. The minimum radius of curves proposed along the alignment of Coastal Road which is an Urban Road, is not less than 230m. Other relevant design parameters are referred from IRC: 38.

5.6.1 SUPER ELEVATION

The minimum radius of curves proposed along the alignment of Coastal Road which is an Urban Road, is not less than 230m and hence super elevation required for the main carriageway with a design speed of 80kmph shall be restricted to 4.0% for the ease of construction.

5.6.2 SIGHT DISTANCE

The safe stopping distance (SSD) and Intermediate sight distance (ISD) for both horizontal and vertical directions will apply in design. The sight distance values as per IRC SP: 86-2018 recommendations are as follows:

TABLE 5-4: SAFE SIGHT DISTANCE

Design Speed (Km/hr)	Safe Stopping Sight Distance (m)	Desirable minimum Sight Distance (m) (Intermediate Sight Distance)
80	120	240

5.7 VERTICAL ALIGNMENT

The vertical alignment is design so as to provide for a smooth longitudinal profile. Grade changes are proposed not be too frequent as to cause kinks and visual discontinuities in the profile. Desirably there is no change in grade within a distance of 150m. The directions given in IRC: 73 and IRC: SP: 23 is complied.

Decks of small cross drainage structure (i.e. culverts or minor bridges) are proposed to follow the same profile as the flanking road section, without any break in the grade line. The aspect of efficient drainage is kept into consideration while designing vertical profile and cross-sections of the Project Road as stipulated in IRC: SP: 42 and IRC: SP: 50.

5.7.1 GRADIENTS

Vertical gradient has been limited to 3.5% as per IRC 92 2017 with desirable gradient is 2.5%. Minimum 0.5% gradient shall be ensured subjected to absolute minimum of 0.3%.

5.7.2 VERTICAL CURVES

Vertical curve design parameters are referred from IRC SP 23.

5.8 JUNCTION IMPROVEMENTS

Junction improvements are proposed at start on Dahisar Link Road and end on Uttan Road of the project road. The improvements are proposed so as to reduce detour considering regional network and nearness to places of importance.

6 ALIGNMENT STUDIES

6.1 GENERAL

The consultant worked out the best suited alignment from Link Road at Dahisar (West) to Mira Road (West) upto Subhash Chandra Bose ground at Bhayandar (West) with minimum land acquisition, less footprints in Mangrove areas.

6.1.1 ENGINEERING CONSTRAINTS

- Alignment passes through Creeks, Mangroves, Salt Pans, Urban areas, Agriculture land and Barren Land.

6.1.2 SOCIAL CONSTRAINTS

- Significant reduction in travel time is necessary.
- Project must also provide for speedy public transport.
- Alignment passing through Coastal Regulation Zones.
- Impacts of climate change and sea level rise.
- Land Availability.
- Aesthetic issues related to flyovers or any other road structures.
- Noise and air pollution due to fast moving, breaking and standing vehicles.

6.1.3 ENVIRONMENTAL CONSTRAINTS

The proposed D.P road starts from Dahisar Link Road and passes through dense Mangroves and cross the creek portion and traverse through salt pan in Bhayandar west. Presently, traffic moves at an average speed of 20 kmph due to heavy congestion on the existing surrounding road network like New Link Road and WEH. This has resulted in air and noise pollution. Noise levels in most parts of the city during day and night time have exceeded 65 decibels. This High level of noise pollution is resulting in long term impacts on citizens including degradation of mental health and loss of hearing. The air pollution which is of high levels also results in various diseases. There are very less green spaces and public areas. Every day public spent average time in commuting for work in overcrowded public transport. All these aspects have resulted in degradation of quality of life of the people living in this area.

Following are the Environment Constraints which should be considered:

- Alignment in CRZ/ coastal area
- Climate change/ sea level rise
- High pollution due to congestion
- Aesthetic and social aspects

6.1.4 FINANCIAL CONSTRAINTS

The following prime objectives are considered for selecting alignment options:

- Optimal use of existing infrastructure and land.
- Minimum Rehabilitation and Resettlement.
- Minimum impact on Mangroves and other environmentally sensitive areas.
- Integration with proposed/ongoing and existing Infrastructure.

6.2 PROJECT ALIGNMENT DESCRIPTION

The alignment starts from existing New Link Road and terminates at Uttan Road near Subhash Chandra Bose Ground. The alignment traverses through Salt Pans, Mangroves, and Crosses Metro line No. 9 at -grade level.

6.3 PROJECT SECTIONS

The components of alignment considering based on the terrain classification as detailed below:

Section No.	Type of Road/ Structure	Start Chainage	End Chainage	Length of Alignment (m)
Part 1 - Dahisar to Bhayandar				
1	Interchange at Dahisar : VIADUCT + RAMP	0	280	280
2	Road on Stilts in Mangroves	280	1450	1170
3	Road on Stilts in Mangroves	1450	1480	30
4	Elevated Road in Creek	1480	1580	100
5	Road on Stilts in Mangroves	1580	1700	120
6	Elevated Road in Creek	1700	1800	100
7	Road on Stilts in Mangroves	1800	1980	180
8	Elevated Road on Salt Pan	1980	3450	1470

9	Road on Stilts in Mangroves	3450	4110	660
10	Interchange at Bhyandar ; VIADUCT + RAMP	4110	4330	220
11	Interchange at Bhyandar ; VIADUCT + RAMP	4330	4580	250
Part 2 – Realignment of Dahisar Link Road				
1	Realignment of Dahisar Link Road	0	464	464

6.4 SALIENT FEATURES OF THE ALIGNMENT

Sr. No.	Feature	
1	Total length	4580m
	Within BMC Jurisdiction	1450m
	Within MBMC Jurisdiction	3130m
2	Lane configuration	4 + 4
3	Elevated length	3830m
4	At-grade length	750m
5	Proposed ROW	45m
6	Design Speed	80 kmph

7 PAVEMENT DESIGN

Design of Pavement has been carried out in accordance with IRC guidelines. The guidelines and recommendation given in IRC-58:2015 has been used for main carriageway with rigid pavement. Design of flexible pavement for side strips is carried out as per IRC 37 2018.

7.1 DESIGN PARAMETERS

7.1.1 DESIGN LIFE

The design life for the rigid pavement has been considered as 30 years in accordance with Clause 5.4 of IRC: 58-2015.

7.1.2 TRAFFIC GROWTH RATES

Traffic forecasting is made by use of economic models developed to co-relate past vehicle registration data, population growth and economic indicators such as Per Capita Income (PCI), Net State Domestic Product (NSDP) and Gross Domestic Product (GDP). By using the elasticity values obtained from the econometric models and the likely rate of growth of indicators, the mode wise growth rates are arrived at. Applying these growth rates, future traffic volume is estimated.

Estimated traffic growth rates are reproduced below in Table 7.1.

TABLE 7-1: ESTIMATED TRAFFIC GROWTH RATES

Year	Growth Scenario – Per Annum (%)
2018 -2023	7.00
2024 - 2028	6.00
2029– 2033	5.00
2034– 2038	4.00
2039 - 2049	4.00

However, as per the clause 5.5.2.1 of IRC: 58-2015, annual growth rate of commercial vehicles shall be taken to be a minimum of 5%.

7.1.3 ESTIMATED TRAFFIC IN CVPD

Design traffic, in terms of commercial vehicles per day (CVPD), has been estimated as 13,725 commercial vehicles per day (2022).

7.1.4 TEMPERATURE CONSIDERATION

The current project corridor is in coastal areas unbounded by hills. The temperature differential as per Table 1 of IRC: 58-2015 for Maharashtra has been considered for pavement design and the same is presented in Table 7.2.

TABLE 7-2: TEMPERATURE DIFFERENTIAL, ^{0}C IN SLABS

State	Max. Temperature Differential, ^{0}C in Slabs of Thickness			
	15 cm	20 cm	25 cm	30-40 cm
Maharashtra	17.3	19.0	20.3	21.0

7.1.5 MATERIAL CHARACTERISTICS

Characteristics of subgrade materials play a major role in the design of pavement. The effective / design CBR of subgrade soil is considered as 6% for the design.

7.2 MODULUS OF SUBGRADE REACTION

The strength of subgrade for design of rigid pavements is expressed in terms of modulus of subgrade reaction which is determined by plate load tests. Alternatively, modulus of subgrade reaction can be calculated from the effective/ design CBR of the subgrade as per IRC: 58- 2015 specifications.

The effective / design CBR of subgrade soil is considered as 6%. The relation between the CBR and k value as per Table 2 of IRC: 58-2015 is given in Table 7.3.

TABLE 7-3: RELATION BETWEEN 'K'VALUE AND CBR VALUE FOR HOMOGENOUS SOIL SUB-GRADE

Soaked CBR (%)	2	3	4	5	7	10	15	20	50	100
K - value (Mpa/m)	21	28	35	42	48	55	62	69	140	220

As per Table 2 of IRC: 58-2015, the modulus of subgrade reaction for effective subgrade CBR of 6% is 45 MPa/m.

The support below the concrete slab is represented by the effective modulus of subgrade reaction offered by combined influence of the subgrade and sub-base. A DLC sub base of 150 mm thickness is recommended. As per Table 4 of IRC: 58-2015 effective K values for concrete pavements laid over dry lean concrete layer are given in Table 7.4.

TABLE 7-4: K' VALUE FOR DRY LEAN CONCRETE SUB BASE

K- value of sub-grade (Mpa/m)	21	28	42	48	55	62
Effective K for 150 mm DLC, (Mpa/m)	97	138	208	277	300	300

7.3 PAVEMENT LAYER MATERIAL PARAMETERS

Rigid pavement consists of different layers of materials. Various pavement layers adopted in the design procedure are given below,

- Pavement Quality Concrete (PQC)
- Dry Lean Concrete Base (DLC)
- Granular Sub-base (GSB)
- Subgrade

7.3.1 SUBGRADE

Subgrade material shall confirm to the requirements of MORTH specifications. The subgrade material shall have a minimum CBR of 6% at 97% MDD.

7.3.2 GRANULAR SUB BASE (GSB)

Granular sub-base conforming to MORTH specification shall be provided as sub-base layer. GSB shall have a minimum thickness of 200mm for the drainage cum sub-base purpose and also for high water table.

7.3.3 DRY LEAN CONCRETE

Dry Lean Concrete (DLC) conforming to MORTH specifications shall be provided as sub base course. The DLC shall have average 7-day compressive strength of 7 MPa as per IRC: 58-2015. DLC shall have thickness of 150mm.

7.3.4 PAVEMENT QUALITY CONCRETE

The Pavement Quality Concrete (PQC) shall conform to MORTH specifications and shall have 28-day flexural strength of 4.5 MPa. The design parameters of PQC have been considered in accordance with IRC: 58-2015 and the same have been shown in Table 7.5.

TABLE 7-5: PROPERTIES OF PQC

Elastic Modulus of PQC, MPa	30000
Poisson's Ratio (μ)	0.15
Unit weight of PQC, kN/m	24
90-days flexural strength, MPa	4.95

7.4 PAVEMENT DESIGN FOR SIDE STRIPS

Flexible Pavement adopted for side strips with following parameters as per IRC: 37-2018:

Sr. No.	Description	Details
1	Design Life	20 Years
2	Design Traffic Axle Load	60 MSA
3	Subgrade Strength	CBR value 6%
4	Traffic Growth Rate	5%

Rigid pavement design for main carriageway has been carried out in accordance with IRC: 58-2015. The pavement design has been carried out by considering the option of tied concrete shoulder.

8 DESIGN BASIC FOR BRIDGE WORKS

8.1 GENERAL REQUIREMENTS

- It shall ensure soundness of the structure and durability.
- It shall ensure speedy construction and lead to appreciable economy.
- It shall be accompanied by preliminary but fairly detailed drawings and detailed description of work and specifications of materials and items. The detailed design assumptions and method statement shall also be given.
- Due importance shall be given to aesthetics of piers and superstructure, the shape of structure should give pleasing appearance and architectural beauty as a whole in harmony with the surroundings. The bridge shall have uniform aesthetical appearance to enhance the overall look and thereby the vicinity.

8.2 SPECIFICATIONS FOR DESIGN AND CODES TO BE FOLLOWED

The design of structural components shall conform to the criteria laid down in the latest editions of the applicable IRC codes / Special Publications of Practice and Standard Specifications.

The Codes, Standards and Specifications applicable for the design of the Project Bridge and Project Facilities shall be as under:

The design of structural components shall conform to the criteria laid down in the latest editions of the following codes of Practice and Standard specifications published.

I.R.C. Standard Specifications and Codes of Practice for Road Bridges. :

i. IRC: 5 -2015 Standard Specifications and Code of Practice for Road Bridges Section-I- General Features of Design (in metric units)
ii. IRC: 6-2017 Standard Specifications and Code of Practice for Road Bridges Section- II - Loads & Stresses
iii. IRC:78-2014 Standard Specifications and Code of Practice for Road Bridges section VII- Foundation & Substructure
iv. IRC: 83 -2018 Standard Specifications and Code of Practice for Road Bridges section-IX - Part-III, pot, pot-cum-ptfe, pin and metallic guide bearing
v. IRC: 112 -2019 Code of Practice for concrete road bridges

vi. IS: 456 -2000 Code of practice for Plain and Reinforced Concrete.
vii. IS: 1893-2016 Criteria for Earthquake Resistant Design of structure.
viii. IS:1786 -2008 Specifications for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
ix. IS:2911-2010 Code of Practice for Design & Construction of Pile Foundation (Part 1 Section-2)
x. IS: 6006 -2014 Specification for Uncoated Stress Relieved Strand for Pre-stressed Concrete.
xi. IS: 14268-1995 Un-coated Stress Relieved Low Relaxation 7 ply Strands for Pre-stressed Concrete.
xii. IRC: 24-2010 Steel Road Bridge for Permissible Stress.
xiii. IS: 800 -2007 Code of Practice for General Construction in Steel
xiv. IS: 875-2015 Code of practice for Design Loads (other than Earthquake) for building and structures.
xv. IS:13920-2016 Ductile detailing of reinforced concrete structures subjected to seismic forces - code of practice
xvi. IS: 16700-2017 Criteria for structural safety oftall concrete buildings
xvii. I.R.C: SP: 65-2018 Guidelines for design and construction of segmental bridges
xviii. I.R.C: SP: 70-2016 Guidelines for the use of High Performance Concrete bridge
xix. MORT&H specifications for Road and Bridge Work-2013
xx. Indian Railway Codes
xxi. CEB - FIP Model Code 2010

For any item not covered by any of the above Codes and Specifications, the relevant Provisions from EURO (EN) / AASHTO (LRFD) Codes will be followed.

For items not covered by any of the above Standards and Specifications, Sound Engineering Practice and Provisions of relevant Codes of other Nation shall be referred, as per approval of the Engineer.

8.3 OBLIGATORY PROVISIONS ON ROADWAY ON THE BRIDGE AND ALIGNMENT GEOMETRY ETC.

8.3.1 ALIGNMENT AND LOCATION

The alignment, location of the bridges and span arrangements shall be as shown on the Drawings Volume.

8.3.2 CHOICE OF OBLIGATORY SPAN

The terms of reference for the design proposed of the obligatory span to be 300m with central pylon. Specific location of the bridge has creek on north and south sides with an island in between. It is proposed to provide the main pylon approximately at the centre to this island to facilitate pile foundation construction. The span configuration will be 150m + 150m = 300m. Also the pylon will be located in the center of both decks.

8.3.3 DURABILITY OF STRUCTURE

Section 14 of IRC: 112-2019 shall be considered during design and construction of structure. The factor influencing durability of concrete includes:

(a) The environment
(b) The cover to embedded steel
(c) The type and quality of constituent materials
(d) The cement content and water/cement ratio
(e) Workmanship to obtain full compaction and efficient curing
(f) The shape and size of the member

8.3.4 DESIGN FOR DURABILITY

Basic steps in designing for durability are:

a) To establish the aggressiveness of the service environment (exposure condition), with respect to the various mechanisms of deterioration. Different components of the structure can be exposed to different service environments.
b) To select the type of structure suitable for the service environment.

c) To select the appropriate materials, mix proportions, workmanship, design and detailing, including minimum cover to steel.

8.3.5 DURABILITY PROVISIONS

a) Concrete mix proportions and cover
b) Table 14.2 of IRC: 112-2019 shall be considered for concrete mix proportions (20mm aggregate) and clear concrete cover to reinforcement for service life of at least 100 years.
c) Adjustments for other aggregate sizes
d) Table 14.3 of IRC: 112-2019 shall be considered for adjustments in cement content for aggregates of size other than 20mm size.
e) Chloride content - As per cl. 14.3.2.3 of IRC:112
f) Sulphate content - As per cl. 14.3.2.4 of IRC: 112
g) Maximum cement content -
h) Cement content (excluding fly ash, GGBS or Silica Fume) shall not exceed 450 kg/m3.
i) Corrosion of reinforcement

The normal way to design against corrosion is to ensure that there is an adequate cover to the reinforcement and that the concrete in the cover region is of a high quality and is well cured. In extreme environments, however, there is other measure which may have to be adopted, such as:

i. Use of galvanized reinforcement or reinforcement with fusion bonded epoxy coating
ii. Use of surface coatings to the concrete to inhibit the ingress of chlorides or carbon dioxide. Such coatings need periodic renewal.
iii. Use of waterproofing membrane over the bridge deck.
iv. Use of controlled permeability formwork (CPF) liners, which effectively reduce the chloride diffusion into the concrete.
v. application of cathodic protection to the structure
vi. use of stainless steel reinforcement
vii. Durability provisions considered in DPR are extreme exposure condition, water proofing membrane over bridge deck, reinforcement with fusion bonded epoxy coating, steel liner with epoxy coating, painting over substructure & superstructure, admixture in concrete.

8.3.6 DESIGN LOADS

8.3.6.1 DEAD LOADS

The Bridge shall be designed for Loading as per IRC: 6 2017. The Bridge shall also be designed for Loads due to service lines if any required as per BMC. The density of material shall be as listed below.

Material	**Density**
Plain Concrete	24 kN/m^3
Reinforced Cement Concrete (RCC)	25 kN/m^3
Prestressed concrete (PSC)	25 kN/m^3
Structural steel	78.5 kN/m^3
Wearing coat	22 kN/m^3
Bulk density of soil	18 kN/m^3
Saturated density of soil	20 kN/m^3

If there is a requirement for using data from the code which is in MKS units, the same will be used by applying a conversion factor 1 kg = 9.81 N.

8.3.6.2 SUPERIMPOSED DEAD LOAD

Super imposed dead load includes:

(1) Plain Cement Concrete fill having a minimum thickness of 300mm (cut and cover and transition ramp structures)

(2) Curbs and Railing loads.

(3) Any finishes/toppings on structure

8.3.6.3 LIVE LOAD

Live Load shall be as per IRC: 6. Special vehicle as per IRC: 6 Clause no 214.5 shall be considered in the design.

As per cl. 214.3 & 215 of IRC: 6 -2117, the bridge will be designed for the worst effect of live loads combinations as mentioned in Table-2. For carriageway width of 18.00 m - 5 lane live load (one lane of class 70R for every two lanes with one lane of class A for the remaining lanes OR one lane of class A for each lane) shall be considered .Impact Load will be as per Cl 219 of IRC: 6 -2117. Live load moments shall be increased by 20% to consider the effect of distortion and warping.

Each component of the structure shall be designed/checked for all possible combinations of loads in accordance with IRC 6 - 2014.The structure shall resist the effect of the worst combination.

Maximum number of axles will be loaded on the structure to arrive at maximum longitudinal force, maximum shear and maximum bending moments. The structure shall be checked for one-lane load condition as well as (both) 2-lane load condition.

8.3.6.4 LONGITUDINAL LOAD

1. Braking force: Braking Force shall be as per Cl. 211 of IRC: 6 -2017Braking load is taken as 15% of the unfactored vertical loads. Traction load is taken as 18% of the unfactored vertical loads.
2. Transverse/ longitudinal seismic condition, only 50% of gross tractive effort/braking force shall be considered.
3. Seismic load: Seismic force has been discussed in separate para.
4. Wind forces: This shall be considered as per clause no 219 of IRC: 6-2017. The longitudinal force on bridge superstructure shall be taken as 25 percent and 50 percent of the transverse wind load as calculated as per Clause 219.3.3 for box girder superstructure and truss girder superstructure respectively.

8.3.6.5 CENTRIFUGAL LOAD

The structure on curves shall be designed considering the centrifugal force as per Cl. 212 of IRC: 6 -2017. General design speed considered shall be 80 kmph. But this shall specifically be reviewed case to case as per the geometric design of highway.

8.3.6.6 CONSTRUCTIONAL LOAD

Construction Equipment load shall be considered in the design as per launching system. Class-A one lane load shall be considered as static load acting on superstructure.

8.3.6.7 WIND LOAD

IS 875: Part 3 shall be applied to determine the appropriate design wind loads in combination of other loads. Wind effects from venting in below-ground areas shall be designed appropriately.

8.3.6.8 SEISMIC LOAD

Seismic effects shall be considered on all structures, including underground structures. Evaluation of seismic loads shall conform to the relevant Indian Standards or to other

relevant seismic standards or references where the Indian Standards do not provide sufficient guidance.

The zonal demarcations for levels of seismicity shall be evaluated as per IS 1893-2016.

The structure is required to be evaluated as an "important service and community building" for the purpose of "functional use" as stated in IS 1893:2016.

The effects of load changes and deformation as a result of soil behaviour (e.g. liquefaction) shall be allowed for in the assessment and design.

8.3.6.9 WATER CURRENT LOAD

Water current forces shall be considered as per cl. 210 of IRC: 6 -2017. Maximum mean velocity of water current shall be considered as 3.5m/sec.

8.3.6.10 TEMPERATURE LOAD

Temperature loads shall be considered as per Cl. No. 215 of IRC: 6 -2017.

8.3.6.11 SHRINKAGE AND CREEP

Provisions shall be made for the effects of shrinkage and creep within concrete structures. This includes interface shear transfer mechanisms as a result of differential creep and residual shrinkage effects from staged casting of concrete elements. The shrinkage and creep strains shall be included in calculation of long term deflection of all structural elements in accordance with Annexure C of IS 456-2000 and the limits specified in Section 2.8 shall be applied.

8.3.6.12 BARGE IMPACT LOAD

Barge impact loads shall be considered as per Cl. No. 220 of IRC: 6 -2017

Barge impact load shall be considered as an accidental load and load combination shall confirm to provision of Annexure B of IRC: 6-2017.Barge impact load shall be considered only under ultimate limit state. For working load/allowable stress condition, allowable stress may be increased by 50 percent.

The probability of simultaneous occurrence of a barge collision together with maximum flood shall not be considered. Point of impact shall be assumed to act on pile cap top.

8.3.6.13 FATIGUE LOAD

Fatigue loads shall be considered as per Clause No 214.6 of IRC: 6 -2017.

8.3.6.14 BUOYANCY LOAD

Buoyancy loads shall be considered as per Clause No 213 of IRC: 6 -2017.

8.3.6.15 EARTH PRESSURE LOAD

Earth pressure loads shall be considered as per Clause No 213 of IRC: 6 -2017.

8.3.7 SOIL PROPERTIES

The properties of back fill material shall not be less than the values given below for design purposes:

- Dry Density of Soil - 1.8 T/Cum.
- Saturated Density - 2.0 T/Cum.
- Ø = 30O, □ = 20O
- C = 0

8.3.8 LOAD COMBINATIONS

For checking vertical and lateral pile capacity of piles, design load combinations as provided in Table 1 of IRC: 6-2017 shall be adopted. The load combination as shown in Annexure B shall be adopted for limit state design approach.

8.4 BORING DATA AND INVESTIGATIONS AT SITE

- The details of the borings, their locations and tentative rock levels and founding levels are shown in general arrangement drawing / geotechnical investigation report.
- The samples from the bore taken at each foundation shall be tested and analyzed in the laboratory approved by the Employer for establishing design parameters. Tests such as standard penetration test, compression and shear test on undisturbed soil samples, UCS, water absorption on rock samples etc., shall be carried out in conformity with the specifications.

8.5 FOUNDATIONS

8.5.1 FOUNDATION OF PIERS/ABUTMENTS

- The pile foundation shall be provided as foundation for piers, abutment piers and columns.
- Temporary works such as sheet pile, concrete casing, earthwork islands, temporary bridges etc. may require.
- Buoyancy to be considered shall be 100% for open foundation.
- No passive pressure shall be considered for the design of abutment.
- Effects of surcharge, if any, shall be suitably considered in the design.

8.5.2 PILE FOUNDATIONS:

Pile foundations shall be designed and provided as per the provision as specified in IRC: 78-2014.

Pile capacity shall be confirmed by pile load test as per IS: 2911 Part – IV

The design capacity assumed for the piles shall be verified by the initial load testing of test piles in non- working areas, in the vicinity of the bridge site. These piles shall be tested for 2.5 times the design load and number of such tests shall be one per diameter. Additional one pile per diameter which is actually going to be used for piers and abutments shall be tested for 1.5 times the design load. These tests and the routine tests shall be as per IRC: 78- 2014.

8.6 APPROACHES/RETAINING WALLS

The solid approach shall be provided at end of the bridge.

8.7 SUBSTRUCTURE & FOUNDATION

- The minimum diameter of piles shall be 1200 mm. Permanent minimum 6 mm thick M.S. liner shall be provided from HHW to level of refusal.
- The height of pedestals shall be at least 150mm and shall not be more than 500mm including bearing.
- All the piers in the Navigational zone shall be designed for a barge impact load as specified in loadings.
- Scope for accessibility for Inspection and arrangement for lifting of the Superstructure for future replacement of Bearings shall be provided for in the design of Substructure. The positions of jacks shall be distinctly shown on the drawing and also prominently marked on the structure. The shape of substructure shall be such that it shall not add to the turbulence of flowing water. It shall not create large obstructions to the flow of water. The debris shall not get entangled into the substructure.

8.8 SUPERSTRUCTURE FOR 20 / 30M SPAN

Generally superstructure shall be I-Girder for 20m span / PSC box girder Segmental construction for 30m span as shown in General Arrangement Drawing.

- Deck slab thickness shall not be less than 200 mm.
- Minimum thickness of intermediate diaphragm where provided shall be 300 mm and that of end diaphragm shall be 500 mm. Manholes shall kept at a spacing not more than 150 m with arrangement for access inside the box.
- The minimum thickness of web of “I” Girder or the thickness of web in box girder shall not be less than 200 mm.
- In the absence of rigorous analysis for torsional and distorsional moments and forces due to warping torsion at ends, the design live load moments and shear force in the longitudinal direction shall be increased by 20% and transverse reinforcement by 5%.
- Deck continuity is permitted for box superstructures. All box superstructures shall be of uniform depth.

- The design of superstructure shall be as per the provisions of IRC: 112.
- Both superstructures and piers for the main carriageway of each direction shall be structurally independent from the other in order to meet the security requirements.
- Where possible, an abutment for a ramp bridge for interchange shall be set as lower as possible unless the girder depth of the superstructure does not disturb the finishing ground level around the abutment.
- Over the inter-tidal zones, the construction of the superstructure shall be by overhead gantry methods only in order to avoid or minimize disturbance to the mud flats and the marine ecology
- Facilities for inspection and maintenance activities shall be included in the bridge design. Access to the inside of the box girders for main carriageway and ramps shall be located in the soffit of the box girders and shall be provided at minimum intervals of 1.0 km.

8.9 OBLIGATORY SPAN

8.9.1 DECK CROSS–SECTION & POST–TENSIONING

Option 1- Open cross–section of the cable stayed deck can be considered. Open cross–section with edge beams housing the stressing end of the stay cables. Diagrams and deck slab can be suitably included. To reduce the buffeting effect of wind on vertical face of edges small wind facing nose can be added as facia.

Option 2- The cross–section can be multi-cell spine shape box connected by diaphragms and deck slab. This cross section offers lesser buffeting effect against cross wind due to its gradually varying depth. The stay cables should be located at the deck duly thickened to take care of the splitting forces. This cross section shall be finally adopted after carrying out wind tunnel tests.
Any other cross section satisfying all design requirements can be adopted
The spacing of the stay cables at the deck level *can be 10 m c*/c while the diaphragms can spaced at 5 m c/c. The deck girder should be provided with post-tensioning cables near the central zone of the central span where the normal forces due to stay tension should not be available. All the in-situ diaphragms should be transversely post-tensioned with tendons.
The spacing of stay cables and diaphragm can be suitably altered to suit the design finalisation. All those parameter shall be pre-approved from BMC before proceeding for final design.

Wind Tunnel Test

Wind tunnel test should be conducted on a static section model of suitable length in order to validate the static coefficients of lift, drag and moment for consideration in the detailed design of the bridge. The test should be conducted at the Wind Tunnel facilities of Indian Institute of Technology, (IITR) Roorkee or any other recognized Institute.

A representative length of the deck of the bridge should be scaled at 1:50 or as required and to be placed in the open circuit boundary layer wind tunnel. Forces and moments should be measured on the model with load cells in smooth low-turbulence flow (turbulence intensity of 1%). A smoke generator should be used to get a visual picture of the flow around the deck. The model should be provided with tilting facility to fix the deck at the desired angle of attack of the incoming wind. Complete set of instrumentation should be provided for measurement of wind velocity, drag force and moment, lift force and digital integrators with data acquisition system should be used in recording of test data.

Force Coefficients

The static force coefficients for drag, lift and moment shall be given as

$C_D = K_1 \rho V^2 B^2 L / F_D$

$C_L = K_2 \rho V^2 DL / F_L$

$Cm = K_3 \rho V^2 BL / M$

where

ρ = mass density of air

V = mean wind velocity, m/s

L = length of the model, m

FD = measured drag force in N

FL = measured lift force in N

M = measured moment in N-m

8.9.2 AERODYNAMIC CONSIDERATIONS

The bridge deck under consideration should be having an aerodynamically streamlined section. The ratio of torsional to vertical bending frequency should be sufficient staggered to give favorable separation of the torsional frequency from vertical bending frequency for the geometrical shape selected. The flutter and vortex oscillations should be at only large angles of attack and at wind velocity much above the design velocity.

8.9.3 COMPUTER SIMULATION

An analytical computerized wind simulation study of the bridge should also be carried out using proprietary software DVMFLOW or equivalent.

The 2D section model used in software should be based on the same section as adopted for the test.

8.9.4 WIND LOAD COEFFICIENTS

The expressions of the wind load coefficients in the model tests should be as defined earlier.
In the model test, angles of attack can be varied between -6° and +6° with 1° spacing. Lift coefficients to be given in between -4° and +4°. Since the objective here should be to have preliminary check on the results of model tests, only three angles of attack should be modelled with software viz -3°, 0° and +3°. The wind tunnel and software study should be pre -approved from BMC.

8.9.5 PYLON HEIGHT

Pylon height decides the cable inclinations directly and it shall be estimated through approximate analysis that the cable weight and girder deflection (and hence also the girder moment) are related to the function of (1/sin± cos“) where” should be the typical cable inclination to the horizontal.

To minimize this function, ± should be maintained approximately between 25° to 75°. Pylons in most of such cases generally have height between 1/5 and 1/7 of main span. Raising of pylon height would lead to reduction in girder moments, in normal forces and in cable forces. The overall arraignment should be got pre-approved form BMC.

8.9.6 PYLON CROSS–SECTION

Two alternative pylon configurations may be considered. In the first alternative, the cable planes can be truly vertical and the legs have a gentle slope from top tie girder level to deck level and then converging in a diamond configuration below deck level towards pile cap.

In the second alternative, the pylon takes the shape of an inverted “A,H,Y.” The cable planes

have a higher degree of inclination towards the top and spacing of the pylon legs at top of pile cap level will be larger. After detailed technical evaluation and costs, one of the alternatives should be adopted.

The dead ends of the stay cable shall be housed in pylon top and stressing ends at girder soffit level with provision of dwarf walls. The pylon leg cross section all along the height may be a hollow section in order to achieve optimality in the design and to provide uninterrupted inspection access inside pylon shaft from base level right upto the top anchorage zone. The design should be done for detailed dynamic modal analysis of the entire bridge according to seismic and wind design code of Bureau of Indian Standard. The detailed design also should caters for entire construction stage analysis of the pylon.

The governing load case for the design of pylons should be the construction phase just before the closing pour of the deck. The pylon width in the longitudinal direction can be kept uniform throughout the height. Required number of post-tensioned bars or equivalent of suitable mm dia with UTS of 1030 MPa or equivalent should be provided in the pylon top cable anchorage zone at various levels in both X and Y directions to take care of the splitting forces due to tension in the stay cables.

8.9.7 DESIGN OF STAY CABLES

The maximum stress levels in the cables due to permanent loading should be limited to 0.45 UTS as per international practice. At this stress level, relaxation effects can be neglected and the cable may be considered to behave elastically upto the level of design forces. The bridge shall also be designed for the condition that any of the stay cables may get snapped (or inoperative) under full live load condition or due to possible replacement of any stay cable in future. Under such condition, the maximum allowable stress in the stay cables shall be increased by 25%. The anchorage details for the stay cables in the pylon and deck shall be carefully worked out after detailed review of the various available international stay cable systems in India.
Another important factor for the bridge should be that it is located in one of the most corrosive climates in India, being very close to the sea. After detailed review of the entire international scenario, the stay cable system shall be adopted.

8.9.8 SELECTION OF STAY CABLE SYSTEM

Site assembled stays with galvanized, PE coated, greased strands have a high protection against corrosion and a good fatigue resistance. These are particularly feasible for long and large size cables.

Factory made stays with parallel wires can also be suitable for long and large size cables, but they require very heavy equipment for installation/stressing compared to strand by strand installation with site assembled stays. Also, this system should be supplied by only single proprietary agency in India and abroad. Corrosion protection system shall be either cement grout or others (e.g., Polyeurathene/Polybutadene). Very high accuracy in fabrication to predetermined length should also be required.
Factory made stay with Carbon Fibre (non-metallic) material shall be suitable in extremely aggressive environment and has very high fatigue resistance.

Helical strands/locked coil ropes: in highly corrosive climate, these type of cables do not provide a long term durable solution and future replacement of stays poses a major problem. Also, they have low fatigue resistance due to conventional zinc socketting and have lower young's modulus compared to parallel strand or parallel wire cables. Hence, these shall not be considered for the proposed project in the extremely corrosive climate.

8.9.9 SPECIAL ASPECTS OF STAY CABLES

Cable Ducts
It is a standard practice to utilize high density polyethylene (HDPE) ducts as stay cable sheathing because of their UV resistance. For black HDPE pipes, 2% carbon black shall normally use in the granules for the production of the duct.
However, nowadays, UV stabilized and colored co-extruded HDPE ducts are available which satisfy long-term durability and are also aesthetically attractive. Such ducts can be produced in any color; however the UV-resistance depends on the tone chosen. The following duct options shall be examined alongside the black HDPE pipes.

- Coextruded pipes, whereby the outer 1.5-2.0 mm can be of any color desired, the internal ring bearing the grouting pressure, however should be made of black polyethylene.

- Fully colored HDPE pipes, whereby the entire cross-section consists of colored material. Caution must be taken with certain colors e.g., shiny red which are not suitable for long term UV exposure.

8.9.10 CABLE VIBRATIONS

A problem associated with longer span stay-cable bridges is wind-rain induced cable vibration, which may cause distress to the stay-cables. Investigations have shown that longitudinally or spirally ribbed and dimpled ducts reduce the vibration considerably. The neoprene damping device provided in the ring space between the cable and steel exit pipe of pylon and deck anchorages as well as the use of profiled ducts may not be always sufficient to suppress this wind-rain induced vibrations. Therefore provisions shall be made in the design to enable implementation of complementary vibration suppressing measures viz attachment of friction/viscous dampers to the anchorage ends at deck level.

8.9.11 CORROSION PROTECTION TO POST–TENSIONED ELEMENTS

Corrosion Protection to Stay Cables

i. PE coated strands for stay cable manufacture shall meet the following test requirement.
   - Chemical resistance test as per ASTM G20 standard
   - Chloride permeability test as per FHWA standard
   - Impact test as per ASTM-G14 standard
   - Abrasion resistance test as per ASTM-D968 standard
   - Salt spray (fog) test as per ASTM-B117 standard.

ii. Epoxy coated strands used in stay cables shall conform to ASTM A-882 “Standard specification for epoxy coated 7-write prestressing strand.” or equivalent Indian Standard. These strands shall be of the type in which the interstices of the strand are filled with epoxy and the strand shall be weldless, low relaxation grade.

iii. HDPE pipe: The UV resistance of the colored PE pipe shall be equal to the black ones. Light colour PE pipe having very high UV radiation resistance has been already developed and used in cable stayed bridges in Europe. The acceptance test for this item shall be as per ASTM–D3350 standard or equivalent Indian Standard.

The recommended stay cable system viz. parallel strand cables formed by galvanized, greased and PE coated strands of 0.6" Ø with anchorages and external HDPE tube (no additional grouting inside HDPE) will provide multiple corrosion nested barriers as follows

1. Barrier 1 : galvanizing and greasing for entire length
2. Barrier 2 : PE–coating for entire length
3. Barrier 3 : external HDPE tube

The individual strands and the entire cable can be replaced in future if necessary. The corrosion protection as above should be factory applied under stringent quality control.

8.9.12 CORROSION PROTECTION TO POST TENSIONING CABLES IN SUPERSTRUCTURE

Experience shows that metallic sheathing (in marine climate) should be completely vulnerable to corrosion. In order to prevent this situation and in accordance with the latest international practices, all the sheathing for post tensioning cables shall be considered to be of corrugated HDPE duct which should be available indigenously.

Additionally, anticorrosive admixtures shall be proposed to be used in the cement grouting. These admixtures ensure anticorrosive properties of the cement grout and protect the steel from corrosion when used with cement, reduce the permeability of concrete and ensures long term durability.

8.9.13 AESTHETICS ASPECTS OF DESIGN

The aesthetic attraction of cable stayed bridges lays in the extreme slenderness of the deck which in combination with thin stays, provide an aesthetic impression of transparency and lofty lightness.

For a pleasing appearance of such cable-stayed bridges, it should be aesthetically important that the fascia runs undisturbed throughout the length on the outside the deck. For the adopted deck cross - section, the fascia comprises of the thickened edge of the deck slab of trapezoidal box section. Care has been taken to ensure that in the viaduct portion also, the fascia shall integrate with the above in order to impart an uninterrupted fascia line all through the bridge length. The stressing anchor heads will be visible from outside, but again in the backdrop of the main girder depth, this shall have insignificant visual impact.

Careful proportioning in the spans shall be ensured in order to obtain harmony. The side spans which end with the backstay cables should be less than half of the main span. This not only leads to visual harmony but also keep the stress changes in the backstays within limits.
Illumination of such long span cable stayed bridge plays a very important role in highlighting the structure and creating a location of tourist interest. Also it shall be considered to have different illumination schemes during different seasons (rainbow effect).

8.10 BEARINGS

- Spherical type bearings shall be permitted. These bearings shall be got manufactured from MORT&H approved manufacturers.
- The bearings shall be easily accessible for inspection.
- Scope for lifting the superstructure for future replacement of bearings shall be provided for in the design of bearing.
- The contact surface of superstructure shall project beyond the edge of the bearing plate by a minimum distance of 100 mm at any location.

8.11 EXPANSION JOINTS

- Only strip seal / modular strip seal joints shall be permitted. These shall conform to modified interim specifications for expansion joints.
- The expansion joints shall conform to M.O.R.T. & H. Specifications. The detailed working drawing for the joint shall be in conformity with overall geometry of deck. Geometrical profile shall be achieved by adjusting the dimensions of Superstructure. The joint shall be jerk free. Differential deflection in bearings shall be considered in design.
- The expansion joints shall be leak proof. The joint shall be provided for the full width of the bridge.

8.12 RAILINGS/PARAPETS & CRASH BARRIERS.

Railing/Crash barrier shall be provided as indicated in the Drawing.

8.13 WATER SPOUTS

Waterspouts shall be as per MOST Type design. The water spouts shall be provided @ 3m C/C along the bridge and the top portion of water spout should be 500 mm X 500 mm at deck level.

Waterspout shall be 150 mm G.I. and connected to runner pipe (HDPE type) of suitable diameter (Minimum 150 mm) and taken down by down take HDPE pipes of suitable diameter at approved locations. Arrangement for clean out plug shall be made.

8.14 WEARING COAT

A wearing coat shall be as shown in the drawings.

8.15 MATERIALS

8.15.1 CONCRETE GRADES FOR VARIOUS STRUCTURAL ELEMENTS.

Grade of concrete in various structural elements shall be for extreme exposure conditions of exposure. High performance concrete with micro silica may be recommended.

- Superstructure:

PSC Superstructure	M60
Deck Slab	M60
RCC Crash Barriers/Kerb	M40

- Substructure:

RCC Pier /Pier cap	M50
RCC pile cap and foundations	M40
All PCC members	M20
Pedestals	M50

8.15.2 STEEL

- Reinforcement Steel

Fe 500D HYSD bars conforming to IS: 1786 having minimum elongation 14.5%. Reinforcing bars shall be coated by fusion bonded epoxy conforming to IS: 13621

- Prestressing Steel

The pre-stressing strands shall conform to IS: 14268

System: 19T13 or 19T15 low relaxation multiple strands system

Cables: low relaxation with strands of 12.7mm or 15.2mm nominal diameters. Sheathing: HDPE sheathing duct

- Structural steel

This shall conform to IS: 2162 of grade E350 (Fe 490)

8.16 ANTICORROSIVE TREATMENT TO CONCRETE AND REINFORCEMENT

(Applicable in case of marine and severe environment.)

The entire structure shall be given anticorrosive protection, which shall be got tested from approved laboratory and shall be of approved quality, colour and shade.

Protection for Steel composite superstructure shall be provided as per Annexure D of IRC: 24-2010

The protection shall consist of:

- Over mild steel liner: One coat of Zinc-rich Epoxy primer and two coats of Coal Tar Epoxy. (Total dry film thickness 50 + 80 + 80 = 210 microns) to outside surface. Aluminium based paints shall be prohibited as they have deleterious influence on the concrete surface.
- Part of Substructure in contact with earth and up to (H.T.L.+0.9m) / H.F.L. (whichever is higher) - One coat of primer and two coats of Coal Tar Epoxy. Part of Substructure exposed to atmosphere - water proof cement paint.
- Parapets: Waterproof cement based paint in three coats of approved quality and colour.
- Deck/Girder/Box: All outside faces - Epoxy based paint with one primer and further two coats. The inside faces will be painted in cement paint of approved colour and shade in three coats.

9 CONSTRUCTION METHODOLOGY

9.1 METHODOLOGY OF CONSTRUCTION IN CREEK AND SALT PAN AREAS.

The proposal for structures in the Creek areas and Salt Pans consists of 30m span Pre-cast Segmental Box Girder Superstructure arrangement and 100m obligatory spans with steel superstructure resting on Piers with Pile Foundations. Segmental Construction in General involves Construction of precast Box Girder elements which are transported to the site and stitched together. The methodology proposed for execution of these spans is explained hereunder in brief,

Following main operations are involved in the precast segmental construction of Bridge superstructure.

i. Preparation of casting yard for casting of precast segments.
ii. Preparation of stacking yard for Stacking.
iii. Transportation of precast segments to erection the site.
iv. Erection of precast segments by using launcher.

9.2 PREPARATION OF CASTING YARD AND CASTING OF PRE-CAST SEGMENTS

- Casting of segments is done in the Pre-casting yard using long line method. In this method, the bed is prepared for the full length of the span.
- Outer side shuttering is prepared in single panel for the length of the segment.
- Inner formwork is collapsible type shutter.
- After levelling and aligning the bed, outer forms are positioned properly and aligned. Reinforcement is placed for the segment after application of remoulding agent. Reinforcement can be made in pre-fabricated cages, which can be lifted by Gantry and placed in position.
- Outer & Inner forms are removed after the concrete achieves sufficient strength.
- Clean & move the outer forms to next segment location. Fix and align the same. Apply wax or few coats of wax based curing compound to the end surface of already concreted segment. Fix reinforcement and sheathing ducts in place. The connection of sheathing duct to the sheathing of previous segment is made perfect so that it does not get dislodged during concreting and grout is not enter into the duct.

- Rest of the sequence is same as 1st segment till all the segments are concreted.
- The segments are lifted up from the bed after the concrete has achieved strength of approx. 300 kg/cm^2. Minimum two adjoining segments are left on bed for the alignment of segment to be concreted. Lifting of segments is done in such a way that no jerk is imparted and the shear keys also do not break.

9.3 PREPARATION OF STACKING YARD

The preparation in stacking yard is as follows:

- Lightly sand blast the end surface to remove laitance from the face and to remove any loose particles. During this process, it is advisable to plug the cable holes so that no sand enters the cable ducts.
- Clean the cable holes by blowing air through the cable duct and ensure that the ducts are free by passing a dummy cable through the hole.
- Repair the concrete wherever required. This should preferably be done immediately after the shutter is opened so that the curing of the repair is carried out along with the curing of the segment itself. The repairs are done by dry packing method or using available high strength mortars.
- Fix foam rubber rings (5 mm to 10 mm thick depending on the quality of foam around the cable holes to avoid epoxy entering the holes when temporary prestressing is being done (to avoid problems later while threading the cables)
- Attach connection beams to all segments in the span using Dywidag thread bar and nut.
- Fix temporary stressing brackets to all segments by stressing vertical stress bars in the casting yard. Stress vertical bars of bracket to required force using central hole jacks operated simultaneously using manifold.
- Cure the segments in stacking yard using sprinklers for minimum 14days from the date of casting.

9.3.1 TRANSPORTATION OF PRECAST SEGMENTS TO ERECTION SITE:

- The transportation of the segment is proposed to be done by use of trailers.
- The segment is tied down to the trailer positively to prevent toppling and sliding.
- The Transportation of the Segments will be done right upto the point where it is lifted by the Launcher i.e. on a span preceeding/succeeding to the Span under construction. This is

done as there is very less possibility to float the Segments in the Creek owing to zero draft in low tide.

9.3.2 ERECTION OF PRECAST SEGMENTS USING LAUNCHER MOVING FROM ONE END TO OTHER

The step by step operations at site is as below:

i. Setting of launcher for erection of segments:
ii. Erect Launcher on piers
iii. Place and fix longitudinal and transverse shifting arrangement and for alignment of precast segments.

Erection of segments:

Lift the precast segments directly from Trailer. Start the erection of precast segments from one end, proceeding towards the other end of span.

Alignment of segment:

Following steps are followed for alignment of segments

- Align first segment true to line and level keeping a gap of about 10 mm between top of bearing and soffit level. Restrain this segment from shifting from its place by providing ties etc. from pier cap / previous span.
- Fix the balance fixtures i.e. horizontal stress bar for temporary stressing of 1st joint.
- Align second segment to line and dry match it to first segment.
- Repeat steps at (b) & (c) for alignment of balance segments.
- Verify the alignment of span as a whole.
- Separate the segments starting from the last segment. Keep gap of about 200 mm between the segment faces where epoxy is to be applied.
- Check that there is no disturbance to the first segment.
- Apply epoxy glue as per specification between 1st & 2nd segment interface within pot lift of epoxy.
- Join the segments together by moving the second segment.
- Apply temporary prestress simultaneously to all the bars. Use separate hydraulic pump + manifold unit for application of prestess at Deck & Soffit slab bars.

Prestressing of segments:

- Thread the permanent cables.
- Fill the gap between top of bearing & soffit of segment using high strength non shrink cementations grout and allow it to cure for 12 hours. After achieving a strength of 200 kg/cm^2, stressing can be started.
- Prestress permanent cables to take dead weight of superstructure in the sequence so that load transfer takes place from staging support to bearing. .
- Distress all temporary stressing bars and detach temporary stressing brackets, vertical stressing bars & send to casting yard.
- The above methodology can be adopted for construction of typical superstructure box girder span in creek area and salt pans.

9.4 METHODOLOGY FOR CONSTRUCTION IN MANGROVES AREA:

- First temporary bridge shall be constructed at one side of the carriageway for carrying out materials and equipments.
- From temporary bridge platform on temporary pile arrangement shall be constructed.
- Then working piles shall be constructed.
- Brackets shall be connected with piles and shuttering will be placed. Then casting of deck slab will be done.
- On completion of the superstructure, balance miscellaneous activities shall be completed.

9.5 CONSTRUCTION METHODOLOGY OF FOUNDATION AND SUBSTRUCTURE:

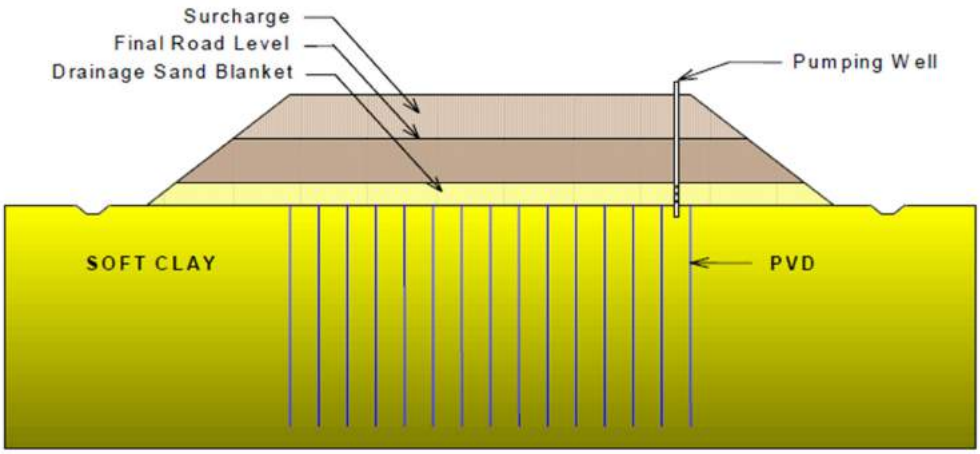
- For construction of pile foundation in creek area, jack up platform is most suited. Construction materials and equipments will be transported through barge at pier locations during high tides. Temporary bridge also can be constructed from accessible shorelines where mangroves are not affected. Through temporary bridge construction materials and equipments will be reached at pier locations.
- Construction stages are below:
- Steel liner will be installed upto top of rock level in pile location.
- Boring will be done.
- Caging will be laid inside.

- Concreting of piles shall be done using tremie.
- Pile cap shall be cast once the piles of particular locations completed. Pile cap shall be cast in situ.
- On completion of foundations, immediately substructure shall be cast in one go with a suitably designed shuttering.
- For construction of pile foundation and substructure in salt pan area same methodology shall be used. Approach road shall be constructed to reach pier locations.

9.6 GROUND IMPROVEMENT TECHNIQUES FOR EMBANKMENT-

9.6.1 BAND DRAINS OR PREFABRICATED VERTICAL DRAINS (PVD)

In construction of various structures on compressible, saturated soils like soft clay, excessive settlement is a common problem to deal with. The ground improvement technique using prefabricated vertical drains (PVD) is one of the most suitable methods to overcome this problem. The sole purpose of vertical drain system is to shorten the drainage path of the pore water from a low permeable layer to free water surface or to pre-installed drainage layer, thereby accelerating the rate of primary consolidation or the process of settlement. Application of ground improvement method using PVD coupled with surcharge or preloading can significantly shorten the period of primary settlement.



Application of PVD with surcharge loading for ground improvement work of road embankment

9.6.2 STONE COLUMNS

Stone column ground improvement involves adding vertical columns of stone into the ground to depth of at least 4m below the ground surface. The construction of stone columns involves partial replacement of weak soil with the stones (aggregates). The stones are compacted by ramming or vibrations. General practice is to replace 15 – 35 % of weak soil by stones. Design loads of stone columns typically vary from 20 to 50 T. The installation of stone column creates a composite material of overall lower compressibility and higher shear strength than the virgin weak soil. Also as stones are free draining material helps to drain the pore water and reduces the possibility of liquefaction. Stone columns technique is suitable for carrying out ground improvement of soft to medium stiff cohesive soil or loose cohesion less soil.

9.6.3 BASAL REINFORCEMENT (USE OF GEOGRIDS / GEOTEXTILES)

When the depth of treatment i.e. depth of the weak soil is small, the Geotextiles or Geogrids can be used to increase the Safe Bearing Capacity by way of load dispersion. For achieving the required factor of safety for Global Stability of embankments to be constructed on weak stratum, basal reinforcement in the form of high strength geogrids/ geotextiles can be considered.

9.6.4 EXCAVATION & REPLACEMENT

If the embankment is failing in global stability or the estimated settlement of the embankment post construction is more than the allowable limit, the weak layer of soil can be excavated and replaced with suitable soil meeting the specifications of embankment fill. The thickness of replacement shall be identified by iterative method, to achieve required factor of safety for global stability and/ or reduce the post construction settlement within allowable limits.

9.6.5 DYNAMIC COMPACTION

The densification of weak soil increases the ability of soils to carry the loads safely. The Dynamic Compaction is method which can be adopted to increase the safe bearing capacity of the existing soil and reduce the post construction settlement. Dynamic Compaction also helps to reduce the liquefaction Potential. Dynamic Compaction is useful in silty / sandy deposits present up to a depth of 5 to 7 m. Dynamic Compaction involves the application of high levels of impact energy at the ground surface. The energy is applied by raising and dropping a dead

weight of 10 to 50 T from heights of 5 to 30 m. The energy is applied in grid pattern and alternate passes are given to achieve the required densification.

9.6.6 EXCAVATION & REPLACEMENT WITH CNS SOIL

Expansive soils are inorganic clays exhibiting high compressibility and characterized by high shrinkage and swelling properties due to changes in moisture content. The expansive soil shall be identified based on following basic (prime) parameters:

a) Swelling pressure (Sw) > 0.5 kg/cm2

b) Clay content (< 2μ) > 25%

c) Differential Free Swell (DFS) Index > 30%

The thickness of cohesive non-swelling soil (CNS) layer shall be decided giving due consideration to the overall height of embankment and swelling pressure of expansive soil. Refer Table for CNS layer thickness for given swell pressure.

10 ENVIRONMENT IMPACT ASSESSMENT

10.1 ALIGNMENT OVERVIEW

This 45 m wide DP Road is much necessary to public as an alternative route for entering in Mumbai, and save time of transport. Currently only entrance to Mumbai from north India is located at Dahisar Check Naka through Western Express Highway. The Proposed 45m wide road from extension of link road at Dahisar (west) in Brihanmumbai Municipal Corporation Limit to Bhayander (west) in Mira Bhayander Municipal Corporation Limit. The DP Road would decongest the Dahisar Check Naka, the entry point of the Mumbai. The construction of the road will relieve traffic congestion in inner areas of Mira Bhayander and to improve the mobility of Mira Bhayander and Dahisar area.

The proposed 45 DP road will create an environmental impact and change in the physical-chemical, biological, cultural and/or socioeconomic system of the Western Mumbai Suburbs and Mira Bhayander. The DP Road will impact on the CRZ notified area and mangroves Eco system as the proposed alignment passes through the Dahisar Creek.

10.2 APPLICABLE ENVIRONMENT POLICIES AND LAW

10.2.1 THE APPLICABLE INDIAN LEGISLATION RELATED TO ENVIRONMENT:

- Environmental (Protection) Act, 1986 and applicable prescribed rules and notifications under the Act.
- The Maharashtra (Urban Areas) Preservation of Trees Act, 1975.
- Air (control of pollution) Act, 1981 and
- Water (control of pollution) Act, 1974
- Coastal Regulation Zone Notification 2019.
- Forest Conservation Act 1980
- Forest (Recognition) Act 2006.
- Maharashtra Maritime Board Act, 1996

The Following table presents the applicable rules and regulations and how they are applicable in implementation of this project.

Applicable Regulations & Status of Compliance

Applicable Regulations	Status of Compliance
Forest Conservation Act 1980 and Hon High Court Permission	As the proposed alignment passes through mangroves area notified as forest. The Forest diversion is mandatory as per the section 2 of Forest Conservation Act 1980 to carry Non Forest Activity in forest area. Also, as per PIL No.87 of 2006, a Prior High Court Permission needs to be taken while working in mangrove areas.
Coastal Regulation Zone Notification 2011.	The proposed alignment passes through CRZ notified area hence CRZ Clearance shall be taken from Maharashtra Coastal Zone Management Authority (MCZMA) and further from State Environment Impact Assessment Authority (SEIAA)
Environmental (Protection) Act, 1986 and applicable prescribed rules and notifications under the Act	This is an umbrella act for environment protection. Various standards in terms ambient air, noise are given in this act. The proposed road is not covered ambit of the EIA Notification 2006 A rapid Environmental Impact Assessment is required to prepare for envisaging the impact on environment and covering mitigation measures.
Air (control of pollution) Act, 1981 and Water (control of pollution) Act, 1974	Implementing Agency needs to obtain the consent-to-establish and consent-to-operate for the batching/hot mix plants to be erected/commissioned
The Maharashtra (Urban Areas) Preservation of Trees Act, 1975	As per this act no tree can be felled without the permission of local tree authority. Trees in the premises of schools can be removed with the permission of tree authority which may prescribe

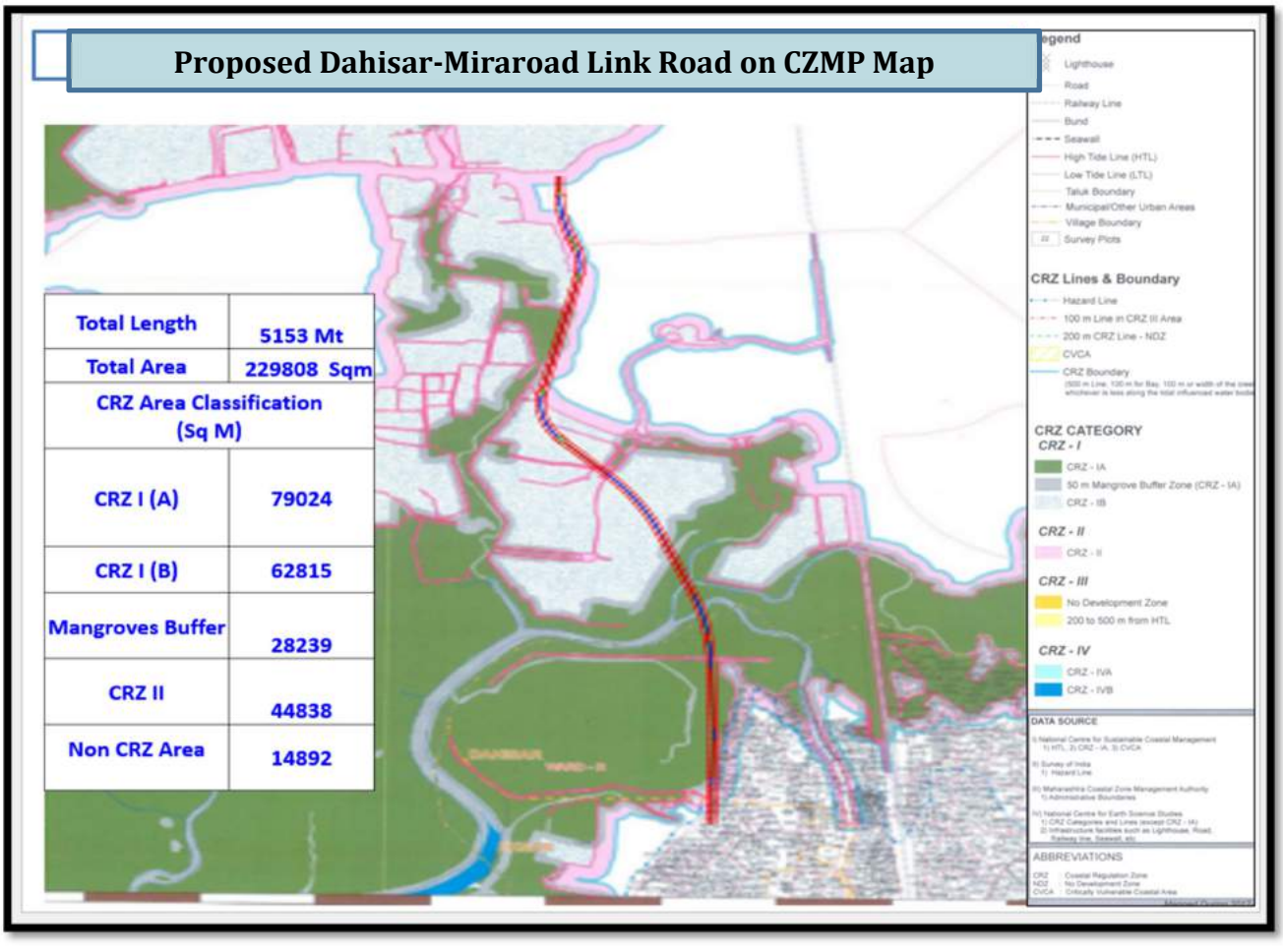
Applicable Regulations	Status of Compliance
	transplanting or compensatory plantation.
Maharashtra Maritime Board Act, 1996	The Proposed Alignment passes through the Dahisar Creek. Dahisar Creek is under jurisdiction of the Maharashtra Maritime Board. The No Objection Certificate will be required for the alignment with respect to fishing boats navigation.

10.3 IMPACT ON THE ENVIRONMENT.

10.3.1 COSTAL REGULATION ZONE

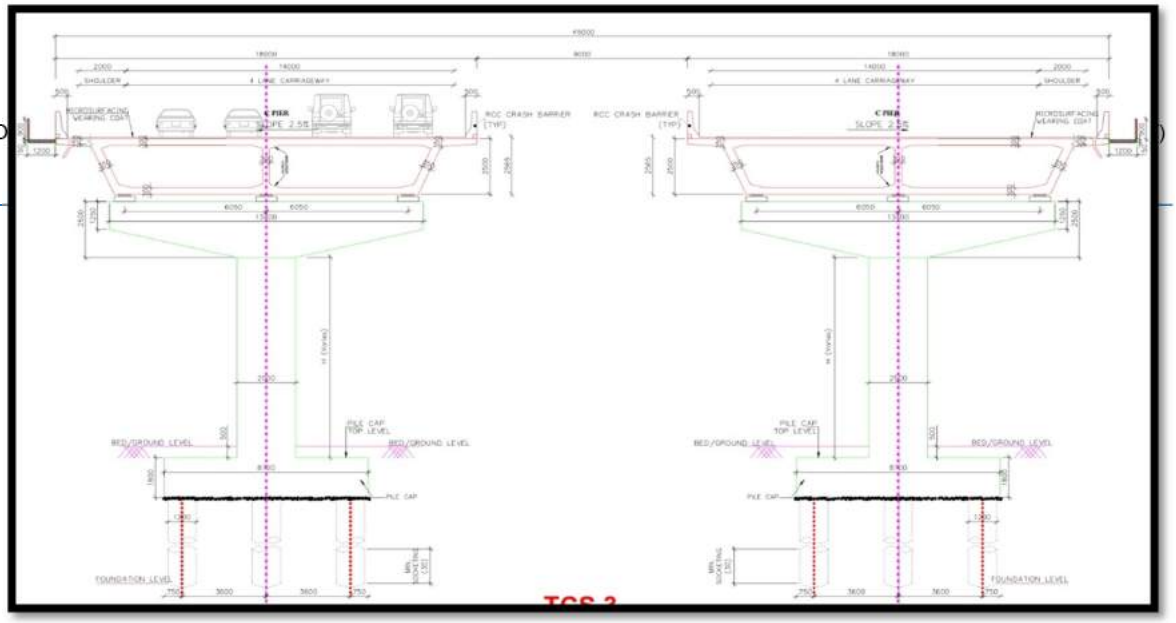
The Alignment passes through the Notified Coastal Regulation Zone as per Costal Regulation Zone Notification 2011. The Alignment passes through the CRZ-I Notified area of Mangroves Buffer Zone, CRZ I (B), CRZ I (A), and CRZ II.

FIGURE 10-1: ALIGNMENT SUPERIMPOSED ON THE CZMP MAP 2011.



The Details of the land under coastal regulating zone are as given below:

Ch From	Ch To		CRZ I			CRZ II	CRZ III	Survey Plot	Proposed Section
			CRZ I(A)	Mangrove Buffer Zone	CRZ I(B)				
4,580	4,110	470				470			AT-GRADE
4,110	3,680	430		430					
3,680	3,530	150	150						ROAD ON STILT / OBLIGATORY SPAN
3,530	3,380	150				150			
3,380	2,130	1,250			1,250				
2,130	1,980	150		150					
1,980	1,780	200	200						
1,780	1,730	50		50					
1,730	1,580	150	150						
1,580	1,525	55		55					
1,525	280	1,245	1,245						
280	180	100		100					
180	30	150				150			AT-GRADE
30	-	85						30	
			1,745	785	1,250	770	-	30	



The alignment passes through the mangroves and CRZ-I are designed on Stilt.

10.3.2 MANGROVES ECO SYSTEM

The alignment passes through the mangroves Patches. Around 20 out of the 35 species of true mangroves found in India have been identified along the Maharashtra coast and 15 species of these are found in Mumbai. The Alignment is passing through mangroves patch in three village viz Bhayander, Dahisar, and Penpada.

Along the alignment, species of mangroves are found. The details of mangroves species in alignment as below

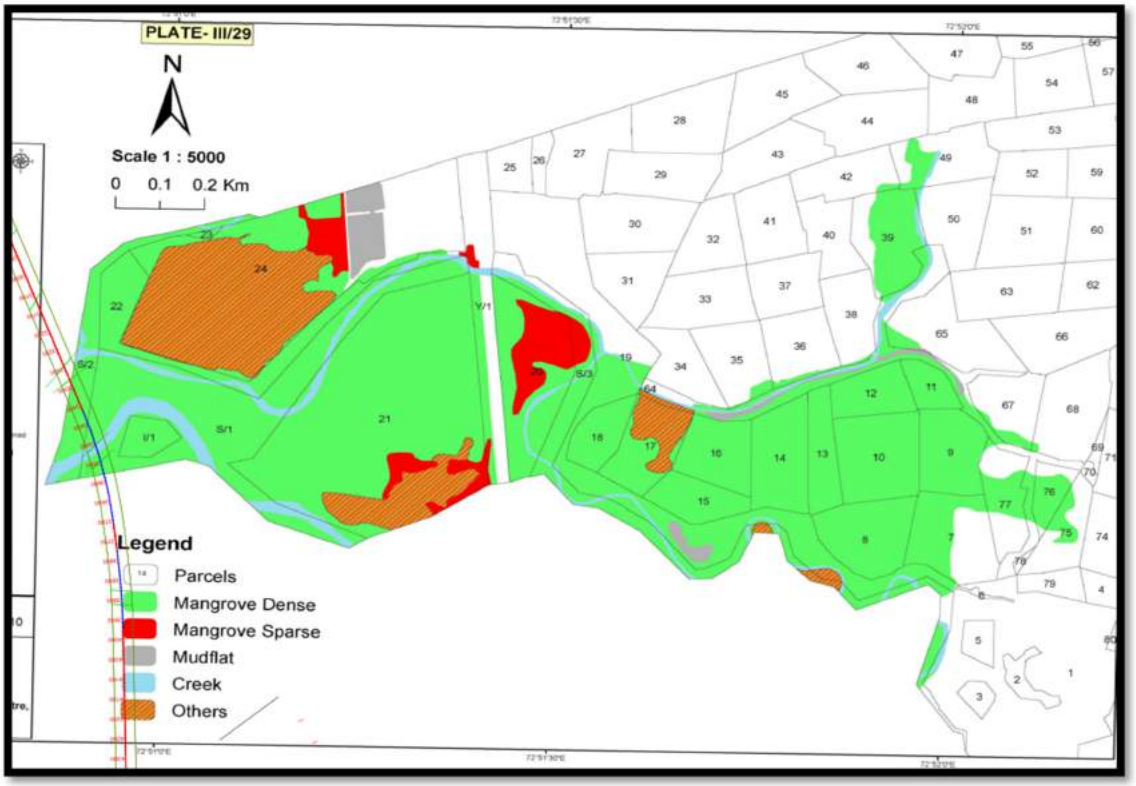
Sr. No.	Botanical Name	Common Name	Image
1	*Rhizophora mucronata*	Red mangrove	
2	*Avicennia marina*	Tivar	

3	*Bruguiera cylindrica*	Bakau putih (malay)	
4	*Acanthus ilicifolius*	Holy mangrove	
5	*Ceriops tagal*	Kirkiri	
6	*Sonneratia alba*	Mangrove Apple	

The alignment passing through the patches of mangroves as below

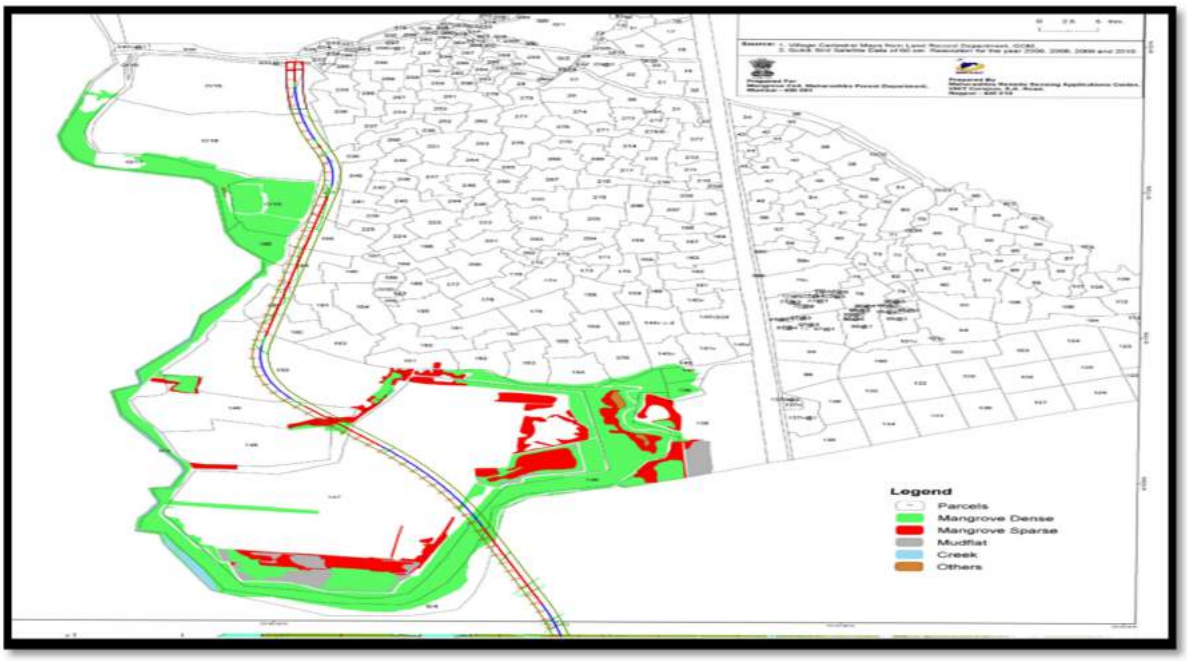
Mangrove Patch in Village Penpada- 0.89 Ha

(Chainage from 1600 to 1750)



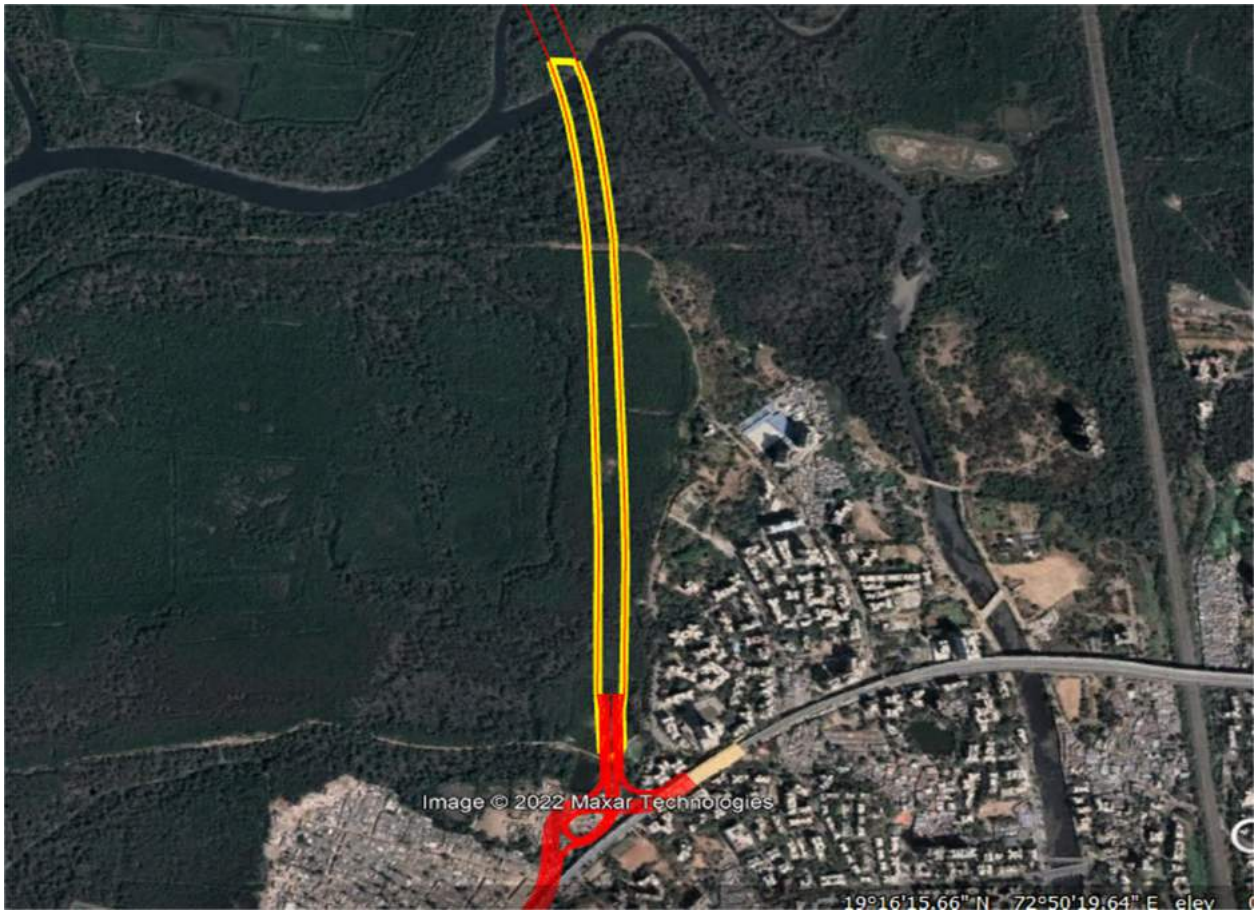
Mangrove Patch in village Bhayander- 2.46 Ha

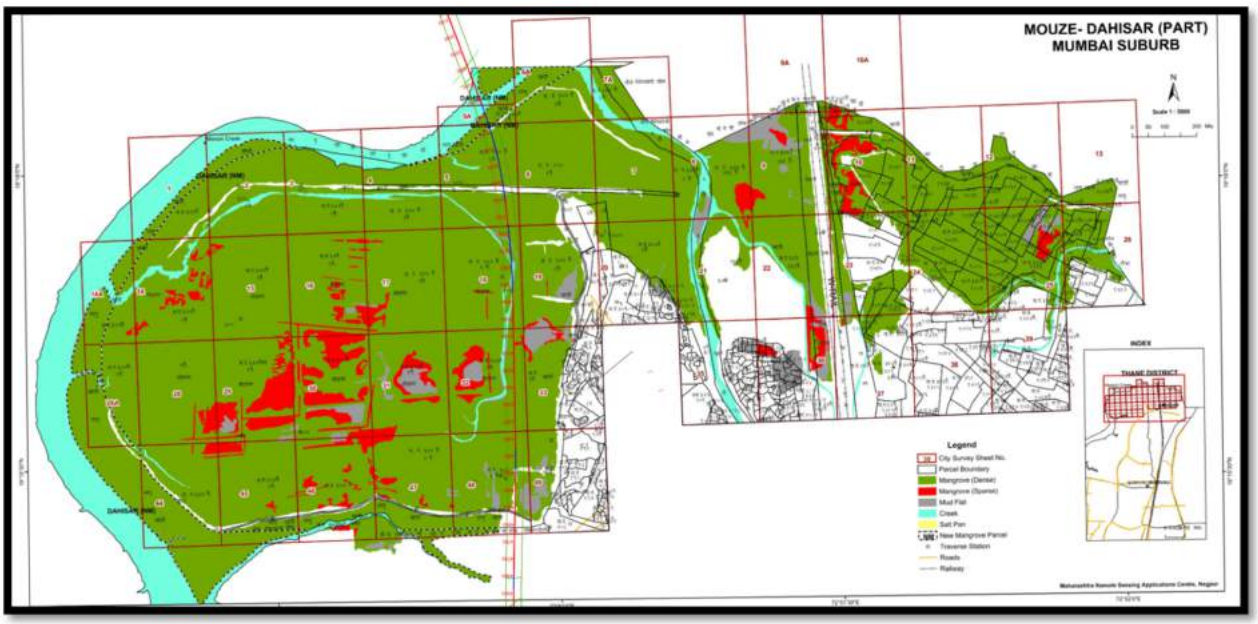
(Chainage From 1800 to 1950 & 3750 to 4000)



Mangrove Patch in village Bhayander- 2.46 Ha

(Chainage From 1800 to 1950 & 3750 to 4000)





Mangrove Patch in Village Dahisar- 6.21 Ha (Chain 200 to 1550)

The Total Mangroves Area that is impacted is 9.56 Ha

The Bifurcation of the mangroves along the alignment as below

Sr. No.	Village	Taluka	District	Length	Area (Ha)
1	Bhayander	Thane	Thane	300	2.46 Ha
2	Penpada	Thane	Thane	200	0.89 Ha
3	Dahisar	Borivali	Mumbai Suburban	1250	6.21 Ha
				Total	**9.56 Ha**

10.3.3 WILDLIFE AND ECO SENSITIVE ZONE.

The Proposed alignment is not the part of Sanjay Gandhi national park or it's Eco-Sensitive Zone. The areal distance from Sanjay Gandhi National Park is 2.6 Km.

10.4 ENVIRONMENT MANAGEMENT PLAN

10.4.1 METHODOLOGY FOR MINIMIZATION OF IMPACT ON MANGROVES

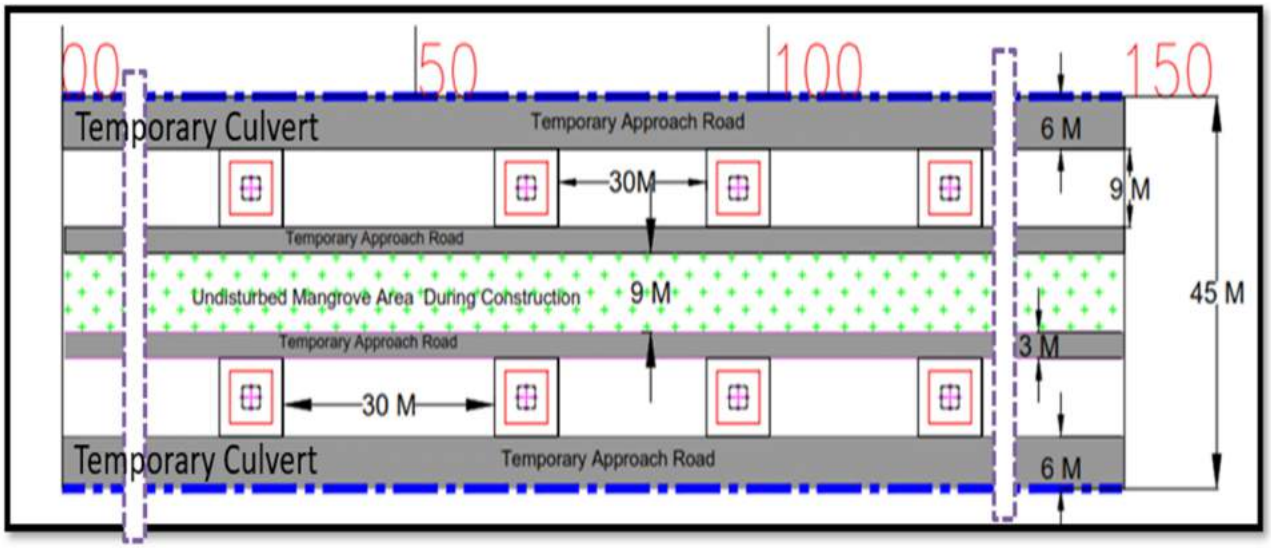
10.4.1.1 METHODOLOGY DURING CONSTRUCTION

The construction methodology proposed so there is minimum impact on the mangroves and creek bio diversity, The minimum use of mangroves land is proposed to use in the construction of the road in the mangroves patch.

The Methodology is as follow

1. Post cutting of the mangrove in working pace a Temporary Culvert will be constructed so ensure the free flow along the mangroves.
2. A temporary approach road is constructed on Right Hand Side or as feasible on either side of the proposed pillar location for the movement of heavy trucks and Machinery.
3. A temporary approach of 3 Meter to additional temporary road for the workers movement to be constructed.
4. The Pillar construction and gridder placing shall be carried out through this temporary approach road.

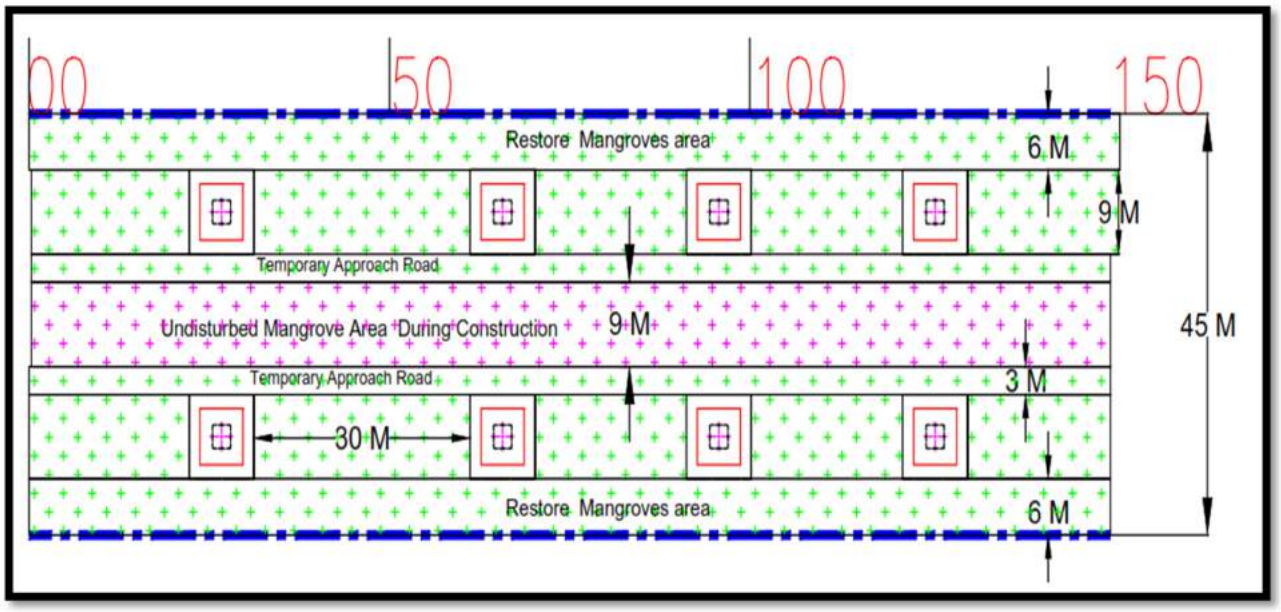
5. The space of 9-meter space of mangroves in the total 45 meter right of Way (RoW) i.e 20% of total area between two piers will untouched even during the during construction.



The above figure demonstrate the construction Methodology for minimum impact on mangroves.

10.4.1.2 POST CONSTRUCTION

Post Construction the Temporary Road will be removed and the land will be filled with sluddy soil and planation activity will be carried with the suitable mangroves and mangroves associated species as per the direction of the Mumbai Mangroves Conservation Cell.



The above figure demonstrate the post construction Methodology for minimum impact on mangroves.

10.4.2 ENVIRONMENT MANAGEMENT PLAN

An Environmental Management Plan (EMP) has been recommended in this Section. This EMP takes into account all the environmental issues and the corresponding mitigation measures to minimize the impacts.

It also includes a monitoring plan to enable evaluation of the success or failure of environmental management measures and reorientation of the plan if required. Several of the protective and enhancement measures can be implemented by adopting suitable planning and design criteria during construction of the project. Further, it is necessary that the resources required for the mitigation / protection, enhancement measures and monitoring are provided for in the cost estimates of the project, to ensure proper implementation.

The Environment Management Plan is prepared in respect to mitigation measures and minimize the impact on Environment. The Plan is as below.

Cost Estimates toward Implementation of Environment Management Plan and Environment & Forest Clearances

Sr. No.	Item	Unit	No	Rate	Amount
1	Mangroves Tree Feeling and Disposal Cost	Ha	9	40,00,000	4,00,00,000
2	Fencing of the Compensatory Land	Ha	9	15,00,000	1,35,00,000
3	Towards conservation of habitat and Avifauna rehabilitation plan.	Job	1	25,00,000	25,00,000
4	Carrying out the Preventive Measures for the marine Environment as per the approved conservation & Management plan during the Environment Clearances	Job	1	75,00,000.00	75,00,000

5	Cost Towards Construction and Demolition Waste Management Plant (Setting up & Operations)	Job	1	15,53,00,000	15,53,00,000
6	Terrestrial Tree Felling Replantation and Rehabitation	Job	1	15,00,000	15,00,000
7	Cost towards Installation of Temporary Sound Barrier	Job	1	25,00,000	25,00,000
8	During and Post Construction Environment Monitoring	Job	1	1,07,47,011	1,07,47,011
9	Cost toward the Reinstitution of the Mangroves/Forest Land post Construction	Ha	9.00	2,50,00,000	22,50,00,000
				Total	**45,85,47,011**

Justification of EMP and cost estimates

1. As the proposed bridge passes through CRZ Notified area, prior approval from Maharashtra Coastal Zone Management Authority (MCZMA) is required. MCZMA in its 144th meeting, instructed to submit scrutiny fees towards MCZMA for any project taking place in CRZ Notified area.
2. Considering forest clearance, as per Forest Conservation Act 1980, User agency needs to pay Net Present Value (NPV) to forest dept. with respect diverted land. Cost of NPV is given in FCA Handbook. As the proposed forest land is approximately 9 Ha Forest land, BMC shall give non-forest land in lieu of the diverted land.
3. Plantation cost on compensatory afforestation land shall be borne by BMC.
4. Tree felling cost in diverted land shall be borne by BMC.
5. Cost for fencing of compensatory afforestation land shall be borne by BMC.
6. Rehabilitation of temporarily required forest land shall be borne by BMC.
7. Environmental Monitoring shall be done in Pre-Construction, During Construction and Post construction stage.

11 COST ESTIMATE

11.1 GENERAL

The project cost for project components as described in this report is prepared based on drawings produced and using MCGM Road & Bridge Department Unified Schedule of Rates (SOR) for 2018.

12 CONCLUSIONS AND RECOMMENDATIONS

12.1 GENERAL

The preceding chapters of this report give detailed discussions on the various aspects of the study carried out by the Consultant for construction of project road.

12.2 PROJECT CONSTRAINTS/BOTTLENECKS

- Various constraints have been studied while finalizing the alignment (Minimum Rehabilitation and Resettlement, Minimum impact on Mangroves and other environmentally sensitive areas, etc.). After finalizing the alignment, BMC to obtain various clearances as detailed below:
  - CRZ clearance from MCZMA and MoEF, GoI.
  - Environmental clearance from MoEF, GoI.
  - Forest Clearance from Forest Department/MoEF, GoI.
  - Land Acquisition.
  - Clearances from Hon High Court Bombay as per Judgement in PIL 87 of 2006.

12.3 NOCS TO BE OBTAINED FROM THE FOLLOWING CONCERNED GOVERNMENT AUTHORITIES:-

- MSETCL
- Fisheries Department
- Salt Pan Commissioner
- MMRCL

12.3.1 TRAFFIC DISPERSAL

In order to cater to proper traffic dispersals and connectivity to proposed/ongoing roads or existing roads we have studied various options and recommending junction improvements as shown in Drawings.

12.3.2 PAVEMENT

We have recommended rigid pavement for "At grade" road main carriageway with bituminous pavement for side strips which is a small component of total project length. The major length of project comprises of structures. Microsurfacing is proposed as wearing coat over bridge deck.

12.3.3 TECHNICAL FEASIBLITY

From the above report, it may be concluded that the construction of the proposed Dahisar Bhayander Link road is considered as **Technically Feasible.**